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Astronautics

A PUBLICATION OF THE AMERICAN ROCKET SOCIETY

JULY 1962



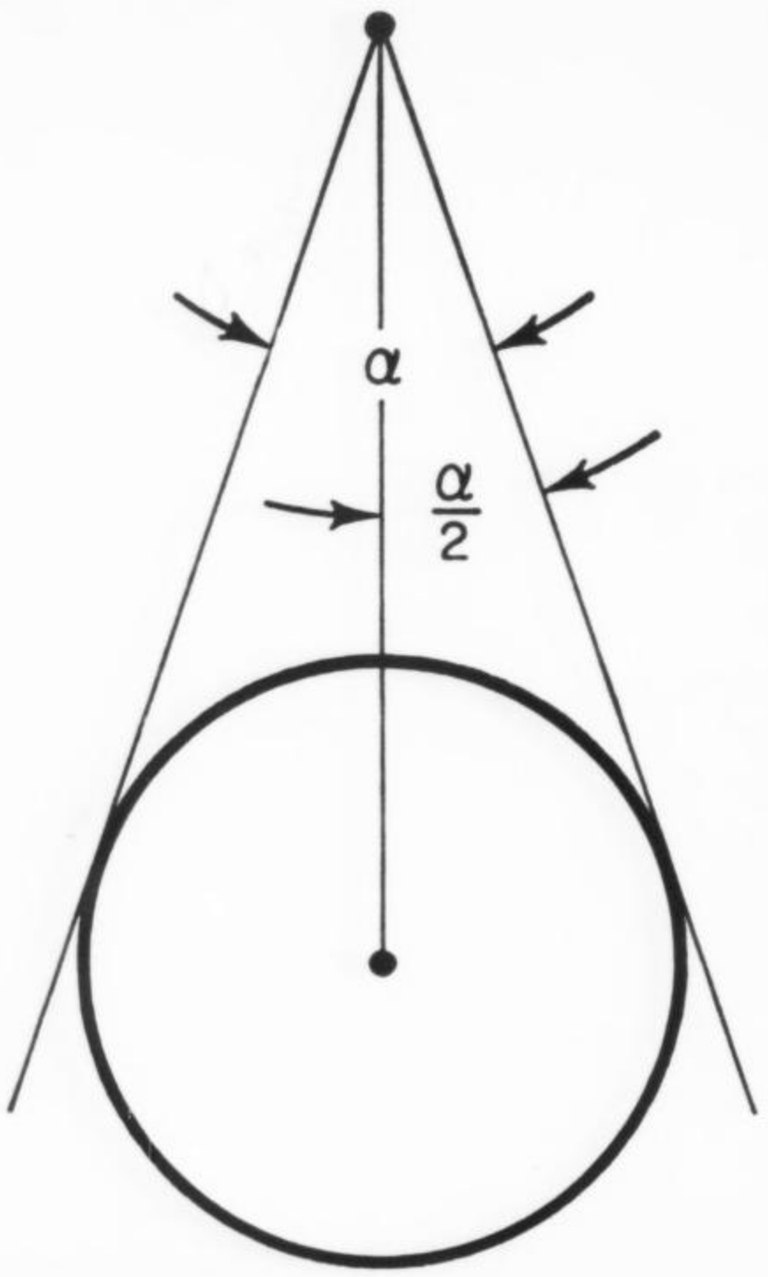
SPECIAL SECTION ON

LUNAR EXPLORATION

Lunar Takeoff . . . . . Kurt Stehling

Venus Mission . . . . . Robert Wyckoff

ARS–IAS Merger Negotiations



ge·o·me·try

Greek **geo·metrein,** from **ge,** earth; **metrein,** to measure

PROBLEM: (Euclid, ca. 300 BC): From a point outside a circle, using only straight edge and dividers, construct a line through the center of that circle.

SOLUTION: (Barnes Engineering Company, 1962 AD): By means of an **infrared straight edge,** the two tangents from the point to the circle are constructed, giving the subtended angle α. By means of **electro-optical dividers,** the angle α is bisected. The bisector is the required line. QED.

COROLLARY: If the point is a space vehicle and the circle is a plane through the earth, the bisector is the local vertical in that plane.



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Astronautics

A PUBLICATION OF THE AMERICAN ROCKET SOCIETY

Vol. 7 No. 7 July 1962



COVER: The big lunar mission, soft-landing a manned spacecraft on the moon, is depicted by artist Charles B. Nardone of the U.S. Naval Ordnance Test Station. Prime goals of the manned lunar mission will be reliable variable-thrust propulsion and a guidance system linked with it to give good manual control of the landing operation. Experiments in this direction are described on page 42.

ASTRO covers laminated on 1/4 in. hardboard base, 11 × 12 in., with clear plastic protective coating are available from ARS Headquarters at $2.00 each.

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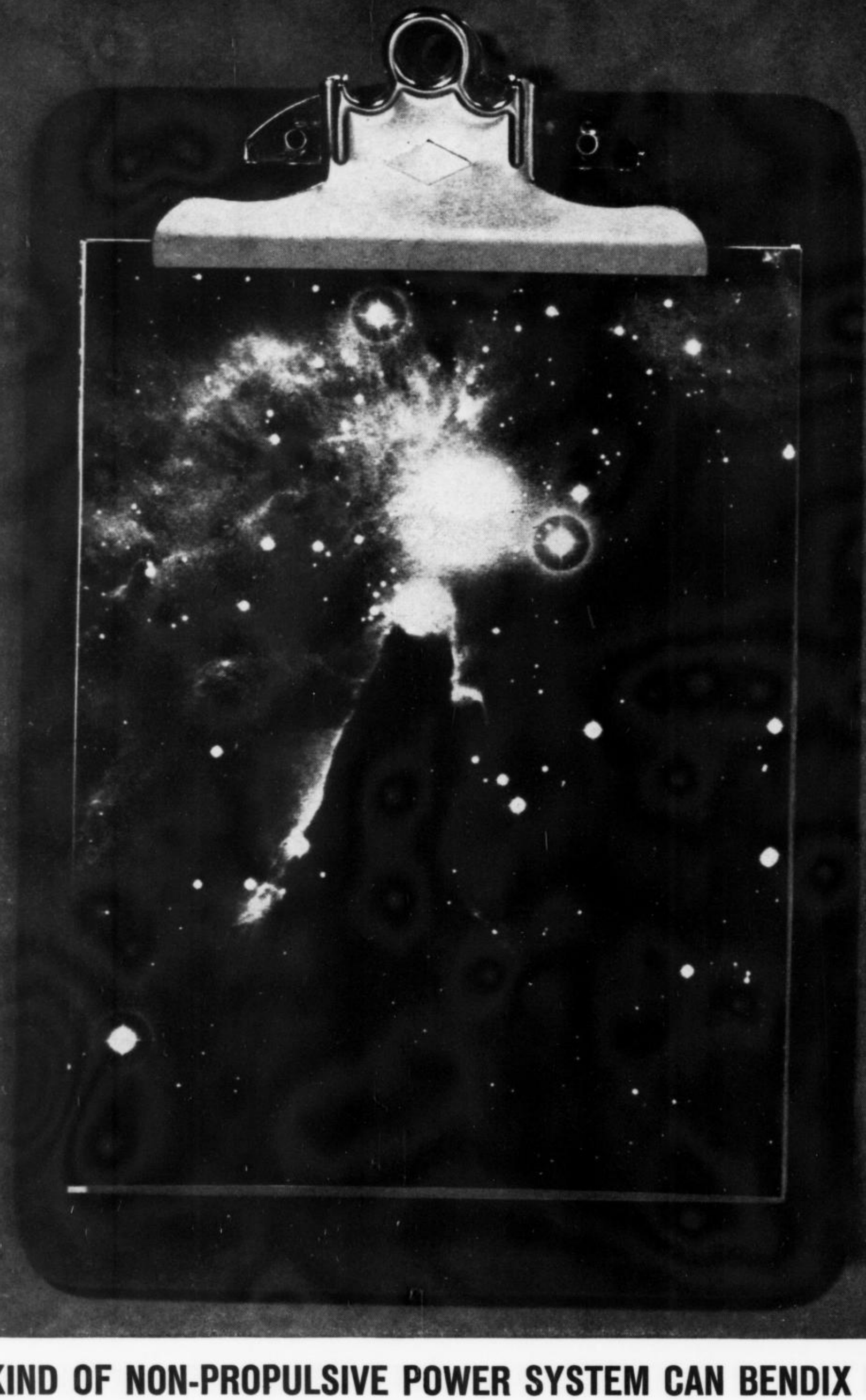
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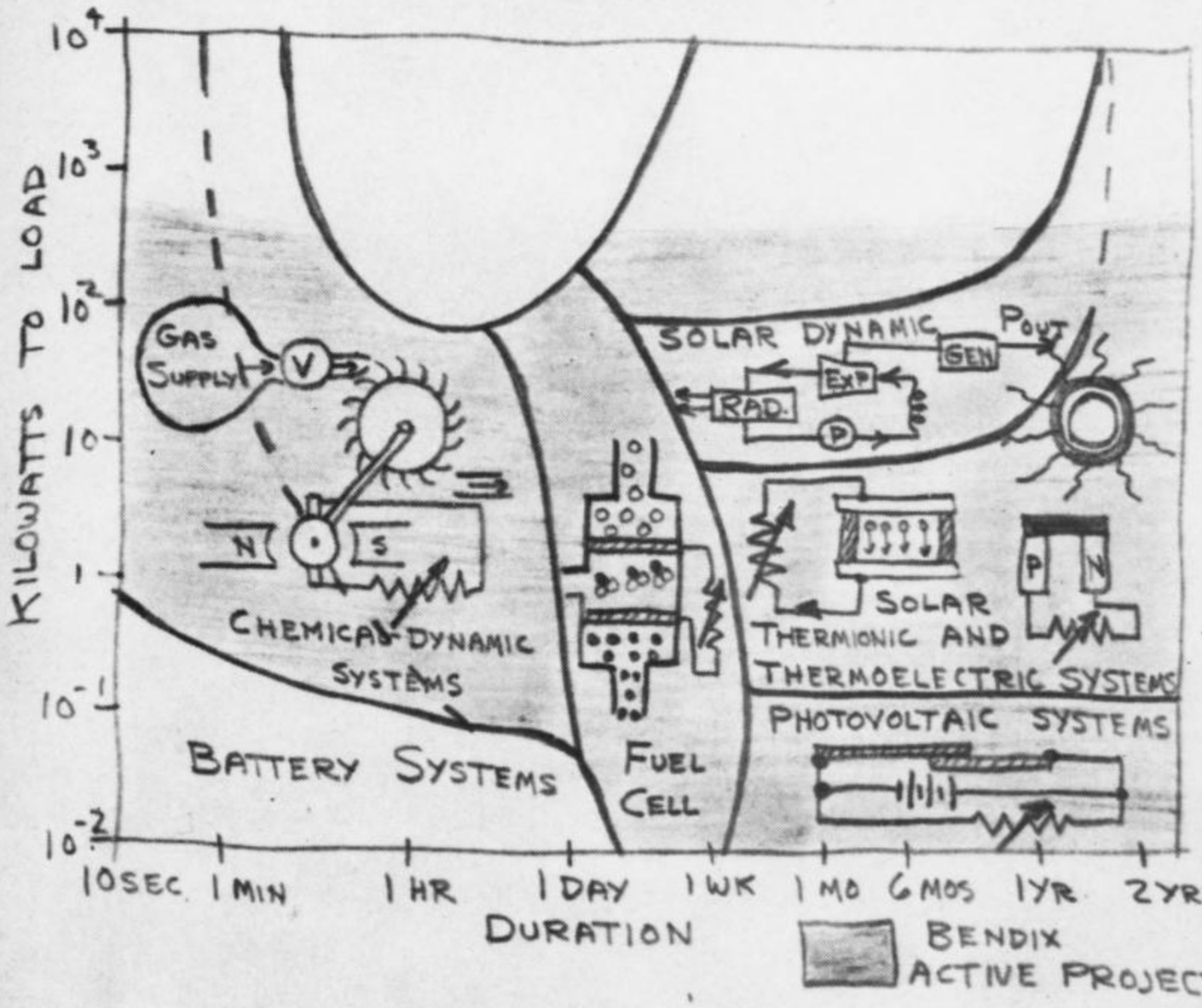
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TYPES OF SYSTEMS



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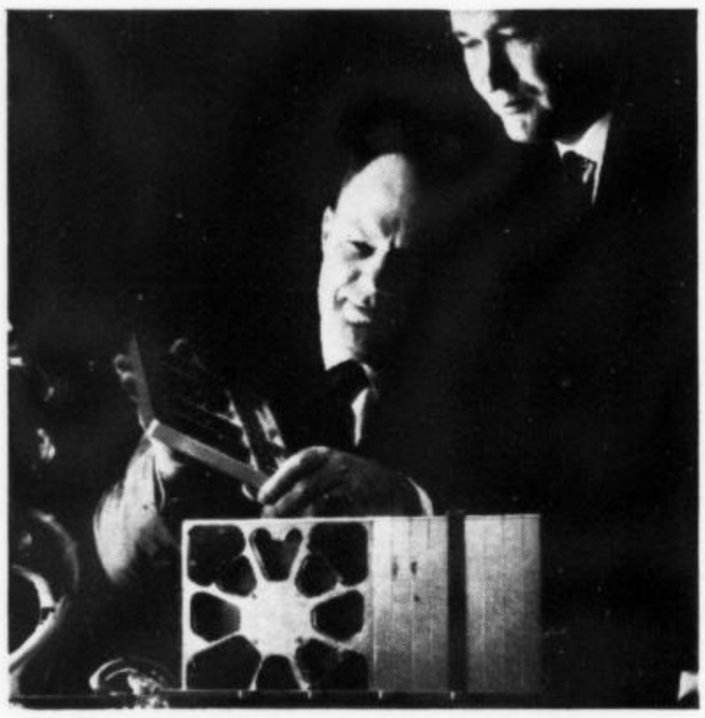
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For the record

May *1*—NASA revises X-15 record flight mark of April 30 downward to 46.7 mi.

May *3*—AF discloses first TV transmission via Echo I was effected from Calif. to Mass. on April 24 and again April 26.

May *6*—Polaris with live atomic warhead fired from submerged Ethan Allen 1400 mi. to Pacific target.

May *8*—Centaur explodes at 30,000 ft in first flight.

—AF Maj. Bob Rushworth takes X-15 for heat-resistance test.

May *9*—Laser pulses are directed at moon and received here in $2^1/_2$ sec in experiment by MIT Lincoln Lab engineers.

—COSPAR establishes Consultative Group on Potentially Harmful Effects of Space Experiments, an international panel of six scientists.

—Maurice Roy, professor of mechanics, Ecole Polytechnic, Paris, elected COSPAR president.

—Polaris, fired from submerged Sam Houston, destroyed when second stage develops trouble.

—Pershing destructed when second stage runs off course.

—Army fires Nike Zeus AMM, third stage fails to ignite.

May *10*—House Science and Astronautics Committee endorses $3671-million NASA space budget for FY 1963, triple current amount.

May *14*—House Committee on Science and Astronautics subcommittee investigates Centaur delays.

—U.S. urges 17-nation Geneva disarmament conference to prevent militarization of space.

May *15*—AF launches secret satellite into orbit, using Thor Agena-B booster.

—European Space Research Organization and European Launcher Development Organization announce plan to spend about $100 million a year on cooperative space projects.

May *23*—House of Representatives approves record $3671-million NASA budget for FY 1963.

May *24*—Astronaut M. Scott Carpenter orbits earth three times in Aurora VII and returns safely. Overshooting of his landing point by 250 mi. is attributed to a 25-deg error in the capsule's yaw attitude at retrofire. Capsule's apogee was 164 mi., perigee, 99 mi.

—Titan I explodes in silo preparatory to flight test.

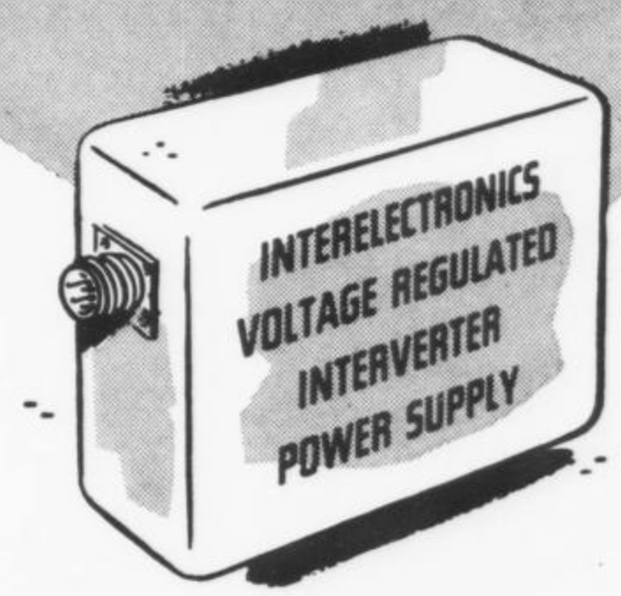
May *25*—DOD says study of cost-plus-fixed-fee contracts for military hardware shows actual production costs exceed target costs by as high as 20%.

—NASA sends 213-lb scientific Aerobee payload to about 125-mi. altitude and recovers it.

May *28*—USSR orbits Cosmos V.

May *30*—France plans to launch a satellite, "Diamond," in 1964 or early 1965. ♦♦

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Meet the authors



MacDonald



Green



Finn



Brown



Eimer

GORDON J. F. MacDONALD, whose analysis of "The Moon and Its Interior" leads off this issue on page 14, is a staff member of the UCLA Institute of Geophysics and Planetary Physics and a consultant to NASA. He graduated *summa cum laude* from Harvard Univ. in 1950 and received a Ph.D. there in geophysics in 1954. In the ensuing years he has done research and teaching at MIT, the Carnegie Institution, the U.S. Geological Survey, and UCLA, where he became a professor of geophysics in 1958.

JACK GREEN, JAMES C. FINN JR., and OSWALD D. R. BROWN, who discuss the advantages of a "Polar Lunar Base" on page 20, are scientists in NAA's Space and Information Systems Div.—Green a geochemist, Finn a botanist, and Brown a horticulturist. Dr. Green, who received a Ph.D. in geology from Columbia Univ. in 1951, did research and field work with the AEC and California Research Corp. before joining NAA in 1959. Dr. Finn received a Ph.D. in botany from UCLA in 1958, and joined NAA after teaching for a year in Texas. Born in Scotland, Oswald Brown received a diploma in horticulture at West of Scotland Agricultural College in 1955, and B.S. and M.S. degrees in horticulture at Texas A&M in 1959 and 1960, when he joined the NAA staff.

MANFRED EIMER, who discusses "Measuring Lunar Properties from a Soft-Lander" on page 30, is deputy director of JPL's Space Sciences Div. Born in Vienna, Austria, in 1925, he attended the California Institute of Technology and there received a B.S. in 1947, an M.S. in 1948, and a Ph.D. in aeronautics and mathematics in 1953. Since joining JPL in 1953, Dr. Eimer has worked in the areas of applied mathematics, aerodynamics, flight mechanics, and space science.

KURT R. STEHLING, author of "Lunar Takeoff" (page 34), is a staff scientist in NASA's Office of Plans and Program Evaluation. Coming to NASA from NRL, where he headed the Vanguard project's propulsion group, Stehling has had wide experience as a research and development engineer, including rocket design at Bell Aircraft and research in propulsion at Princeton's Forrestal Research Center. Stehling is an ARS fellow.

FELTON WILLIAMSON JR. and EARL YIM JR. ("Ugly Duckling—VT 1105R Test Vehicle," page 42) are engaged in propulsion development at the Naval Ordnance Test Station, Williamson as project engineer on the 1105R soft-lander and Yim as head of the Liquid Propulsion Systems Branch. Williamson received a Bachelor of Industrial Engineer degree from Georgia Institute of Technology in 1957, and since then at NOTS worked a year on design and development of hybrid rocket engines and three years as a design and project engineer on both fixed- and variable-thrust liquid-propellant engines. Yim has been engaged in advanced propulsion studies at NOTS since receiving a Bachelor of Chemical Engineering degree from the Univ. of California in 1954, and had been senior project engineer on the solid-fuel ramjet and liquid- propellant variable-demand gas generator developments.

ROBERT A. HEARTZ and THOMAS H. JONES, co-authors of "Mistram and Rendezvous" (page 47), are both with General Electric, Heartz manager of advanced dynamics and control engineering in its Defense Systems Dept. in Syracuse, N.Y. From 1950 to 1955, he was an R&D project engineer at Minneapolis-Honeywell's Aero Div. Jones is a systems engineer, assigned to the advanced systems subsection of the Defense Systems Dept., responsible for analyses of advanced guidance and control systems. Prior to joining GE in 1959, he was an aerodynamicist at Bell Aircraft. Both Heartz and Jones are ARS members.

The "Venus Mission—1962" (page 54) and the instruments for the P-37 and P-38 Venus probes are described by ROBERT C. WYCKOFF, head of the operational analysis group in JPL's Space Sciences Div. and project scientist for the Mariner P-37, P-38 mission. A graduate of the Univ. of Illinois, Wyckoff was a ballistician for the Army and a Naval officer in WW II, later taught physics, and then was engaged in intelligence work for the Army and Navy from 1951 to 1960.



Stehling



Williamson



Yim



Heartz



Jones



Wyckoff

Scientific predictions indicate that solar activity will be at a minimum between July, 1964 and July, 1965. This has been designated as the International Year of the Quiet Sun, and during it a world-wide magnetic survey will take place. □ The Douglas Space Physics and Planetary Sciences Group is studying scientific experiments to be performed on satellite and space probe missions during this period. Instruments to be used will be among the following: magnetometers; ionization chambers; G-M detectors; scintillators; solid state detectors; and spectrometers. □ The present Douglas Antarctica Riometer Station program for the study of cosmic rays will continue through this "Quiet Sun" period and will provide important data relative to solar cosmic ray and auroral events and the geomagnetic K-index. Douglas was invited to participate with the National Science Foundation in this program.

THE YEAR OF THE QUIET SUN
...AND WHAT DOUGLAS IS DOING ABOUT IT



Preparation for the Year of the Quiet Sun world scientific survey is one of more than 500 research projects that are under way at Douglas. Some of these relate to the solution of problems on programs of today and tomorrow. Others range through development and research programs whose effects may not be evident until ten or twenty years in the future.

DOUGLAS

The Question of Merger

THE MEMBERS of the American Rocket Society soon will be confronted with the question: Should ARS terminate its separate existence and join the Institute of the Aerospace Sciences to form a new large society to be known as the American Institute of Aeronautics and Astronautics? The question is not a simple one, and the consequences of such a move cannot be foreseen in entirety. Nor is it an unimportant one. From the broad point of view, a technical society contributes to the continuing education of its members and to the advancement of the profession as a whole. We should not do anything that might weaken this vital force; or, putting it another way, we should do only those things that will strengthen this force. The question becomes: Will merging the two societies be beneficial?

Those who favor the merger argue that a single large society will be more effective in various ways than two societies, and that there will be greater efficiency in matters of staff activities, publication programs, etc. They have assured the Board of Directors that industry executives and government officials strongly favor the merger, mainly as a way to reduce the number of national meetings.

Those who are against the merger are skeptical of the presumed benefits, argue that coordination of meetings is a broad problem that is being attacked and solved by inter-society cooperation among *all* the societies in the aerospace field, and believe that the consolidation of the two societies will lead to a large, slow-moving bureaucracy, less responsive to the wishes of the membership, and less eager to improve its program of services to the members.

The advocates of merger argue that it is confusing to have two societies on the national scene claiming to offer similar services in matters of meetings and publications, both of them engaging in similar efforts to solicit funds and to enroll qualified members. The parallelism in their activities leads to an atmosphere of competition which, they say, is quite improper for such nonprofit institutions dedicated to professional service.

The opponents of merger argue that the IAS and ARS are not really identical in their areas of interest and that, while they overlap to an important extent, so do other societies; that the two societies are quite different in their concepts of the services to be offered to their members and in their concepts of society democracy, and that the existence of a choice is good; that some constructive competition between the ARS and the IAS is beneficial to the members of both societies and to the profession at large, just as the competition between universities for better professors, better students, and better facilities (and for funds!) has produced in this country the most highly developed system of universities in the world.

It is this issue of competition and duplication that is really at the heart of the matter. Is such duplication always bad? Much can be

said in favor of having two or several scientific journals competing with each other. If an author (or a company) finds that one editor refuses to publish his paper, perhaps with incorrect justification, he can always turn to the other, and a good idea that might otherwise be stifled is brought to the attention of the profession. This is similar to the situation that exists in the funding of research and development by the government, a situation that we regard with favor.

However, in addition to the central issue of duplication, there are many subsidiary issues involved, and these arise when we try to visualize the organizational set-up and the operating procedures of of the proposed AIAA. For example, what will be the sources of funds of the merged society, and will it be possible to maintain the existing services at the dues level of the ARS? Also, what will be the role of the Technical Committees? What will be the voting procedure of the new society? To develop these and many other organizational aspects, lengthy and intensive negotiations took place from last January until now. The two negotiating teams found they could agree on many matters, and those points of agreement were embodied in the preliminary draft of the Principles of Consolidation which has been issued to the members of both societies.

But it would be misleading to convey the impression that we have agreed on everything. In some areas we found it impossible to reach agreement, and the only thing we could agree to do was toss the problem to the new Board of the AIAA when and if it is elected. Some rather important matters remain to be decided, but the negotiators still are hoping to resolve the differences. This may take a little longer than we first expected.

It would be unfair to a minority of the Board of Directors to give the impression that all of them are unanimously in favor of the merger, or that all the Directors are equally pleased with the results of the negotiations thus far. However a majority of the Board is in favor of continuing the merger negotiations and of bringing the matter to a vote at an early date, after the membership has been given an adequate period for consideration of the question.

At a future date, as soon as it is practicable, we expect to report to the membership on the results of our negotiations, the points on which we have agreed, and, equally, those unresolved points that will have to be decided by the new AIAA Board.

The ultimate choice will be up to the members. To make the best possible choice, you will want to receive all the significant information. You may wish to review the letters you have received from President Pickering; you may wish to examine the letters from the membership printed in the Letters Section on page 74 of this issue and those to be printed in future issues; you may wish to write a letter to the editor for publication in the Letters Section; you may wish to attend discussions of the merger question at Section meetings; and you may wish to present your views at the merger symposium at the national meeting in Cleveland on July 18.

The Society will provide all of these opportunities for democratic discussion on the part of the membership prior to the vote. We welcome your participation.

Martin Summerfield
Vice President

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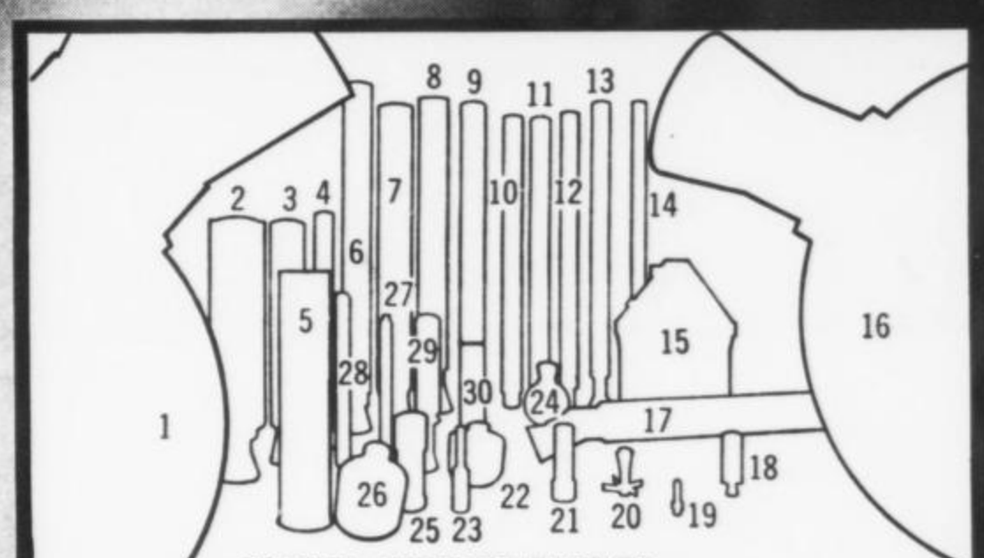
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success of the Discoverer Program and the recovery of the Mercury capsule. □ Pioneer in development of solid-fueled rockets of many performance characteristics for many systems (spherical engines to yield high mass ratios, special units for vernier control and gas generators), the Corporation has built a record which—in terms of reliable engine performance, timely delivery and economical operation—reflects the Thiokol capability required to meet present national demands for leadership in space and defense.

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		21. TE-139	
6. TE-29	Recruit—Mod. IA	22. TE-195	Discoverer Retro Mark I
7. TE-289	Yardbird—Mod. II		
8. TE-289	Yardbird—Mod. I	23. TE-52	Tart
9. TE-29	Recruit—Mod. IB	24. TE-345	Chippewa
10. TE-307	Apache—Mod. I	25. TE-280	5″ CP Test Engine
11. TE-307	Apache—Mod. II		
12. TE-82	Cajun—Mod. III	26. TE-316	Mercury Retro
13. TE-82	Cajun—Mod. II	27. TE-324	Hurler
14. TE-82	Cajun—Mod. I	28. TE-83	
15. TE-238 A	Blackfoot	29. M-58 A2	Falcon Engine
16. TE-184	Cygnus 25	30. M-46	Falcon Engine

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The Moon and its Interior

Information derived from a lunar orbiter and surface experiments should bring long-awaited answers on the internal nature and origin of the moon

BY GORDON J. F. MacDONALD, UCLA INSTITUTE OF GEOPHYSICS AND PLANETARY PHYSICS, LOS ANGELES, CALIF.



Partial Lunar Eclipse. Courtesy of the American Museum of Natural History.

THE INTERNAL constitution of the moon holds the answer to many questions regarding the solar system. The chemical composition of the moon may be typical of material of the solar system. The thermal history of the moon, as revealed by its present thermal and density fields, will provide clues to the process by which the earth–moon system formed.

Studies of the lunar surfaces have produced a wealth of observational material. By contrast, very few data relate to the nature of the moon's interior. The inaccessability of the moon's interior makes it unlikely that any detailed picture of its nature will be forthcoming in the near future. However, a number of critical experiments may settle problems relating to the origin and history of the moon.

The external face of the moon experiences bombardment by meteorites. The bombardment alters the surface at a slow rate, perhaps so slow that evidence of the moon's early history still exists in its outer layers. An interpretation of the surface features requires a detailed understanding of crater formation. Great advances have been made in the past few years in the physics of crater formation and of impact phenomena. These advances have resulted from a combination of geologic studies of craters combined with the theoretical and experimental investigations of explosive craters. (See Cratering Symposium, *Journal of Geophysical Research*, Vol. 66, pp. 3371–3470, 1961.)

But here we will not be concerned with the surface, but rather with the internal structure of the moon. Locked within the internal structure are many clues unaltered by time concerning the early history of the moon and earth.

Data relating to the lunar interior have been derived from astronomical observations. These data fix the mean density of the moon and provide an estimate of its gravitational figure. The mean density is well established at 3.34. This value is tantalizingly close to the density of a large number of silicate materials found on or near the surface of the earth. Yet, the mean density presents a number of major problems.

Urey and others have argued that the best sample of the heavy-element-composition solar system is provided by chondritic meteorites. The density of the moon is about 10% lower than one would expect for chondritic

Ratio of Chondritic Abundance N_c to Solar Abundance N_s

(After Aller, 1961)

Element	N_c/N_s	Element	N_c/N_s
Na	0.77	Ca	1.23
Mg	1.59	Ti	1.52
Al	1.18	Cr	1.07
Si	1.00	Mn	2.24
P	0.66	Fe	6.03
S	0.17	Co	1.59
K	3.72	Ni	1.20

material at temperature-pressure conditions estimated within the moon. The fact that the moon is less dense than the meteorites suggests that material composing the moon either contains less of the heavy elements or the heavy elements are in chemical compounds less dense than those of the chondrites. An important heavy element is iron. Iron could form less-dense compounds in the presence of abundant water, as Urey has pointed out. Another possibility is suggested by the abundance of solar elements.

The table on page 14 gives ratio of abundance of the nonvolatile elements in the chondritic meteorites to the abundance in the solar atmosphere. The solar and chondritic abundances are close except for sulfur, potassium, and iron. These last two elements are of great interest. Iron is important in determining the mean density of the moon and K^{40} is a major heat-producing radioactive isotope.

A silicate material having the heavy-element composition of the solar atmosphere will have a density on the order of 3.2–3.3, values near that of the moon. The low abundance of iron in the sun and the low density of the moon suggest that the lunar material may have a composition more nearly like that of the sun than that of chondritic meteorites.

The abundance of the radioactive elements determines the internal temperature distribution of a planet. Urey (1952) pointed out that a limit on the possible temperature distribution within the moon can be derived by an indirect argument using the moon's gravitational figure. If the temperatures within the moon approach the melting point of the silicates, then the figure of the moon should closely approximate that of a fluid with an equivalent density distribution. The physical librations of the moon provide an estimate of the ratios of the difference in moment of inertia to the mean moment of inertia. The ratio of the difference in the moments of inertia to the mean moments of inertia are much larger than would be predicted for a homogeneous moon in hydrostatic equilibrium.

Like the earth, the moon is flattened at the poles and has a bulge all around its equator. Unlike the earth, the moon also protrudes along the direction between the center of the earth and the center of the moon. There is thus an additional bulge on the side of the moon that always faces the earth and on the opposite side. If the moon were fluid or acted like a putty-like plastic, then the very slow rotation of the moon should produce an equatorial bulge, but the equatorial radius should be only 50 meters greater than its polar radius. The measured equatorial radius is 1 km greater than the polar radius.

Similarly, the gravitational attraction of the earth on the moon should pull the moon out by about 40 meters, but the actual protrusion toward the earth is more than a kilometer. The difference between the shape of the real moon and that of an ideal plastic moon indicates that the moon has great strength. This conclusion is independent of the process by which the observed equatorial bulge and protrusion were formed. Estimates of the stress differences created by the inequalities of figure are on the order of 10 to 100 bars and depend on the detailed assumption of the elastic properties of the moon.

The astronomical data on the rotation of the moon suggest that it is a relatively strong body, capable of supporting stress differences comparable in magnitude to those supported within the earth. If a major fraction of the moon's interior were molten or nearly molten, the distorted figure of the moon could not be supported.

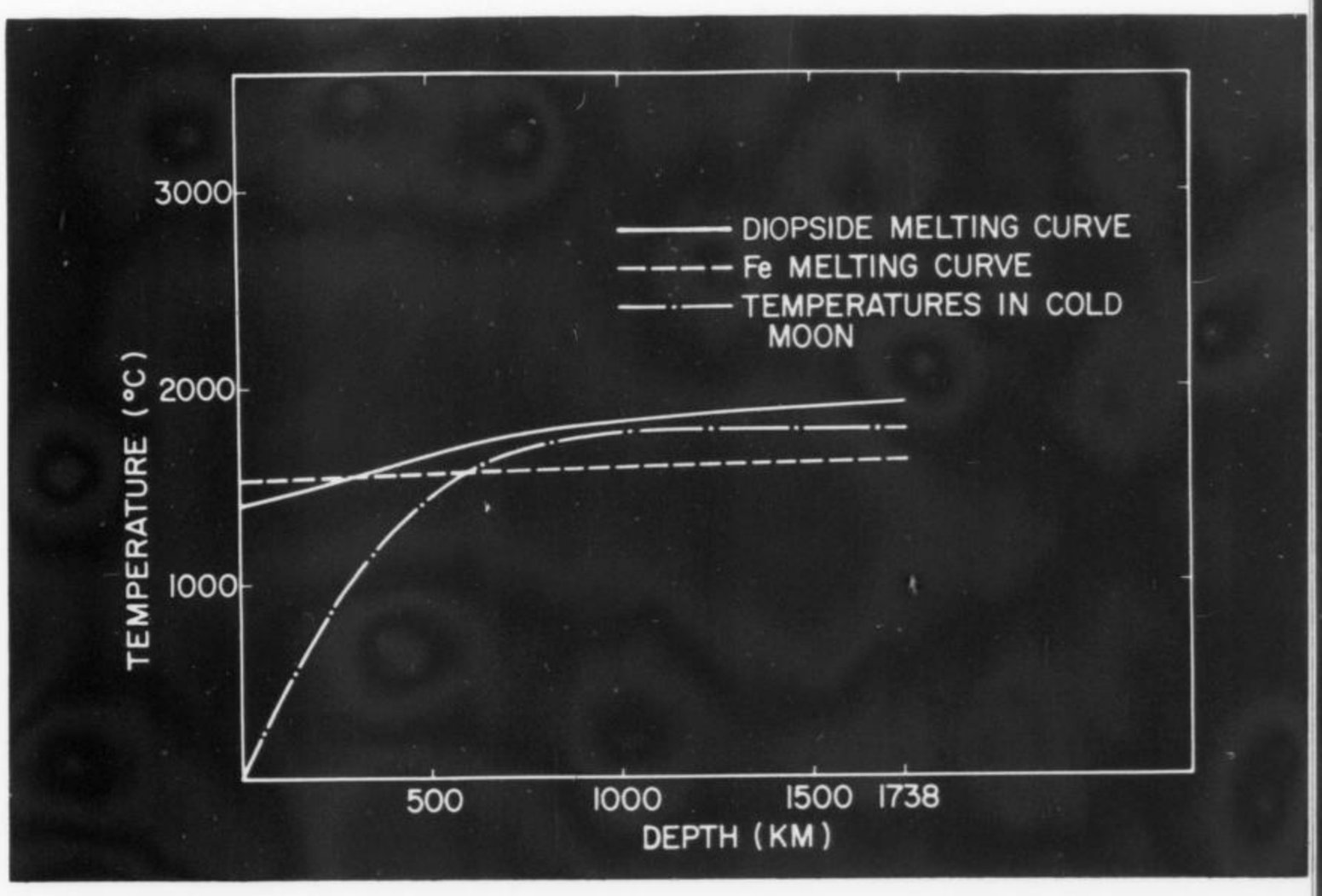
Astronomical data can also be used to obtain an estimate of the distribution of density within the moon. The inclination of the moon's axis of rotation to the pole of the orbit is determined by the ratio of the differences between equatorial and polar moments of inertia to the mean moment of inertia. Similarly, the ratio of the differences of the principal moments to the mass times the square of the radius is determined by the mean motion of the perigee and node. It is possible to compare the observed values of the mean motion of the perigee and node with calculated values appropriate to a homogeneous moon.

If the astronomical data are thus reduced, it is found that the data require that the interior of the moon be less dense than the outer parts. Indeed, it would seem that the moon is more like a hollow than a homogeneous sphere. This suggests that there are inconsistencies either in the reduction of the observations of the moon's motion or in the numerical development of the lunar theory.

There is, then, no reliable estimate of the internal density distribution, and it is impossible to say whether the moon is chemically homogeneous. Various workers, including Baldwin

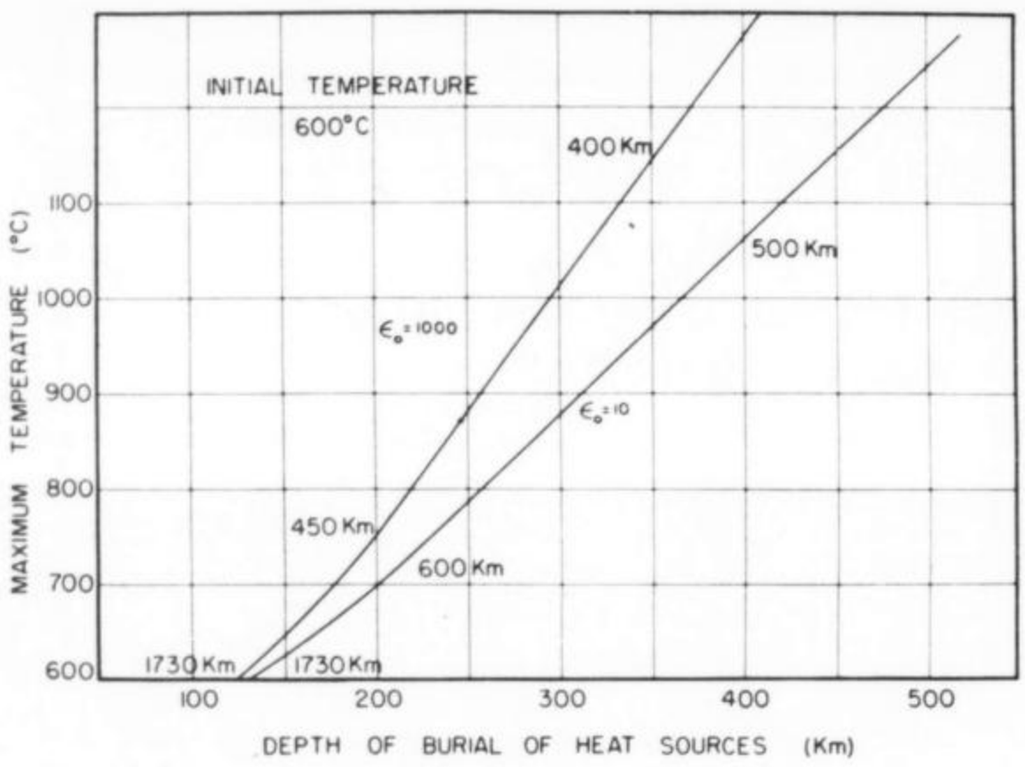
TEMPERATURE DISTRIBUTION FOR CHONDRITIC MOON COMPOSITION

Radioactivity uniformly distributed; initial temp. 0 C; curves of diopside and iron for comparison.

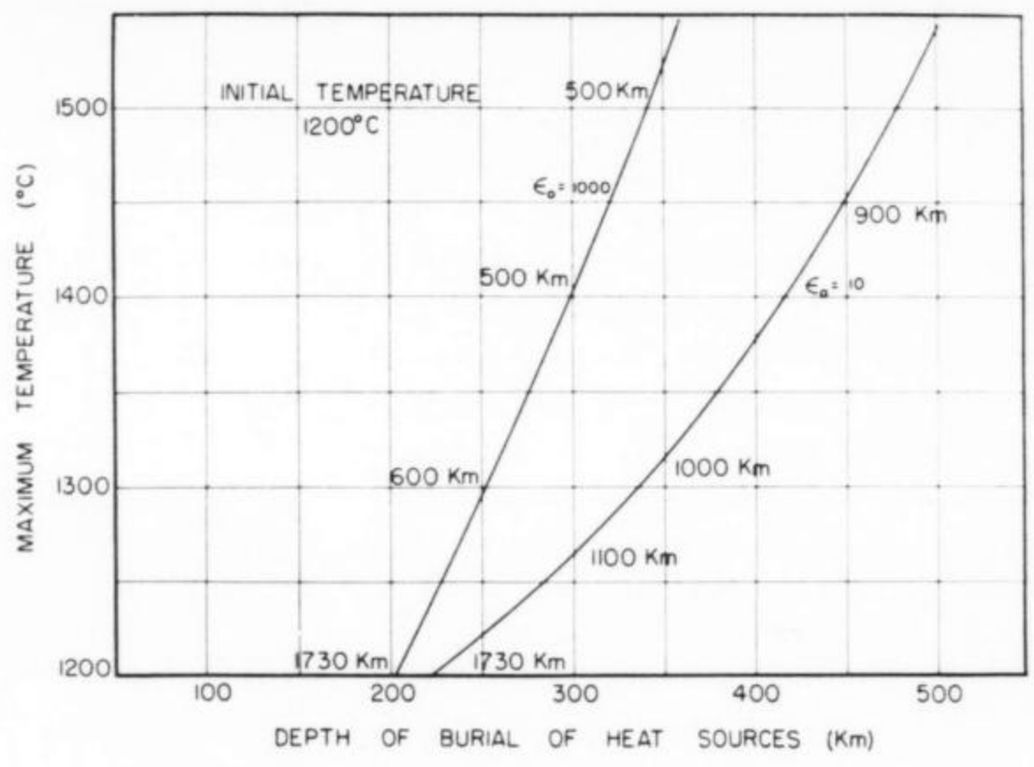


MAXIMUM TEMPERATURE IN MOON VS. DEPTH OF HEAT SOURCES

Total Radioactivity Equals That of Chondrites



INITIAL TEMPERATURE OF 600 C



INITIAL TEMPERATURE OF 1200 C

and O'Keefe, have suggested that the surface is composed of rocks of differing chemical composition. These arguments indicate a chemically inhomogeneous moon, but the evidence presented is inconclusive so far.

The thermal state of the moon's interior is determined by the distribution of radioactivity, of thermal conductivity, and of the temperature distribution at the time the moon was formed. Of these parameters, the thermal conductivity has the least influence on the temperature distribution; but the distribution of radioactivity and the initial temperature play an important role in fixing the present thermal state of the moon.

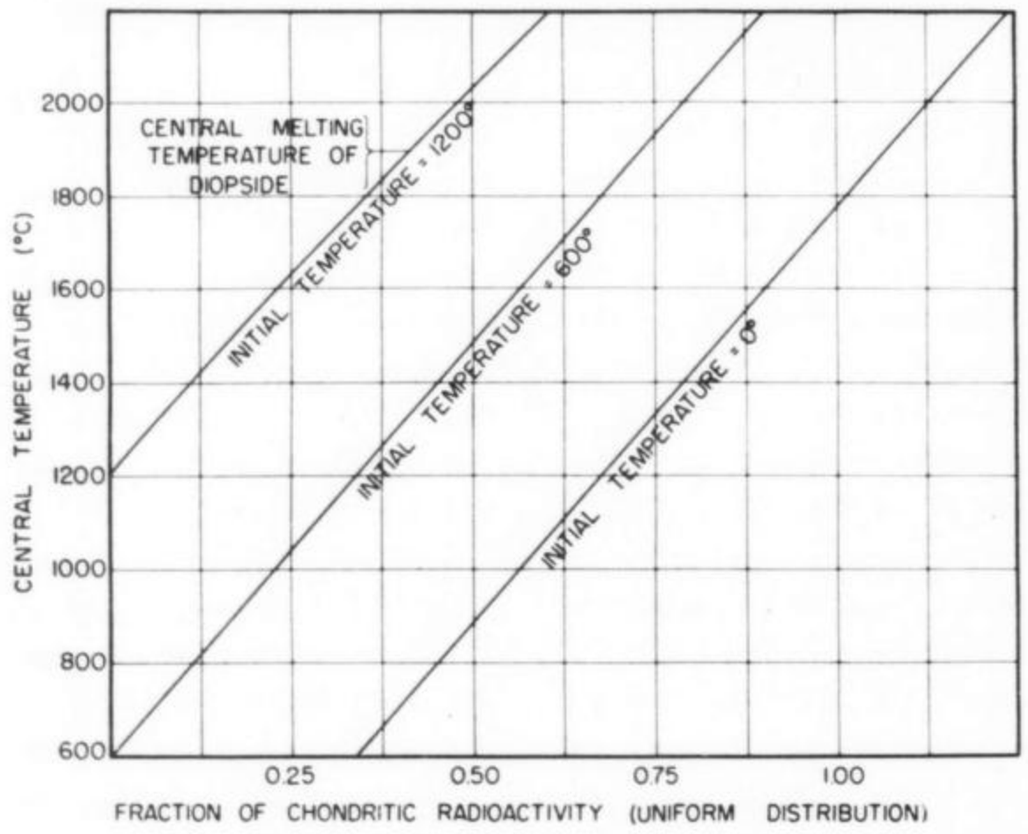
Urey (1952) and MacDonald (1959) made a large number of calculations on the thermal state of the moon using methods developed for the study of the thermal history of the earth. If the moon is initially taken at a cold 0 C, then the graph on page 15 gives present-day temperature distribution, provided a chondritic radioactivity is uniformly distributed. For comparison, the melting-point curve of diopside ($CaMgSi_2O_6$) is shown, as is the melting point of iron. The melting point of a multicomponent silicate material will be lower than that of diopside. The close approach of the diopside melting-point curve and the calculated temperature shows that much, if not all, of the moon would be near or at the melting point. A uniform chondritic composition results in temperature above the estimated melting temperatures of silicates even if the assumed initial temperature is low.

The outstanding feature of the temperature-depth curve for the moon is the shallow depth at which melting points of various materials are reached or exceeded. Since the moon is a relatively small body, the central pressure is low—on the order of 46,000 atm. The low central pressure does not markedly raise the melting points of possible constituents. Thermal conductivity is sufficiently low so that only the outer portions of the moon are cooling to any extent. A combination of these two circumstances results in the close approach of the melting-point curve and the calculated temperature distribution as illustrated in the graph on page 15. In the earth, the pressure increases with depth, raises the melting point, and helps keep the earth's mantle solid.

In a homogeneous moon the melting temperature of silicates is approached or exceeded provided the moon has the composition of chondritic meteorites. But assumption of chondritic radioactivity and of homogeneity are inconsistent with the observed strength of the moon. There are two possible solutions: (1) The moon is a differentiated body in which the radioactivity is concentrated toward the surface. (2) The total radioactivity of the moon is less than the radioactivity of the chondritic meteorites.

We first consider the temperature distributions in a differentiated moon. The graph top left shows maximum temperature and depth at which this

MAXIMUM TEMPERATURE IN MOON VS. TOTAL RADIOACTIVITY UNIFORMLY DISTRIBUTED



temperature occurs in a moon having a radioactivity equal to that of chondritic meteorites but concentrated in near-suface layers. In the upper curve the opacity ϵ_0 is 1000 cm^{-1} and corresponds to a case where the radiative transport of heat is unimportant. In the lower curve the opacity is 10 cm^{-1} and radiation begins to dominate ordinary thermal conduction at temperatures on the order of 700 C. The initial temperature is taken to be 600 C. If the radioactivity is concentrated in the outer 100 km, then the maximum temperature is the initial 600 C, as the central regions do not lose heat. These calculations illustrate that in a differentiated moon the melting point is not reached. The assumption of a differentiated moon removes the difficulty of a present-day partially molten moon, but raises the problem of how differentation could go in a solid body.

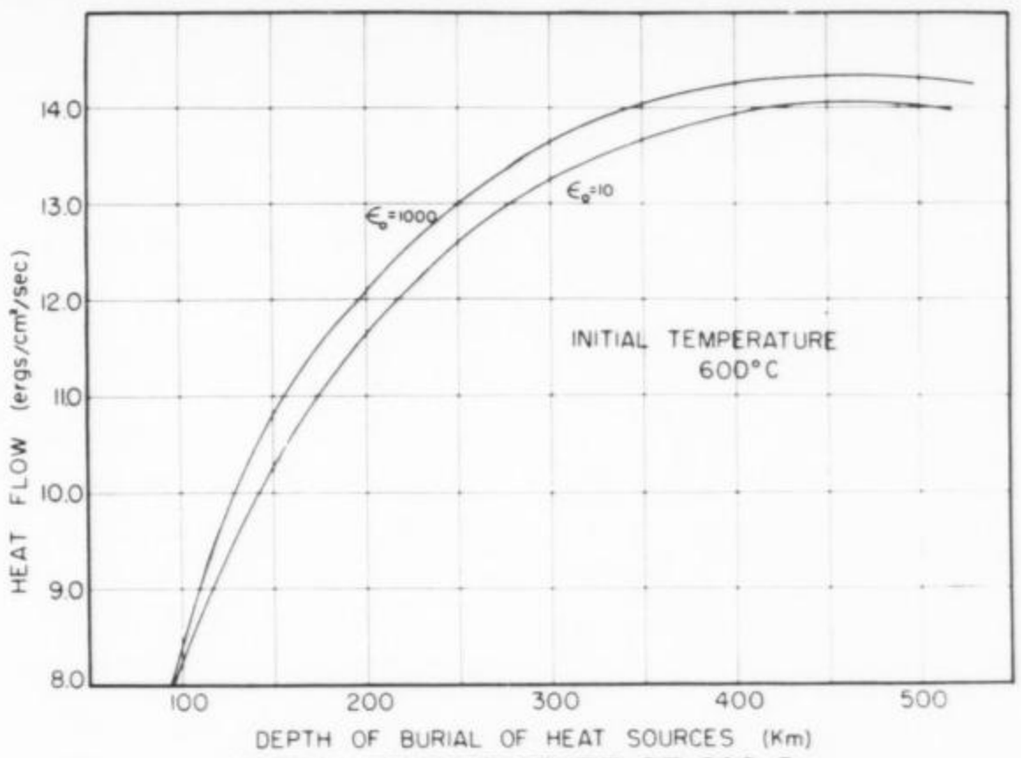
The graph at the top right of page 16 shows temperature vs. depth of the heat sources, for an initial temperature of 1200 C. Again the maximum temperatures lie well below melting at the depths involved.

A graph on page 16 shows the effect on maximum temperature of lowering the total radioactivity, which is assumed to be uniformly distributed. In this case, the maximum temperature is reached at the center of the moon. The central temperature is plotted as a function of the fraction of chondritic radioactivity maintaining the chondritic ratio among the heat-producing elements. It is to be noted that the solar abundance of potassium corresponds to about one-fourth the chondritic radioactivity. If the initial temperature is zero, the central temperature lies below the melting temperature for a total radioactivity equal to that of chondritic meteorites. If the initial temperature is 600 C, then the moon remains solid throughout, if the radioactivity is 0.75 or less than that of chondrites. A central temperature of 1200 C requires that the radioactivity be less than 0.4 that of chondritic meteorites for the present central temperature to lie below the melting point of diopside. If radioactivity were as low as that indicated by the potassium content of the solar atmosphere, then the initial temperature could be rather high, greater than 1200 C, and the lunar material would remain solid.

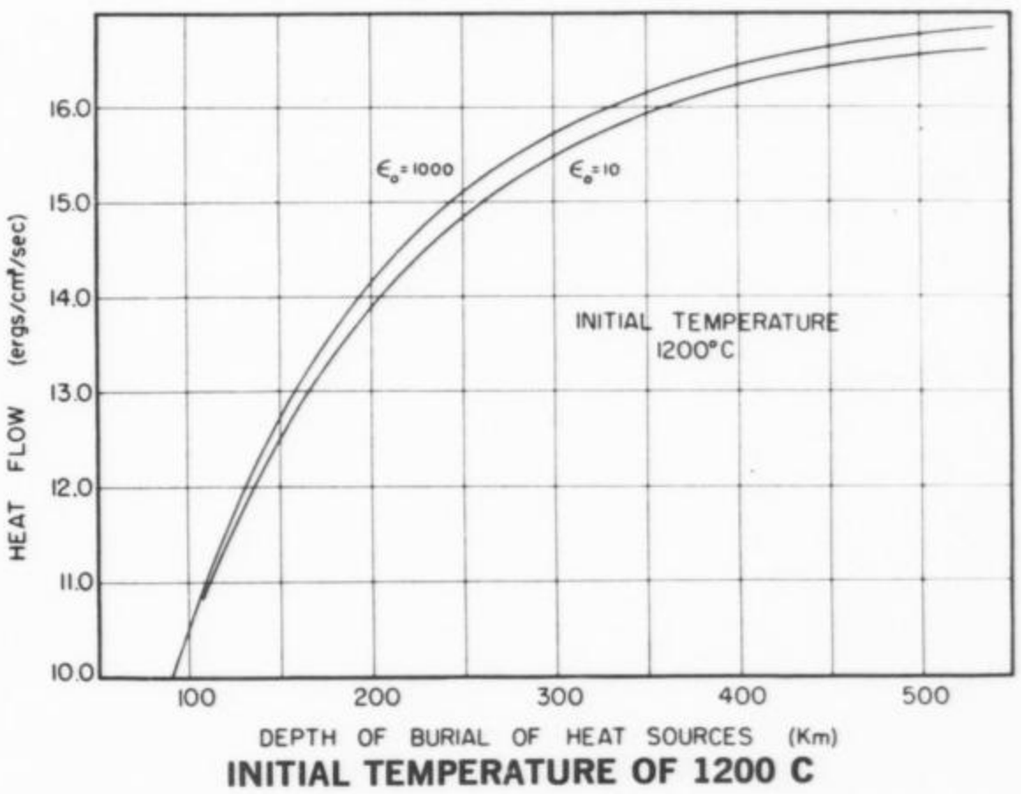
The composition of the moon and the associated internal temperature distribution and internal structure poses a problem whose solution will be aided by three kinds of observations. A better determination of the gravitational figure of the moon will fix whether the moon is homogeneous or is differentiated with a higher-density inner core. Placing a satellite in orbit about the moon and tracking it in detail will allow determining the mean moment of inertia. A knowledge of the mean moment of inertia determines the degree of differentiation and provides data of a fundamental character for the investigation of

SURFACE HEAT FLOW VS. DEPTH OF HEAT SOURCES

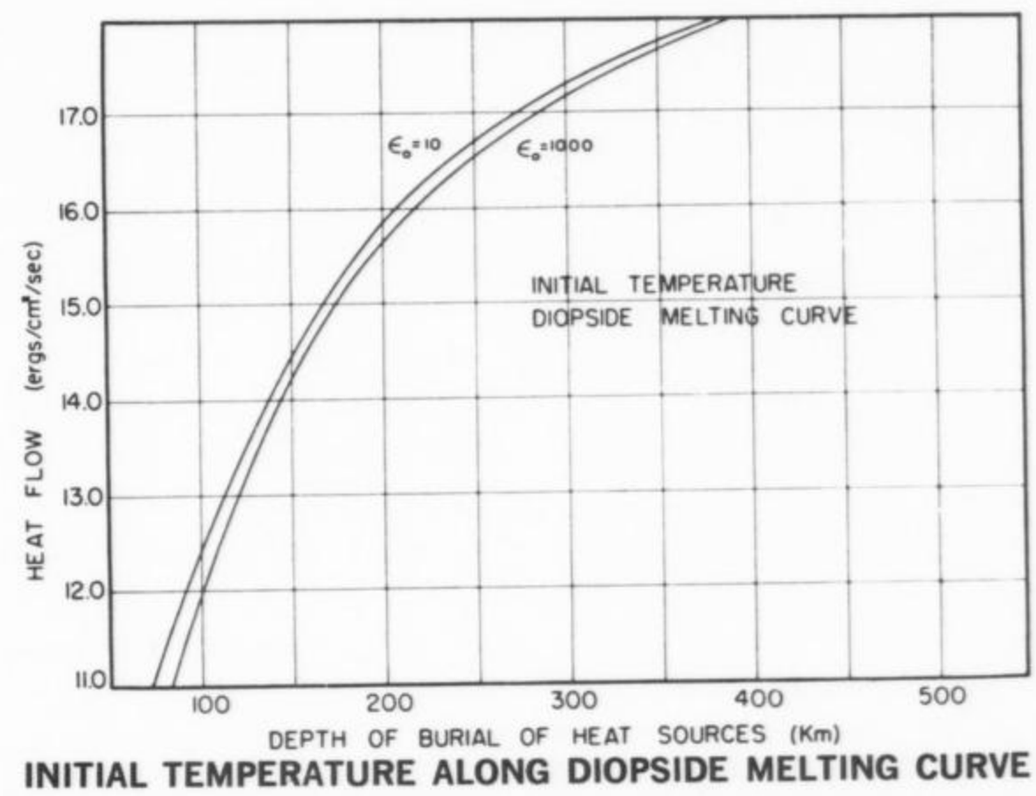
Total Radioactivity Equals That of Chondrites



INITIAL TEMPERATURE OF 600 C



INITIAL TEMPERATURE OF 1200 C



INITIAL TEMPERATURE ALONG DIOPSIDE MELTING CURVE

a large number of specific lunar models. This observation is perhaps most critical of all, since it gives an immediate measure of the bulk properties of the lunar interior.

A second experiment of great importance will be determining the surface heat flow. This requires a measurement of both the near-surface thermal gradient and the thermal conductivity of the materials where the thermal gradient is measured. A high heat flow would be associated with high radioactivity and a considerable depth of burial of the radioactivity, as shown at the top of page 17. The surface heat flow is shown as a function of the depth of burial of heat sources, assuming a chondritic radioactivity and initial temperature of 600 C. Two values of the opacity are shown, and these indicate that the detailed assumptions regarding thermal conductivity are not important in the determination of surface heat flow.

If the heat sources extend to a depth of some 500 km, then the surface heat flow is twice that of a model in which the heat sources are located within the upper 70 km. The near-surface concentration of heat sources permits heat produced during the early stages of the history of the moon to escape rather than be trapped. If the heat sources are buried to a depth of some 500 km, most heat reaches the surface.

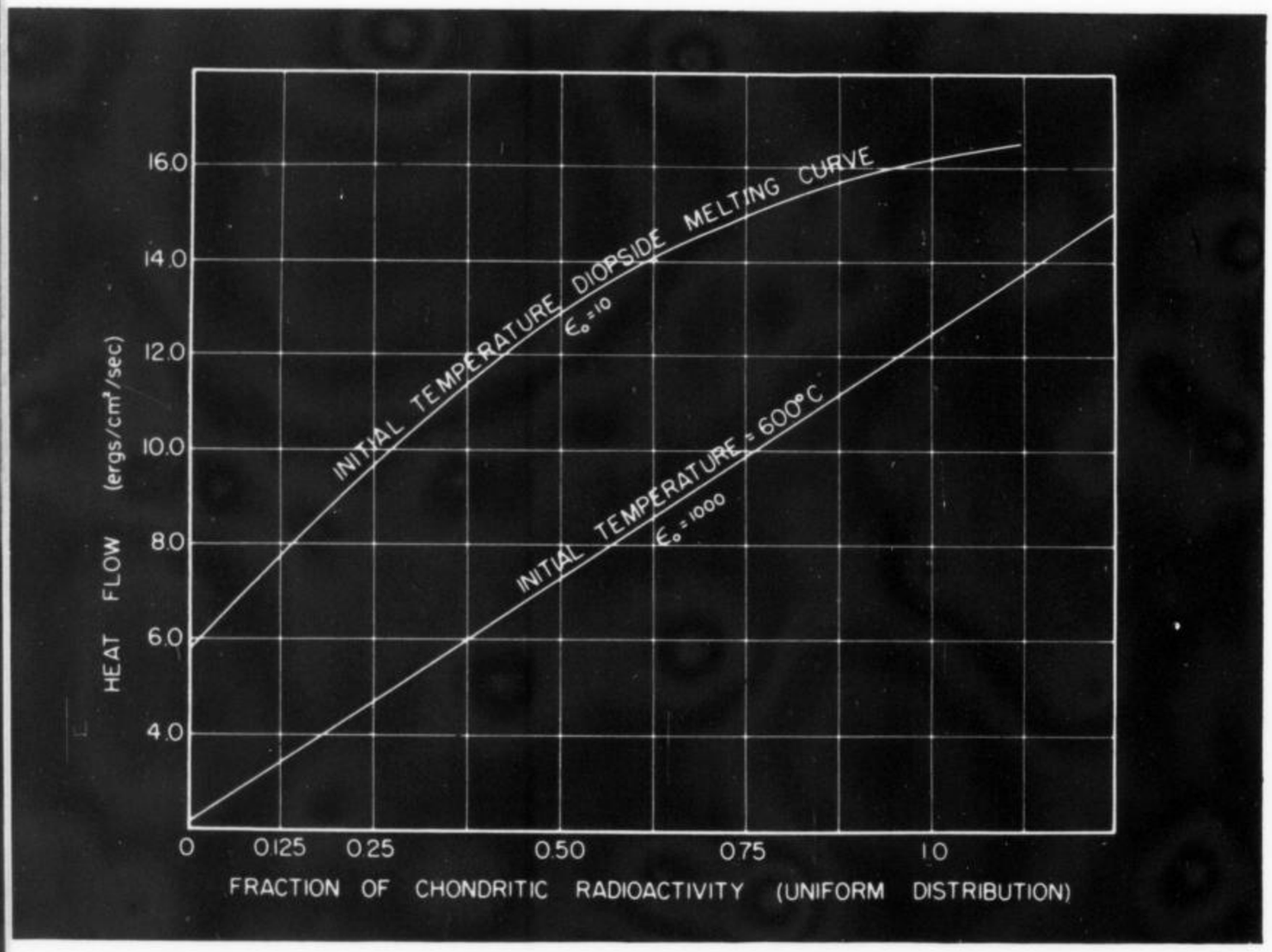
The next graph shows a similar dependence of the surface heat flow upon depth of burial of heat sources, where the initial temperature is taken at 1200 C. If the moon were initially molten, then the surface heat flow would be considerably higher, as shown by the last graph on page 17.

Finally, the graph here below shows dependence of surface heat flow on the amount of radioactivity for two initial temperature distributions. The radioactivity is assumed uniformly distributed throughout the moon.

Measurements of the surface heat flow combined with calculations of the type illustrated on this and the previous page could provide limits on the bulk chemical composition of the moon. The measurement of heat flow is a point measurement and so subject to uncertainties associated with lateral inhomogeneities in the moon. Determination of the seismicity of the moon is therefore important. It can be shown that the rate of release of thermal stresses is proportional to the integrated surface heat flow (MacDonald, 1960). Measurements of the average seismic activity thus provide another method of estimating the heat flow.

We have focused on the question of the moon's composition and internal structure. A most intriguing problem is associated with the question:

SURFACE HEAT FLOW VS. TOTAL RADIOACTIVITY UNIFORMLY DISTRIBUTED



Has the earth always had a moon? A detailed study of the moon's motion shows that it moves away from earth at a rate of about 2 cm/yr. As the moon moves away, the earth in rotating about its north-south axis slows down. The rate of slowing down is very small, but it can be observed. Both modern astronomical observation and ones made in Babylon thousands of years ago confirm this slowing down of the earth and the moving away of the moon. The combined motion is due to frictional effects of the tides raised by the moon on the earth. The tides are both in the solid earth and in the oceans. The relative contributions to the dissipation of energy by the oceanic and solid tides is uncertain. If these frictional effects have remained constant in time, then it is possible to trace back to the time at which the moon was very near the earth. It turns out that this time would be only a billion years ago.

The earth is more nearly five-billion years old. Did the earth possess a moon during its first four-billion years? The answer is difficult. The extrapolation of the present rate at which the moon is moving away depends on assuming that the frictional processes have remained constant in time. If they are associated with ocean tides, then they may have undergone large changes as the oceans have changed in geologic time. On the other hand, if the frictional effects are associated with tides in the solid earth, then the rate of motion of the moon away from the earth could have remained constant. The problem of where the energy is being dissipated is under active study, but the final answer is not yet known (MacDonald, 1961).

The earth and moon may have formed together. The moon may have formed at a great distance and was captured by the earth relatively recently. Observations of the tides on the moon raised by the earth will provide significant evidence relating to this problem.

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New problems of space communications

Part II—Where Point the Antennas?

BY SOLOMON W. GOLOMB

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ON MARCH 10, 1961, *Homo sapiens terrestrialis* established his first direct contact with another planet. To state it in journalese, "Scientists from the Jet Propulsion Laboratory of the California Institute of Technology, under contract to the National Aeronautics and Space Administration, successfully bounced a radar signal off the planet Venus and detected the returning echo." For most of the next two months, whenever Venus was visible, the transmitter and receiver antennas at the Goldstone tracking station in the Mojave desert of Southern California remained pointed at Venus. Many visiting dignitaries from other universities and laboratories, including many learned professors of physics and electrical engineering, made the pilgrimage to Goldstone. In the control room, two television screens revealed the fields of view of the two antennas with Venus normally in the center of both screens.

Almost without exception, the conversation would go something like this:

Visiting Intelligent Professor: Do you actually have both antennas pointed at where you see Venus?

Local Downtrodden Engineer: That's right.

VIP: And how long does it take the signal to travel to Venus and back?

LDE: About 3 min each way.

VIP: And how far across the sky does Venus move in 6 min?

LDE: Between 1.5 and 2 deg of arc, as seen from the ground.

VIP (Closing in for the kill): And what is the beamwidth of your antennas?

LDE (Resignedly, because he's gone through all this a hundred times already): About $^1/_2$ of a degree.

VIP (Triumphantly): Then I could improve your system by—I'd say—7 or 8 db. It's really very simple. You should point the transmitter ahead to where Venus is *going* to be, and the receiver behind to where Venus *was*.

LDE (Levelly): Nope.

VIP (Beginning to smell a rat): What do you mean, "Nope"?

LDE: Well, let's start with the receiver. We point it where we *see* Venus. That isn't necessarily where Venus is *now*. The light left Venus 3 min ago, just like the radar signal. They both travel at the speed of light, you know.

VIP (Trying to pull a fast one): Well, that's certainly true about the *receiver*, but what about the transmitter? That's what I was really thinking of. Instead of pointing it where you see Venus, which was where Venus was 3 min ago, you should point it ahead to where Venus will be 3 min from now—a couple of degrees, didn't you say?

LDE (Doggedly): You don't understand. The "couple of degrees" is relative motion. But in absolute terms, Venus only moves a minute or less of arc. The real contribution is from the earth's rotation.

VIP (Haughtily): What the devil does it matter how you choose to look at it? It's still 2 deg, isn't it?

LDE: No, it isn't the same. Look at it this way. Since Venus is hardly moving at all relative to the fixed stars, where we see Venus is to all intents and purposes where Venus "really" is. So we point our transmitter there, to transmit to where Venus really is, and we point our receiver there, to receive from where Venus really is.

VIP (More confused than convinced): But you can look at it the other way just as well, can't you? And you know, according to Einstein's Theory of Relativity, the choice of coordinate system should not influence the outcome of the experiment.

LDE: I'm glad *you* brought up Relativity. Have you heard of the Michelson-Morley experiment?

VIP (Indignantly): Young man, I knew Michelson personally! But what has that got to do with it?

LDE: As I understand it, it demonstrated that light is neither speeded up nor slowed down, nor otherwise accelerated by the earth's motion. Thus, a signal emanating from earth at the speed of light has no sideways component due to the earth's rotation. This was the basis of Einstein's theory, wasn't it?

VIP: I think you have something there (muttering mostly to himself). But if you did it with rifle bullets . . . now let's see . . .

As radar astronomy becomes ever more commonplace, subsequent generations of school children will know almost intuitively, we might hope, that you point the antennas where the planet "really is." However, for the time being, the colleges will continue to teach that Relativity doesn't really enter into any of the macroscopic phenomena of everyday life, except in the remotest decimal places. And lest the reader feel too smug, is the situation for Venus equally valid with high angular velocities and short distances, as for a 1000-mi.-high communications satellite, on the one hand, and for low angular velocities but greater distances (e.g., the planet Saturn) on the other?

Hint: $\sin \theta = v/c$. ♦♦

Although not knowing yet precisely where to build a base on the moon, we can deduce certain biological and geological advantages of

The Polar Lunar Base

BY J. GREEN, J. C. FINN JR., AND O. D. R. BROWN

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SELECTING A lunar-base site and constructing and maintaining a base there will involve many new scientific and engineering approaches. On the moon requirements of scientists and engineers for vital materials, facilities, and space may have to be compromised at first. Services of the biological and geological sciences will be basic to these requirements in both early and subsequent phases of base operations. In the early phases, terrain and mineralization may be the controlling factors; in later phases, processing of local raw materials for life support may assume the dominant role. In both phases the duration of the lunar photoperiod will be one of the more important factors in base selection and maintenance.

Presumably, the general site for a lunar base will be established through surveys made by Surveyor- and Prospector-type vehicles, with final appraisal made with the Apollo spacecraft. The data obtained from these early surveys will define the topography of the site and the presence or absence of mineralization. Once established, the lunar base will go through many stages of evolution; and whereas the final development of the base may be more or less independent of the terrain, the early phases will not. It is obvious that lunar-base operations should be preceded by carefully conceived simulated operations in cratered areas on the earth.

As a beginning, we might speculate cautiously about certain geological prospects: impact versus volcanic craters, mare versus nonmare areas, and polar versus nonpolar areas.

In primitive basing operations, naturally occurring rifts and fractures may provide valuable protection against radiation, high temperatures, and micrometeorite bombardment. Because both the mare and nonmare polar and nonpolar areas evidence such fracture systems, no location preference can be based on this criterion. However, volcanic craters on earth offer more protection than impact craters. This protection is in the form of cupola-like spatter cones, terrace rifts, and lava caves. Calderas on earth often exhibit peripheral fractures on their crater rims that could also serve as primitive installation sites, if this type of terrain exists on the moon. From the standpoint of protection, then, a volcanic crater is superior to an impact crater. As a base site, however, a volcanic crater may not necessarily be superior to a basaltic flow terrain, which sometimes exhibits a greater abundance of caves and fractures.

From the standpoint of mineralization and availability of water, a volcanic crater is superior to an impact crater. Volcanic rocks on the average contain 1% by weight of H_2O^+ (with a standard deviation of 0.3). Meteorites contain about 0.1% of H_2O^+. Because more craters occur in the nonmare areas, there would be a greater probability of finding a caldera there. The nonmare polar areas are not necessarily superior to the nonmare nonpolar areas, because centers for volcanic mineralization on the nonmare areas would probably have random distribution. But the occurrence of a larger number of eternally shadowed zones in the polar regions would make these sites favorable for prospecting.

From the standpoint of a cast-basalt technology, we may wish to establish a base near a mare area, the maria presumably being basaltic. The desirability of sulfur mineralization might prescribe a caldera site. Therefore, the existence of calderas or volcanoes in the maria, or calderas bordering the maria, should be regarded favorably. In such a location, basalt for metallurgical processing and sulfur for mineral dressing operations might be found together. Many calderas on earth that are composed of silicic rocks have basaltic flows and sulfur mineralization on their floors. A primitive lunar technology could conceivably be based on sulfur, basalt, hydrous-rock types, and cosmic-infall dust.

With the exception of the cosmic-infall dust, this variety of technologically important substances is not present in craters formed by impact. Impact craters should offer only iron–nickel as a useful product for lunar technology. Presumably iron–nickel would be available in any lunar terrain because of cosmic-infall dust.

A POLAR region, either volcanic or impact, would not necessarily offer more technologically important raw materials than a nonpolar one. However, the polar lunar base may perhaps be superior to a nonpolar one because of the juxtaposition or association of the following factors:

1. Eternal sunlight for power requirements.
2. Eternal sunlight for plant growth.
3. Normal abundance of fractures and caves, as primitive installation sites.
4. An above-normal distribution of



RATES OF DECOMPOSITION OF CERTAIN VOLCANIC PRODUCTS IN VACUUM

Age of the earth-moon crust is taken as $\pm 4.5 \times 10^9$ yr. Maximum temperature required for these compounds to exist over geological time is –70 C for S, –114 C for NH_4Cl, and –105 C for $CuSO_4$.

Material	Years required to vaporize 1-cm-thick layer in vacuum		
	–150 C (Lunar Shadow)	Zero C	100 C (Lunar Sunlit Surface)
Sulfur (S, rhombic)	10^{25}	10^{2}	10^{-3}
Sal ammoniac (NH_4Cl)	10^{15}	10^{2}	10^{-1}
Chalcanthite ($CuSO_4 \cdot 5H_2O$)	10^{18}	10^{1}	10^{-3}

Note: B=rate of sublimation in cm/sec; R=1.99 cal/K/mole; T=K. Equations for calculating B appear below. Equations 1 and 2 come from experimental data by Schultz and Dekker (1955, p. 2136; 1956, p. 1099) and Equation 3 comes from experimental data in the literature recalculated by Schultz and Dekker (1956, p. 1098).[7,8]

(1) $B = 1.1 \times 10^{10}\, e^{-23{,}890/RT}$ for rhombic sulfur

(2) $B = 1.2 \times 10^{2}\, e^{-13{,}500/RT}$ for sal ammoniac

(3) $B = 3.3 \times 10^{7}\, e^{-18{,}300/RT}$ for chalcanthite

FORMATIONS AT THE LUNAR POLES*

Formation	Wall or Peak Elevation		Diameter
North Pole			
Shackleton**	9000 ft; Delta 8000 ft; Beta, "lofty"		No data
Perry	No data		15 mi.
Hansen	Beta 11,000 ft; Gamma, 8000 ft		70 mi.
Main	No data		30 mi.
Vaisala	No data		50 mi.
Gioja	Peak 1	9000 ft	26 mi.
	Peak 2	8000 ft	
	Peak 3 & 4	3500 ft	
	Gamma	7000 ft	
	Alpha	9500 ft	
	Beta 1	8800 ft	
	Beta (unspecified)	8000 ft	
South Pole			
Leibnitz Mts.**	16,000-33,000 ft		—
Malapert	15,000 ft; overshadowed by Leibnitz Beta		35 mi.
Cartes	No data		—
Cabaeus	North wall 20,000 ft		60 mi.
Scott	No data		66 mi.
Amundsen	No data		66 mi.

*Altitude and diameter data from Wilkins and Moore.[4]

**Considered most favorable for a polar-base site.

the eternally shadowed zones.

5. Association of potentially mineralized shadow zones with eternally sunlit zones.

6. Normal distribution of raw materials of possible use in base technology.

Of course, considerations for a site in either polar or nonpolar location must first be integrated with the purpose of the base; secondly, these considerations must be compatible with the logistics of landing, supply, and maintenance.[1]

Johann Heinrich Mädler of Berlin in the 1830's first called attention to and explained the phenomenon of the Mountains of Eternal Light at the North Pole of the moon.[2] Outside of the polar regions, the surface of the moon is bathed in sunlight for about 13.5 days in each 27-day period. But, as Mädler pointed out, since the moon's equator is inclined 1°35′ to the ecliptic, the incidence of the sun's rays will always lie in the angle bounded by the horizon ±1°35′ at the poles. Thus, small areas of continuous light, and nearly continuous light, may be found in the polar regions, and certainly large areas of continuous darkness.

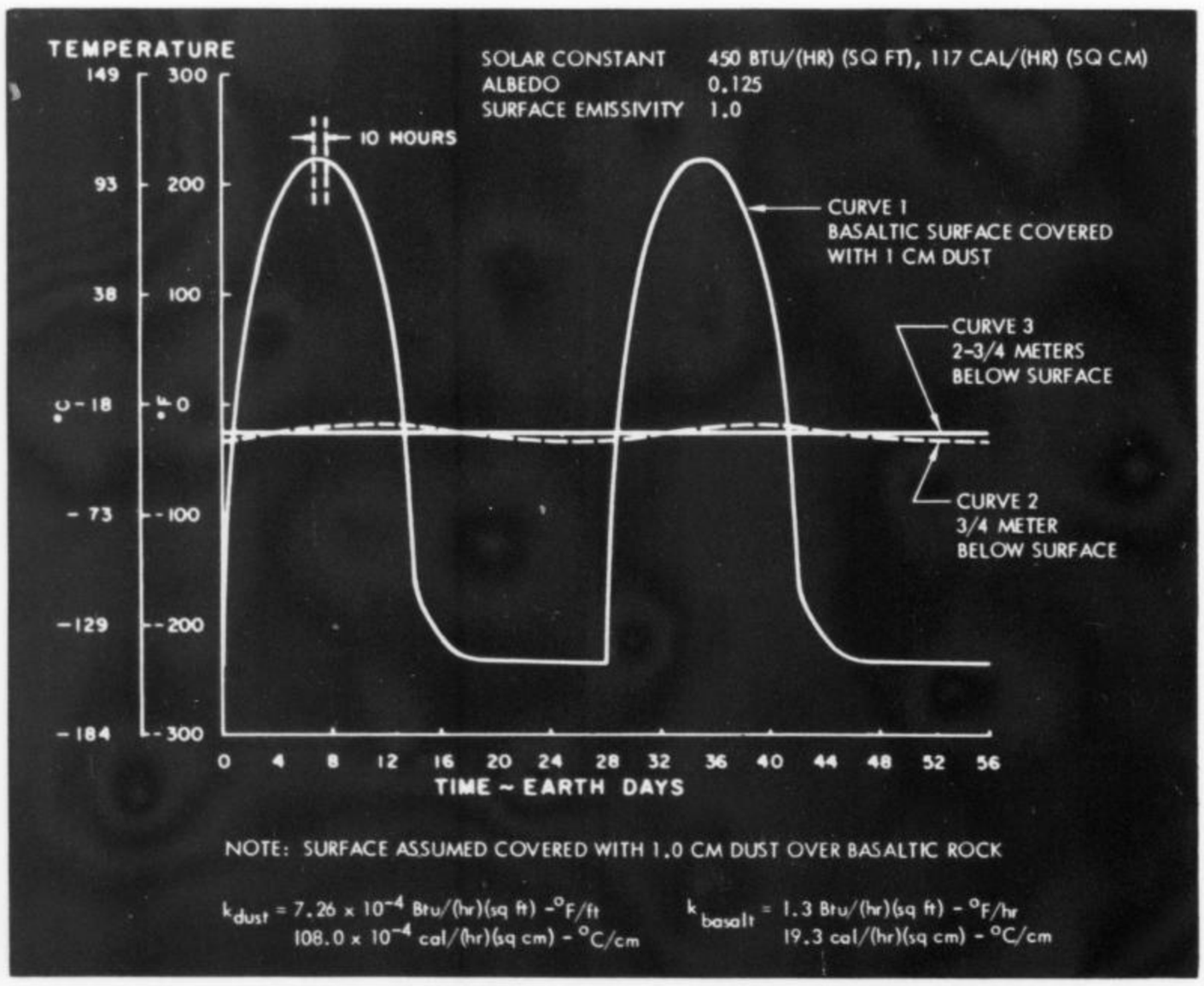
Theoretically, continuous full-intensity sunlight would be available at an elevation of 2170 ft or more from the mean surface at either pole, providing no obstruction existed in any direction from a particular site in these regions. Since the sun's disc subtends an angle of 0°30′, the sun is not completely blocked by obstructions depressed by more than 1°20′ from the polar horizon. The minimum full-sunlight elevation increases to 10,000 ft at 36 mi. in any direction from either pole. A mountain of this altitude and at this distance would be intermittently shadowed by a polar mountain 2170 ft in height.

THESE FIGURES cannot be considered exact by any means. A proper analysis of this problem would seem a critical preliminary to selecting a lunar-base site.

An important consideration for a lunar base at the poles would be retention of heat by surface structures during intermittent sunlight or fluctuating shadow levels. The graph here below, modified after Stevenson and Grafton,[3] illustrates the fluctuation of temperature as a function of time on the moon for a basaltic surface covered by 1 cm of dust. The dashed line represents a 10-hr period after onset of shadow. Inspection of this figure indicates that a dust-covered rock surface (Curve 1) would undergo less than 10-F temperature drop in this time period. A surface structure would therefore undergo a smaller temperature drop in 10 hr. Even these temperature fluctuations could be minimized using thermal rods or other types of heat exchangers.

FLUCTUATION OF TEMPERATURE ON THE MOON

After Stevenson and Grafton[3]



There are numerous formations in the lunar polar areas that might serve as a base site because they are in a constant or intermittent solar flux. The information given in the table on page 21 indicates that, of all the formations within a 30-mi. radius of the poles, the Leibnitz Mountains on the South Pole, or perhaps more specifically selected ridges, spires, or plateaus in the Leibnitz area, or the Shackleton Mountains on the North Pole, may serve as optimum polar-base sites. As Spurr points out, the Leibnitz range is not a mountain system but a complex of crater rims and rim peaks at great altitudes.[5] These "mountains" are also those which visibly rise from the lunar spheroid. Unfortunately, lunar altitudes are not known exactly; and, more seriously, the elevations are made relative to the base of the formation, not to a lunar "sea level."

One of the objections to a polar base on a crater rim complex such as the Leibnitz may be a relative lack in this type of terrain of lava tubes and caves, which are more indigenous to maria-type terrains. However, other natural cavities may exist, including crater-terrace fractures and fissure systems, as may be inferred from the photos on page 23. Low-level reconnaissance of the polar regions will be warranted if a polar base looks more favorable than a nonpolar one.

Associated with the eternally sunbathed peaks of Leibnitz in the south and Shackleton in the north are the eternally shadowed portions of the floors of Newton and Peary, respectively. As suggested by Green, volcanic minerals such as sulfur, or conceivably ice, may persist in such eternally shadowed zones on the moon.[6] Five boundary conditions may control lunar mineralization. First, the minerals must be able to form as sublimates in an environment poor or lacking in oxygen. These minerals would correspond to the "closed tube" sublimates of determinative mineralogy tests, and would include sulfur, cinnabar, realgar, and other substances.

Second, if we assume these minerals to exist in sunlight, they must not photo-decompose. Realgar, for ex-

ample, photo-decomposes to orpiment and arsenolite.

Third, we should discard the possibility of those minerals that would melt under subsolar lunar temperatures. This subsolar temperature approaches the melting point of sulfur. However, the ability of vaporized sublimates to migrate short distances gives reason to believe that minerals may concentrate in the eternally shadowed zones more abundant at the North Pole than elsewhere.

Fourth, we must consider vapor pressure. Many minerals—including ice, sulfur, cinnabar, molysite, and sal ammoniac—have vapor pressures which suggest their existence in unknown quantities in eternally shadowed zones.

Finally, we look at rate of decomposition. From the table on page 21 we can see that sulfur, sal ammoniac, and chalcanthite all have such low rates of linear decompositions that they would persist if once formed in perpetual shadow on the moon. The presence of these minerals at the poles, adjacent to possible base sites in constant sunlight, would make for a convenient association of minerals needed for base technology and solar power for extracting and processing them.

The seemingly lifeless moon holds as much interest for biologists as for workers in other pertinent disciplines. Lederberg has stressed the exciting possibility offered to the evolutionary biologist, or exobiologist, for testing Arrhenius' *panspermia* hypothesis through a search for biota trapped by the moon's gravitational field.[9] Anders pointed out that the earth is incapable of ejecting biota at a rate necessary to attain an arbitrary minimal detectable density of one microorganism per square meter of lunar surface.[10] He also determined that the ratio of terrestrial to extra-solar-system matter gathered by the moon should exceed 8×10^{11}. Certainly there can be no expectation of discovering extra-solar-system microorganisms at a density of less than one organism per 8×10^{11} square meters. But even if the density of biota of terrestrial origin is several times less than one organism per square meter. it seems unthinkable to forsake the chance to seek for them.

Lederberg also emphasized that the chief hazards to microorganisms are ultraviolet radiation and the proton wind. Hence, biota should be sought under protective debris. Considering the probable lunar surface density of microorganisms, would it not be more efficient (and effective) to make vast sweeps of the exposed surface in the polar zones of eternal darkness and constant low temperature?

As man conquers space, the number of applied biological studies requiring space environments for experimentation and test will increase. Again, the lunar polar regions with their zones of continuous light and continuous dark would offer the most suitable sites for space-related studies either promoted or not inhibited by lunar gravity.

Still another factor will be the lunar-base life-support system, which may be determined by the number of men in lunar residence. Lunar operations will at least include astronomical, geophysical, electronic, biological, and launching activities. Consequently, the lunar population may reach, or even exceed, 100 men.

A base of this size should need a fair degree of self-sufficiency. It seems likely, then, that an intermix of chemical, physical, biological, and supply-by-transport elements would make up the total life-support system.

The biological element of a permanent lunar-base life-support system could, from theoretical considerations, comprise the following: algae-bacteria (aerobic) units for water recovery, waste processing, gas exchange, and feed for food animals; food animals for conversion of part of the algae-bacteria biomass harvested each day into animal fat and protein; and higher plants both for broadening the human diet, feeding food animals, and gas exchange.

THE ARTIFICIAL-light requirements would be fairly high—power estimates for lights required to support a 100-man all-algae system range from 0.5 to 1.7 megawatts.[11] This makes the advantage in a polar location immediately apparent. Although the probable meteoroid infall precludes a surface "greenhouse" structure, it appears feasible to collect sunlight and transmit it to underground locations, thereby substantially reducing the lamp and power needs of the green plants. Since the sun always moves about the horizon with slight variation ($\pm 1°35'$), even rather minor obstructions might keep solar collectors in shadow from time to time. Certainly several hours of darkness any one time could be tolerated.



Fracture pattern on flanks (top) and rim (bottom) of San Fernandina caldera in the Galapagos Islands. The bottom photo was taken at an altitude of 20,000 ft. The top photo is a mosaic.

A polar site also offers continuous solar power for base maintenance. Salisbury and Campen have contrasted solar energy with other possible lunar energy sources.[12] They conclude that, for power levels less than 1 kw, silicon solar cells would be used; for power levels between 1 and 30 kw, a solar heat engine would be utilized; and for power levels greater than 30 kw, nuclear power supplies would be required.

However, research on thermionic converters is making rapid strides. The advantage of this type of power source is that relatively low temperatures are adequate for efficient operation. Cesium-gas thermionic generators of a special design with an efficiency of around 12% at 1650 C can generate 1 amp/cm^2 at 0.7 v.[13] According to Gabor,[14] a thermionic generator employing argon or argon-mercury may be able to generate 4 amp/cm^2 or more at 1 v employing temperatures in the region 1200 to 1800 C. The auxiliary discharge rare-gas thermionic-generator devices are thus superior to the conventional cesi-

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um-gas thermionic converters, as has been demonstrated theoretically by Schultz[15] and experimentally by Jamerson[16] and Bernstein.[17] A polar lunar base may therefore find thermionic generators suitable for power generation.

Specific areas suggested for landing and basing compiled by Broner and Lander[18] will probably undergo more intense scrutiny by cislunar photography before they are seriously considered. We do not now know where precisely to locate the lunar base. Only detailed surveillance and mapping will decide this question.

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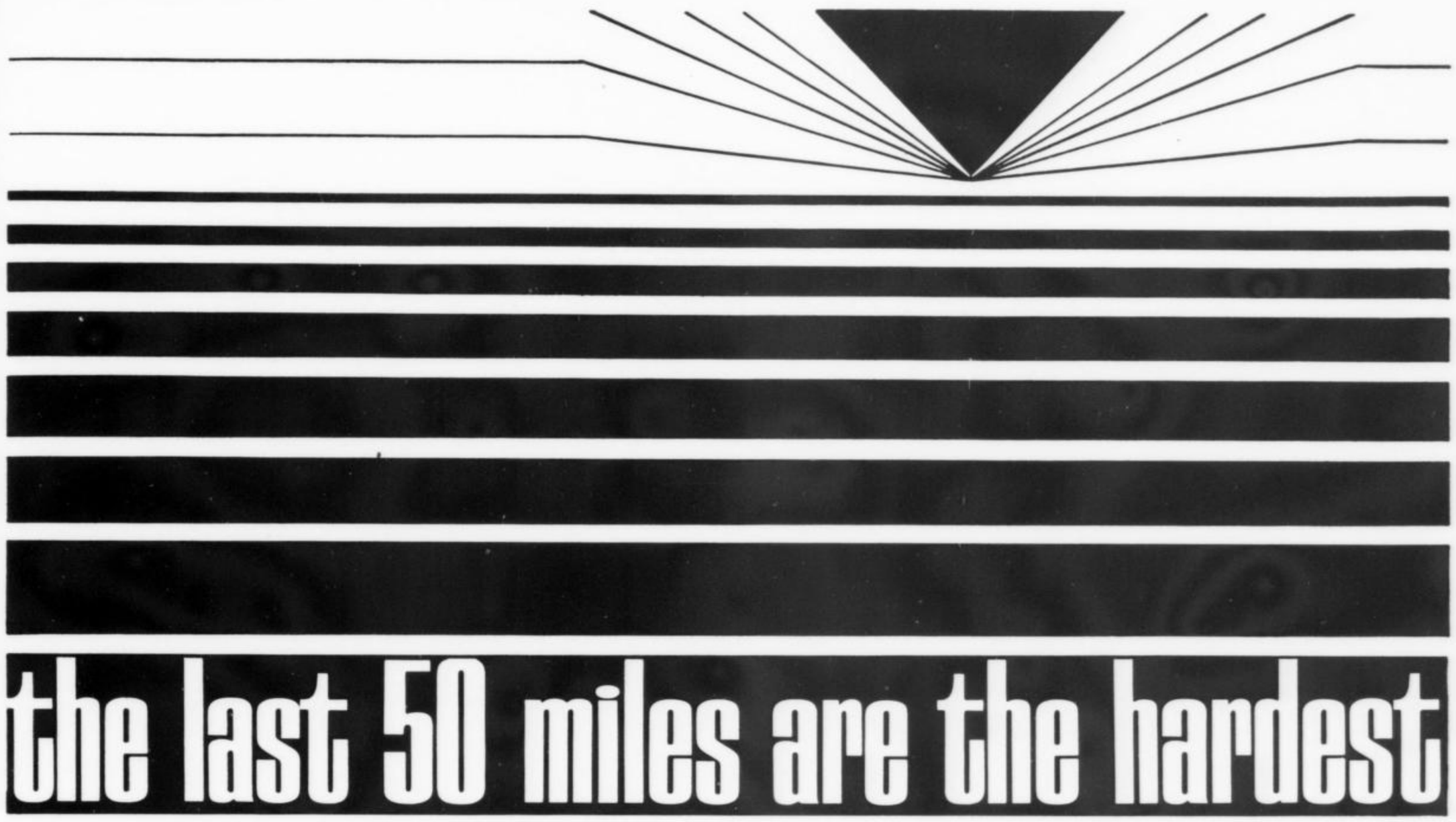
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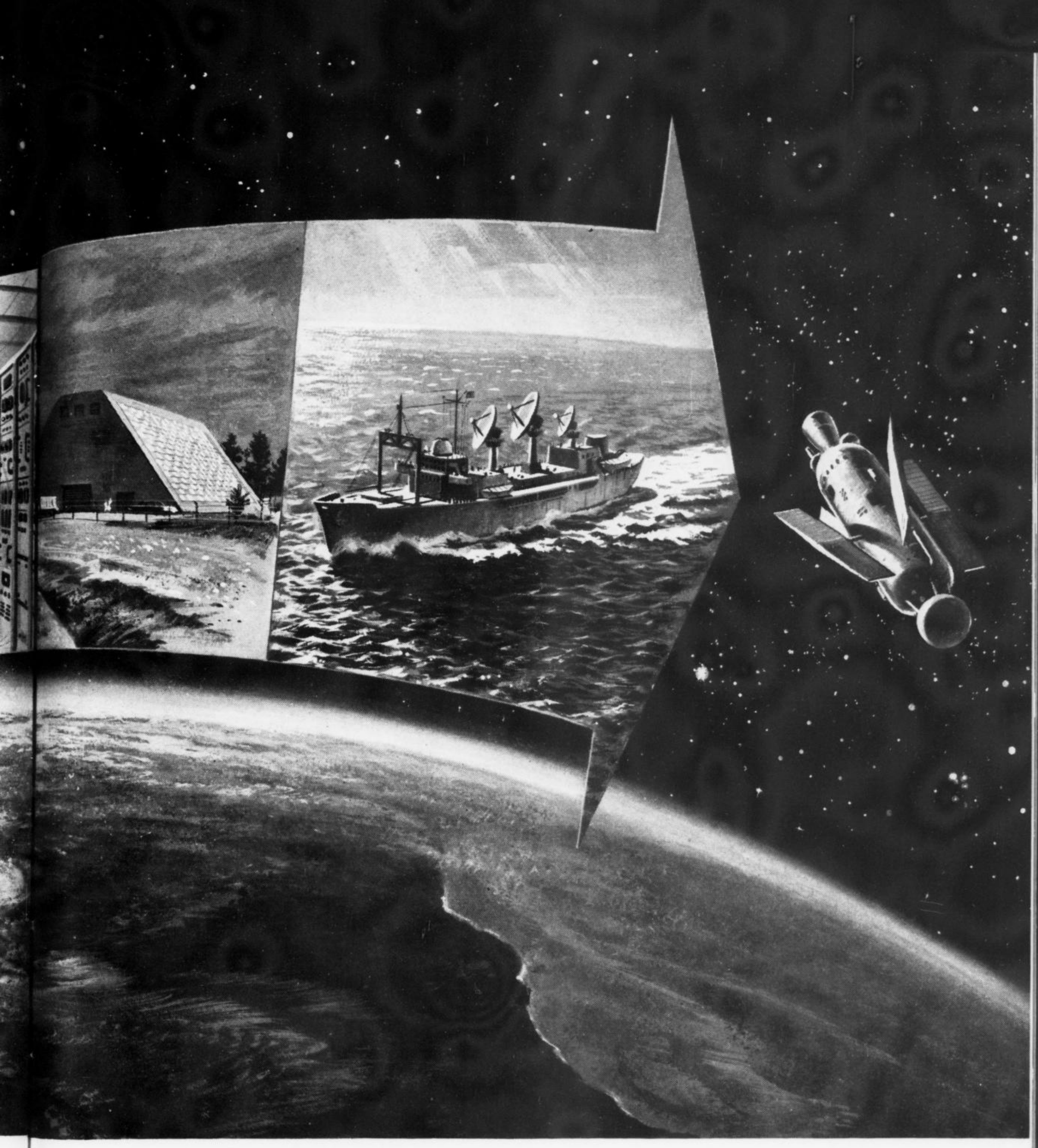
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Measuring Lunar Properties From a Soft-Lander

A variety of instruments will analyze the moon's texture, body structure, petrology, and other physical and chemical characteristics, as well as the nature of any "atmosphere" and fields

BY MANFRED EIMER

JET PROPULSION LABORATORY, PASADENA, CALIF.

THE EARLY steps taken toward the exploration of the moon can be expected to fall into three groups. The first group is comprised of all missions whose prime function is the detailed measurement of surface and subsurface properties at a number of carefully preselected sites. The determination of the variation of properties as a function of depth would be one of the aims of this group of missions.

The second group includes those missions which are oriented toward the exploration of the lunar surface as a whole. It will be the function of these missions to determine large-scale variations in appearance and chemical composition, to determine the relationships among the detailed measurements made at isolated points, and to select areas that would warrant particularly close examination by both unmanned and manned expeditions.

The third group of missions covers preselected areas and not just points to be explored, and will give detailed data on variation of properties with horizontal distance. The bringing of a sample from the moon to the earth and its subsequent examination and study, astronomical and radiometric observations, laboratory simulation of lunar material, and theoretical investigations of thermal and structural models of the moon will all be necessary corrolaries of these explorations.

Here we will discuss measurements of interest for unmanned stationary vehicles. Measurements to be made from a stationary lunar laboratory will cover texture, physical properties, petrological analysis, body structure, and fields, particles, atmosphere, and ionosphere.

With respect to surface material, the first three of these categories correspond to a decreasing scale of examination. At the one extreme, texture is determined from the entire spectrum of surface features, varying from major formations and large craters to surface rubble and porosity. At the other extreme, chemical properties are determined by the various elemental and molecular constituents.

Texture. Observations can be made by sequentially or simultaneously viewing the surface at several wavelengths of light (looking in color), by sequentially or simultaneously examining the same area from two or more different aspects (looking in stereo), and by viewing at various surface resolutions in a range beginning with a fraction of a millimeter. If the coverage to be transmitted per period of time and the bandwidth available for transmission of pictorial information is specified, then tradeoffs can be made among the importance given to color, stereo, and resolution. If it is necessary to take more pictures per unit time than can be transmitted, then a storage mechanism is required. Although electrostatic, magnetic, and thermoplastic tapes and photographic film have all been considered, it appears that the visual observations to be made from a stationary vehicle can be most simply accomplished by using vidicons with long-retention-time targets, where target-retention time to be used varies with the available communication bandwidth.

Physical Properties. To emplace instruments to take samples, the lunar surface can conceivably be penetrated by pushing devices into the surface by means of a static force exerted from an anchored or unanchored spacecraft, electrically or gas-driven percussive devices, and slowly or rapidly burning charges. It is also possible, of course, to emplace instruments in holes prepared either by one of the family of available drilling methods or by blasting with a shaped charge. Manned lunar exploration will require the building of surface and subsurface structures, and the necessary working of the lunar material may be typified by drilling.

A lunar drill would have three primary objectives:

1. To obtain an empirical description of the mechanical properties of lunar material as a function of depth by monitoring depth and rate of penetration, thrust, torque, and power.

2. To acquire samples of lunar material from various depths for compositional analysis.

3. To provide a hole for the insertion of a tool for logging of physical measurements.

A hole at least $1^1/_2$ ft deep (and hopefully, 5 ft deep), with a diameter

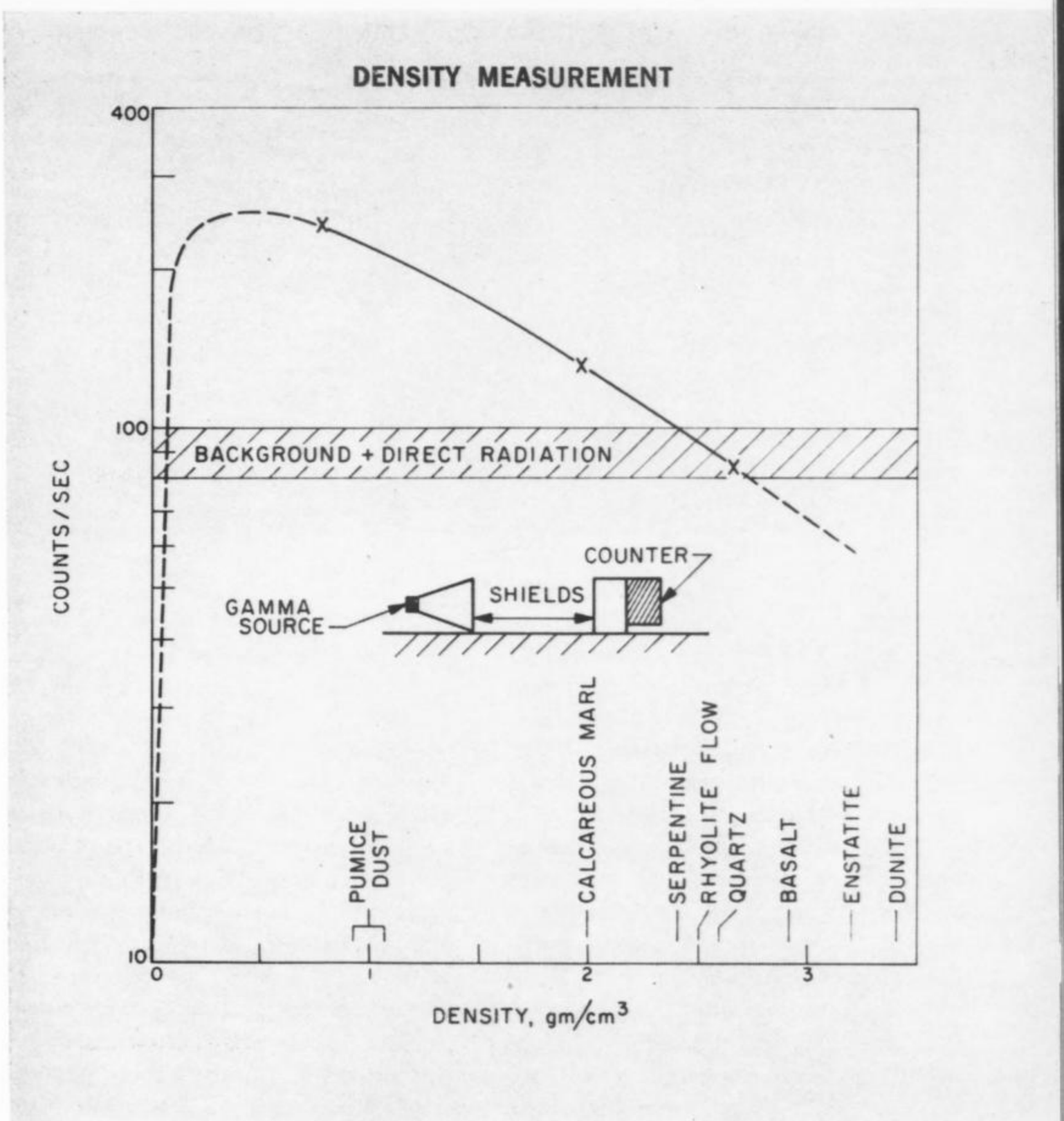
adequate for the insertion of a 1-in. diam probe, would appear to satisfy the three objectives. Because its performance is the least dependent on the exact properties of the surface and subsurface material and since it requires less thrust, torque, and power than rotary drills, a drill depending primarily on percussive action may well be the most suitable for lunar work.

Those physical properties which must be known for a comprehensive understanding and description of the lunar surface and subsurface material can be grouped as follows: density, thermal properties, acoustic properties, electromagnetic properties, and penetrability.

With the exception of the acoustic properties, the measurement of physical properties as a function of depth requires the insertion of a tool into a prepared hole. Because of the special interest in the properties of the very top layer of lunar material, and because of the possible difficulties in preparing a hole for the insertion of a logging tool, all of these properties should also be measured using instruments not requiring a prepared hole.

Density can be measured by the method of gamma-ray backscattering, as described by the diagram shown here at top right, in which a collimated gamma source and a collimated counter are emplaced on or below the surface. The gammas scattered between source and detector are a function of electron density, that is, of density and of Z/A.

Because of the difficulty of providing good mechanical thermal contact, temperature can best be measured by means of a total radiation pyrometer. By shading or unshading the surface whose temperature is measured, or by illuminating the surface or subsurface with an artificial heat source and monitoring the subsequent changes in temperature, a property which is a function of thermal conductivity, density, and specific heat can be measured, as indicated in the graph atop page 32.



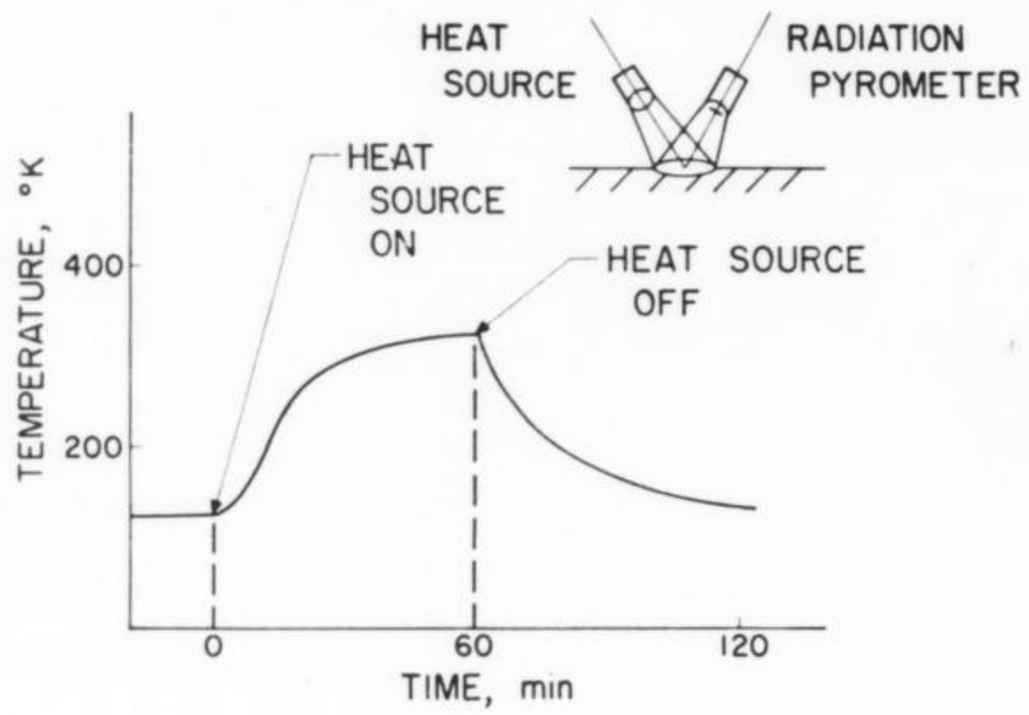
Acoustic properties can be measured by recording the arrival times, amplitudes, and wave shapes of the signals received at geophones emplaced by the spacecraft. The acoustic signal can be generated by a sequence of detonations of various strengths produced by charges emplaced by the spacecraft, or possibly by a single charge ejected some hundreds or tens of hundreds of feet by the spacecraft. Such a set of acoustic measurements can be used not only to obtain a fundamental property of the lunar surface, but also to infer the variation of physical properties to depths greater than can be reached with a drill.

The electrical properties can be measured by determining the changes produced in inductive and capacitive devices when placed near lunar material. Magnetic susceptibility can be measured by determining the mutual induction or the change in mutual induction caused by the presence of lunar material. The presence of ferromagnetic material, of course, can be easily detected by this method, and the presence of other paramagnetic materials may be inferred through it (see graph on page 32). Electrical resistivity can be determined by measuring the Q of a resonant circuit placed near lunar material. A circuit resonant in the megacycles or in the hundreds of kilocycles would be used, and the eddy-current losses at these frequencies sensed. Relative permittivity is determined by measuring the capacitance required to retune a circuit which is in parallel with a plate placed near lunar material. Estimates of relative permittivity are required for the description of a radar-reflectivity model of the lunar surface.

Drillability—The characteristic measured by the drill—is a combination of more standard physical properties, one of which is penetrability. Resistance to penetration can be measured by an identation penetrometer in which the deceleration of various standard shapes which are impacted on the lunar surface is measured, as indicated in the graph on page 32. Deflection, as a function of applied load, and rotation, as a function of applied torque with various standard shapes, should also be measured.

Petrological Analysis. This will be of great importance not only from the point of view of scientific exploration, but also because of its implication for later exploitation of lunar material. Lunar petrological analysis can be considered to fall into four areas: quantitative elemental analysis, determina-

THERMAL DIFFUSIVITY



tive mineralogical analysis, visual microscopic examination, and determination of volatile constituents.

As to measuring elemental abundances, there are two basic questions at issue. First, what is the composition of the moon; and second, what does this composition signify? If we were interested in only the first question, then an instrument capable of detecting those elements which are expected to comprise more than, say, 95% of the moon's material would make a very acceptable experiment, at least for an initial attempt. The great importance of the second question, however, acts as an incentive to seek a better and slightly different experiment. Many of the semi-abundant and trace elements are highly significant in identifying rock types and the degree of fractionation of the rock.

The most suitable instrument thus appears to be one that combines adequate sensitivity with sufficient versatility to analyze a satisfactory number of elements. Ten methods of elemental analysis have been considered: alpha activation, deuteron activation, energetic (14 Mev) neutron inelastic scattering, energetic (14 Mev) neutron activation, mass spectrometry, Rutherford scattering, spectrophotometry, thermal neutron activation, X-ray spectrometry, and wet analysis.

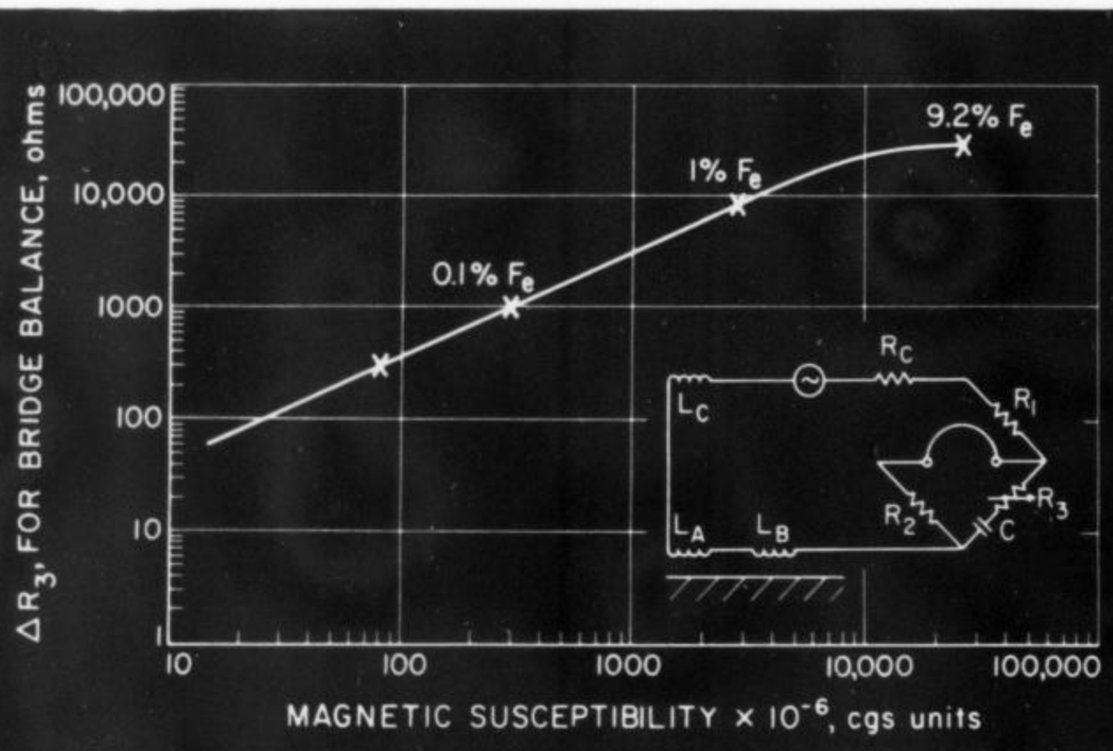
In the evaluation of these methods, careful study must be made of the requirements for the condition of the sample to be analyzed. The question of relative reliability of methods of bringing the instrument to the material and of bringing a prepared sample of lunar material to the instrument must also be evaluated.

An X-ray spectrograph (see page 33) with a 25-kv electron beam to excite a prepared sample brought to the instrument appears to possess the potential to do considerably more than a minimal job of elemental analysis. Through use of dispersive optics, such an instrument can be designed to measure all elements which are expected to be present in the lunar surface in excess of 1 to 2% except oxygen. Oxygen might be inferred by subtraction if the amount of the sample is known, or it can be determined semiquantitatively by an X-ray diffractometer. The less-abundant elements that have been considered for determination include chromium, nickel, manganese, titanium, sulfur, and vanadium, all of which are of some importance in diagnostic lithology and all of which may be in the range of detectability of an X-ray spectrograph.

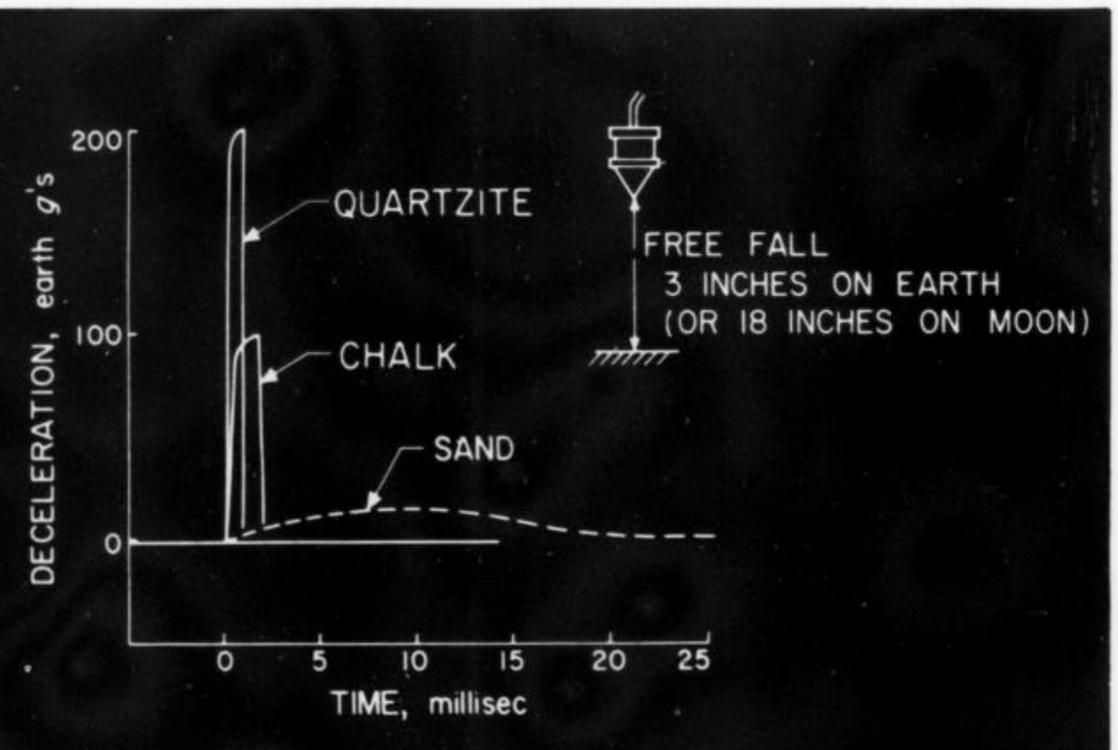
The possibility that an element is present in unexpectedly high abundance can be provided for with a nondispersive system which would include energy determination. A nondispersive system may also be capable of detecting some of the light elements, such as carbon.

A miniaturized X-ray diffractometer using a 25-kv X-ray tube may well be the most suitable instrument for mineralogical analysis of the lunar surface from a stationary laboratory. It is hoped that the assemblages of minerals which comprise the samples analyzed will provide diagnostic evidence as to the mode of origin of the chemical system from which the samples were taken. An instrument with a 2θ range of from 7.5 to 85 deg and a resolution equivalent to that of a

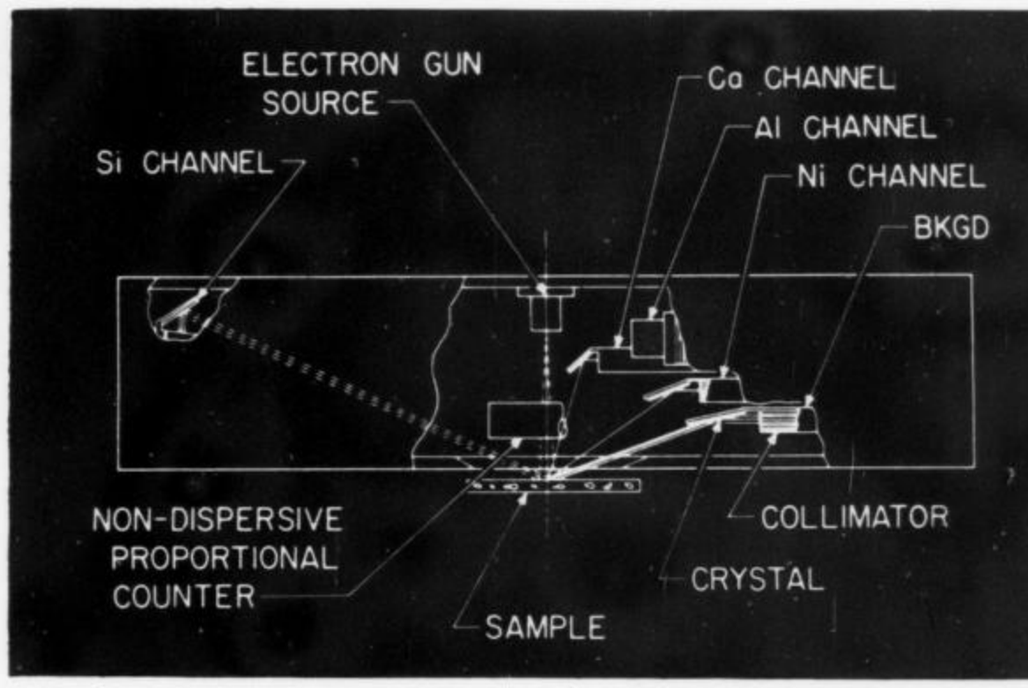
MAGNETIC SUSCEPTIBILITY



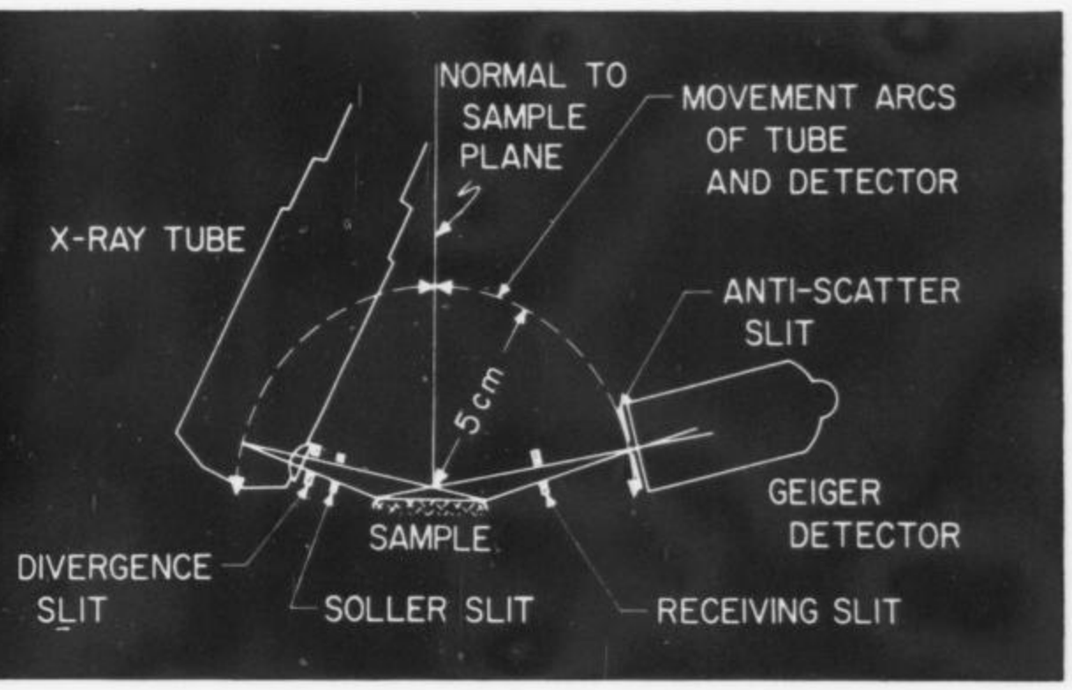
INDENTATION PENETROMETER



X-RAY SPECTROGRAPH



X-RAY DIFFRACTOMETER GEOMETRY



standard laboratory instrument would appear to meet requirements more than adequately. This is illustrated in the diagram at top right.

Visual microscopic examination of samples of the lunar surface can be made with a petrographic microscope system. Primary objectives of this examination would be to determine the presence of noncrystalline phases and to examine external and internal features of grains and, in fine-grained rocks, grain-to-grain textures. Secondary objectives would include estimating glass composition, radiation damage, mineralogy of crystalline phases.

The petrographic microscope system would include an immersion medium, have a system for examination in both plain and cross-polarized light, have an image presented to a vidicon, and provide for magnification of the image.

The volatile constituents of the lunar surface and subsurface samples can be analyzed by means of a gas chromatograph. In the gas chromatograph, the sample material would be heated and then the volatiles would be fractionated simultaneously through three separate columns. It would be desirable to heat the samples to various temperatures so that compounds which are normally gases and compounds which have a high vapor pressure and are trapped in the interstices of the inorganic matrix could be released. For purposes of organic analysis, a maximum temperature of 500 C appears to be desirable, whereas for the analysis of water of crystalline origin temperatures as high as 1000 C are indicated. The three columns to be used could consist of an adsorption column, a partition column, and a partition capillary column. These would fractionate carbon dioxide, carbon monoxide, nitrogen, hydrogen, and methane in the adsorption column; the aromatics, aliphatic alcohol, aliphatic aldehyde, aliphatic ketones, aliphatic esters, aliphatic ethers, water, and ammonia in the partition column; and hydrocarbons, unsaturates, aromatics, cyclids, acids, esters, alcohols, ethers, aldehydes, ketones, substituted aliphatics, halogens, nitrogen, and sulfur in the partition capillary column.

IT SHOULD be pointed out that, although the X-ray spectrograph is not very suitable for determining the light elements (in particular hydrogen, carbon, nitrogen, and oxygen in their elemental form), the X-ray diffractometer can determine the presence of compounds containing these elements and the gas chromatograph can analyze for compounds of these elements.

Body Structure. Knowledge of lunar seismic activity and of the natural modes of oscillation of the moon as a body will be essential to understanding of its nature and origin. It is expected that the fundamental period of oscillation of the moon will lie between 10 and 20 min. So the instrument must be capable of measuring such relatively long-period motion. Use of a three-axis instrument capable of responding to motions with periods of less than 1 sec and more than 10 min, with sensitivity adequate for detecting motions of the order of 10 millimicrons, should be used as the seismic-exploration instrument on a stationary lunar spacecraft.

Fields, Particles, Atmosphere, and Ionosphere. A measurement of the lunar magnetic field is of fundamental importance. Although it should not be expected that the moon has a large magnetic field, considerable scientific importance can be ascribed to the measurement of the structure and variation with time of what field does exist. The measurement of the nature of the magnetic field as a whole can be made by measuring the variation of intensity, as a function of direction, of the low-energy plasma. A measurement of the local magnetic field, using a three-axis magnetometer on or near the spacecraft, can be used to supplement the measurement of the magnetic field of the lunar body.

The structure of a possible lunar ionosphere can be examined by observing the variations in received radio-frequency signals in the region of $^1/_4$ to 1 mc which originate in the galaxy. The pressure of a lunar atmosphere could possibly be measured using a Redhead gauge. Although knowledge of the pressure of the atmosphere is of doubtful value, a determination of the atmospheric constituents would be of substantial importance and must be attempted. Unfortunately, it is not yet clear how one can make even qualitative measurements of those atmosphere constituents expected to exist at such extremely low pressures.

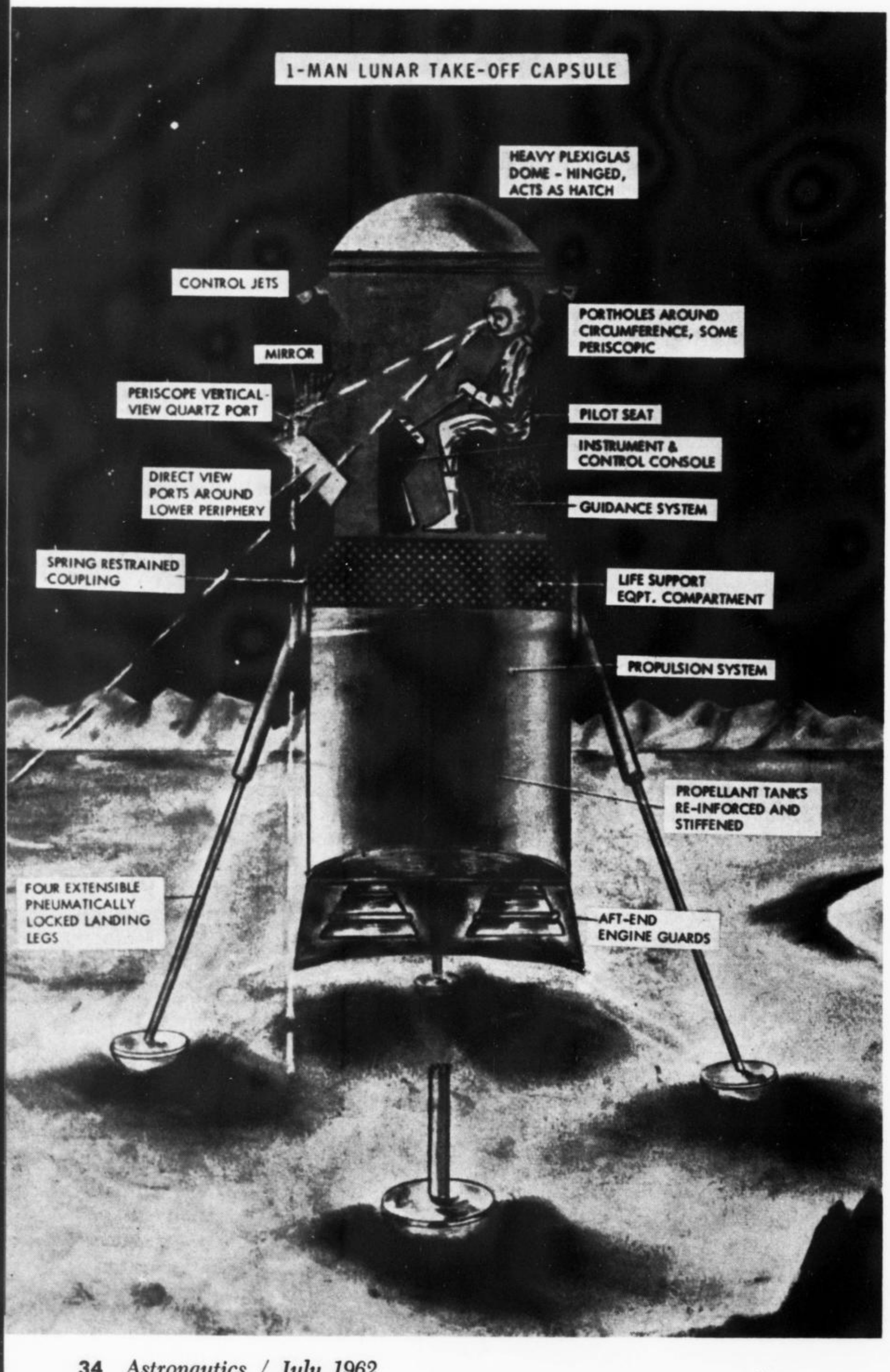
Finally, the moon is not a good platform from which to monitor the interplanetary medium, since its own presence will be a substantially disturbing factor. However, if it is necessary to determine the lunar surface environment related to energetic particles, and with a precision not possible by theoretical extrapolation from measurements of the interplanetary environment, then a surface particle-environment measurement may be of significance. ♦♦

There will be no more critical phase of the manned lunar-landing mission, none more demanding in imagination and technology, than—

LUNAR TAKEOFF

BY KURT STEHLING

NASA OFFICE OF PLANS AND PROGRAM EVALUATION, WASHINGTON, D.C.



This illustration gives the author's conception of a possible design for a one-man lunar takeoff spacecraft. It could also carry two men side by side. The astronaut sits in a "natural" position, with a normal view of the surface and sky. His engine and steering controls would be on one stick, much as in the Me-163 rocket plane of WW II. He would have a control panel integrating attitude, position, and system information. Although showing four legs, the vehicle might be better off with three for landing. The legs would pneumatically adjust to the right length for proper vehicle attitude before takeoff. Liberal use of "styrofoam" at aft end and around tanks would be desirable. Tanks and engine are not, of course, to scale.

A MANNED lunar-landing project can be divided into four major technical phases:

- *Earth departure*—with earth-orbit rendezvous or direct flight to the lunar surface.
- *Lunar approach*—including orbiting, site selection, and landing.
- *Lunar takeoff*—or departure, including initial lunar-orbit maneuvering and departure from lunar orbit.
- *Earth approach*—initial earth orbit, approach, atmospheric re-entry, and landing on the earth's surface.

Each of these phases presents great complexity, requiring a marshalling of many new technical resources and techniques. Lunar-surface departure is by no means the least of these in terms of technical magnitude.

Discussions of the manned lunar-landing project tend usually, and not unnaturally, to center on the difficulties of booster vehicles, rendezvous, midcourse corrections, and lunar landing. These and the great size and cost of the launch facilities seemingly overshadow lunar takeoff.

Yes, because of the *size* of the facilities and the earth takeoff rocket, very large sums of money and many technical resources must be expended to *land* man on the moon. But we will see that a comparable (not necessarily in magnitude) effort must be made to *return* man from the lunar surface.

Let us review briefly the present process of launching a small rocket vehicle from earth. Even if the vehicle is of relatively low complexity, and has standard equipment, and has been fired before, a sizable launch crew seems necessary. These men, rarely numbering less than a dozen and usually around 20 to 50, receive the rocket a week, or weeks, before launch and prepare it under controlled conditions in a hangar or shed. They make elaborate checks of the hydraulic, electrical, and pneumatic circuits, and the engines (if liquid), and all the auxiliary parts, not to mention telemetry and other electronic equipment.

A few days before takeoff, the crew erects the rocket vertically on the launch pad, and again makes an exhaustive check of the entire vehicle, now close to operational condition, with pressure applied and all parts working, hopefully, in unison and properly. The vehicle has had a long history of static testing of its liquid engines, if these are used; if it is a relatively new vehicle, then a short static firing may be done before flight.

Obviously, a solid-propellant vehicle does not require many of the checkouts related to an intricate liquid-engine system. Nevertheless, even with solids, there always seem to be hour-long tests before launching.

If a man will ride the rocket, then the functional-checkout tests become much more complicated and lengthy, and the size of launch and support crews may grow into the hundreds.

Thus, weeks for liquid rockets and at least days for solid rockets are needed for launching, even for a fairly simple mission with a relatively small payload.

Now we may wonder, by what technical magic will one or two men in the fiercely hostile environment of the moon's surface manage the launching job which here on earth requires at least some support crew and ground equipment?

For illustrative purposes, let us consider a "typical" lunar takeoff with a one- or two-man vehicle. The mission of this launch vehicle will be to bring the man or men into a lunar orbit so that they may be transferred to a larger orbiting vehicle, which in turn will return to earth. This scheme would allow a relatively low-weight lunar spacecraft, because it would entail no re-entry heat shielding on the lunar spacecraft proper. Sketches here suggest design principles for such a vehicle. They are illustrative only. For instance, no attempt has been made to show the size of the propulsion system in scale with the over-all spacecraft.

It is at once evident that there are some several limitations that have a direct bearing on the design of the rocket, on the length of time that the men can remain on the moon, and on the kind of work the men have to do, external to the rocket. Some of the conditions that apply are as follows:

1. The lunar surface environment is dusty, a hard vacuum, exposed to solar, cosmic, and other radiation, the surface uneven, containing fissures and cracks, while the sunlight incident on the man and the vehicle raises temperatures to almost 200 F.

2. There are no external facilities to service the spacecraft or the men; they are on their own.

3. Onboard instrumentation *only* indicates the situation in the guidance and control, propulsion, and auxiliary systems.

4. The spacecraft has a "launch





Above appear other author's versions of the takeoff capsule designed mainly to give good vision. Control jets, preferably from pressurized-gas storage, are near the top of the vehicle. Its length is *not* in proper proportion.

window" of only *a few minutes* on takeoff for rendezvous with the lunar or earth orbiter, this window occurring periodically.

We also assume that the spacecraft has no "back-up" guidance, control, or propulsion system, the weight not being available for them. We have deliberately taken the most extreme case of a minimum-weight lunar lander. In practice, various "back-ups" for abort capability should be provided. We can presume that these elements have gotten some checkout during the descent phase if they are used then.

It is not yet apparent whether it will be more economical to send a small vehicle to the moon with a separate stage for landing or to use the same propulsion system for the landing and takeoff there. At first glance, it looks as if a more reliable situation is obtained if the propulsion system is used for both phases, since a thorough check during the descent phase is obtained; this approach means greater over-all weight than a two-stager.

If solid-propellant rockets are used, a multistage vehicle is necessary, or at least a cluster of solid units must be used, with a portion to be fired through the descent phase. The empty cases remain on the moon.

It may be possible to introduce the astronaut into the guidance "link" in such a way that a very complicated or heavy guidance system will not be necessary. Certainly he will need some type of autopilot and reference system, probably backed-up by light and reliable computers. Commands from the earth orbiter, backed up by celestial sightings with reference to instrumentation and telemetry and radar, might permit man to act as a vital and useful link and ease the demands on the guidance system. However, there is nothing that can be done in the more critical area of the propulsion system. No amount of manned attention will change this situation much except when complicated engine operations, such as start-stop or throttling, are undertaken.

It is probably purposeless to state that we will build the astronaut a 100% reliable rocket system. Without belaboring the point, one can state that it should be possible to provide a 99.8% reliable engine system, in whose reliability rating one has a confidence equally high. Such reliabilities are probably higher than those achieved by a vast array of seemingly simple and well-proven mechanical devices that confront us in our daily lives, whether they be washing machines, automobile engines, television sets, or pencil sharpeners.

To repeat, our manned lunar spacecraft has no safety recourse left once the engines are started and liftoff has proceeded. There is no parachute aboard; there is no way of gently landing the vehicle. The facts are clear—the propulsion system *must* work on the first try and must work reliably until the end of its designed action. There are no margins for error.

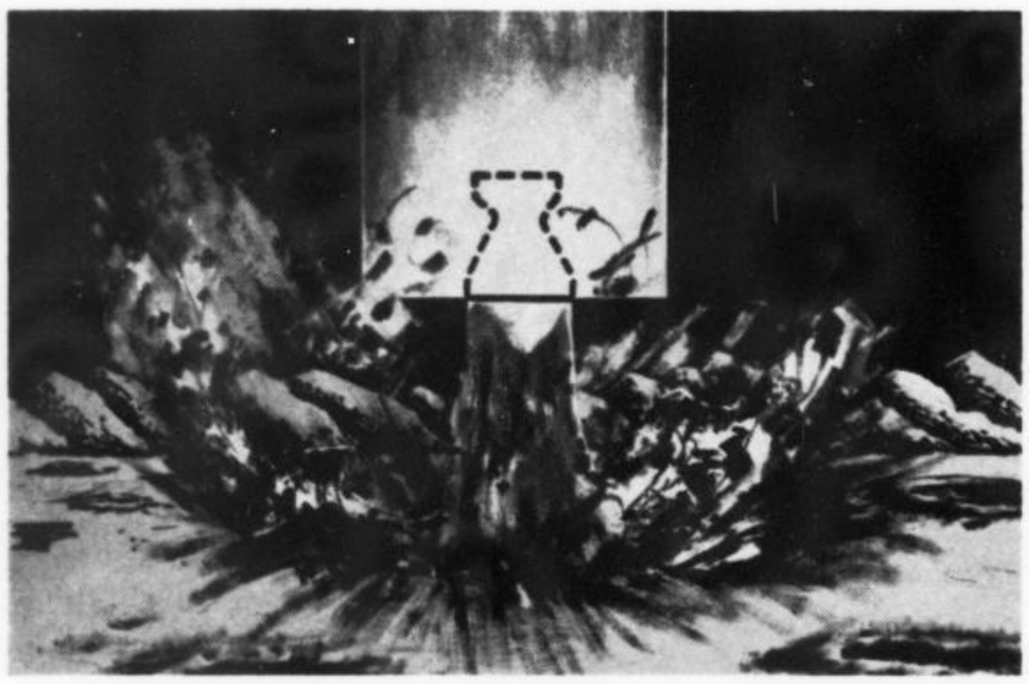
Furthermore, this propulsion system should have a high specific impulse, higher, if possible, than most "commonplace" systems, such as hydrazine–acid or hydrazine–nitrogen tetroxide. The need for high impulse is clear; weight is at a premium. Also called for is a high density–impulse; the vehicle's volume will be limited. Hypergolic propellants seem advisable to ease ignition in the vacuum of space. But then, hypergolic ignition is by no means a sure thing, especially when exposing flow controls and injectors to extremes of temperature and prolonged exposure to an unusual environment. There is the slight but still possible danger of reaction caused by leakage between seals warped either from long exposure to this environment or from landing shock. This shock will surely occur. It will be a considerable act of faith to believe that even a small lunar vehicle can be landed without clanging and banging on touch down.

Thus we must add a requirement for great ruggedness in the propulsion system, and will extend it of necessity to the entire structure, and especially the tanks, if a liquid system is used, or to the case, if solids are used.

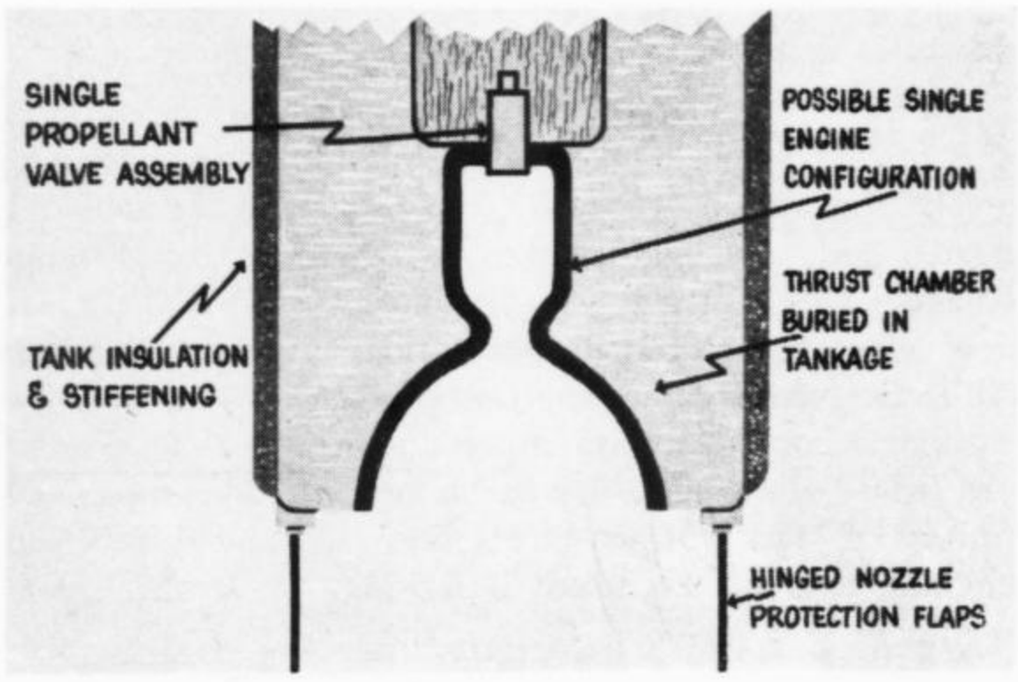
But we stated earlier that a *low* propulsion system weight, or high mass ratio, is desirable. Unfortunately, strength and high mass ratio are not readily compatible, especially as a vehicle becomes smaller. Yet ruggedness here will be a *must*. The touch down will be accompanied by much blowing of dust and sediment from the exhaust jets hitting the moon's surface, even if the engine is shut off 20 or 30 feet above. There is the possibility that the rocket nozzle, always a delicate element of a liquid or solid rocket, will be dented or otherwise damaged. This is especially true on takeoff, since the vehicle departs without having the benefit of a nice, smooth concrete pad with water cooling. Nozzles heavier than usual and special protection for the end of the vehicle's engine would seem necessary.

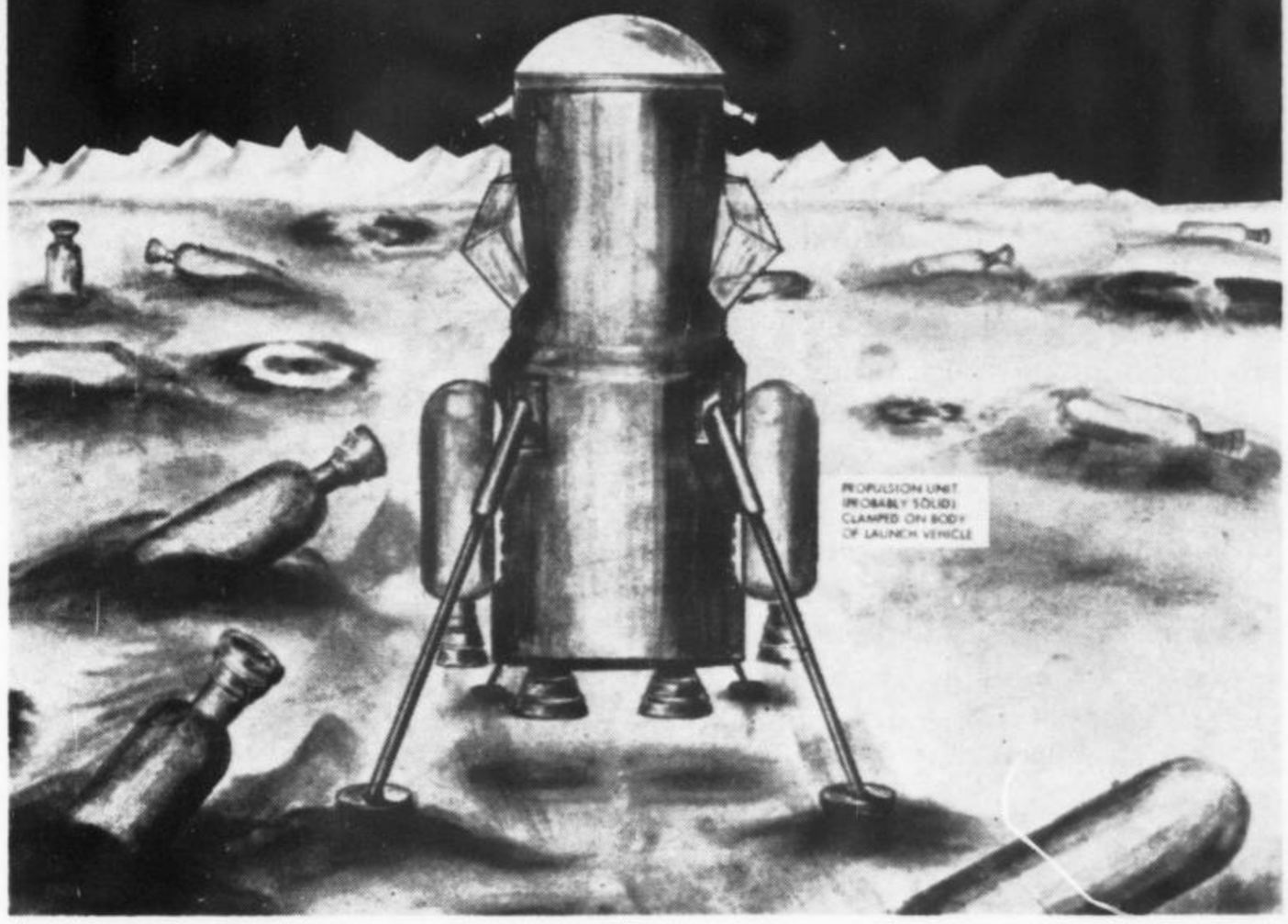
The so-called packaged liquid system seems to have some of the attributes needed for lunar takeoff. It can have practically no moving parts,

DUST AND DEBRIS RAISED BY ROCKET A PROBLEM



RUGGED PROPULSION STRUCTURE NEEDED





Some kind of propulsion and equipment cache on the lunar surface would permit astronauts an extra margin of safety, if the problem of *finding* and using caches would not be too great. This purely conceptual drawing illustrates a possible scheme for building takeoff capability by the astronaut adding solid rockets to the spacecraft. Because of the moon's $^1/_6$ G, even a 400-lb earth-weight unit could be carried by one man and fastened to a vehicle by a simple and foolproof latch-on device. The solid units would actually be in simple protective containers. They could possibly be landed on the lunar surface by unmanned vehicles.

can be stored for long periods of time, and can have reasonably high mass-ratio. On the other hand, it cannot be absolved of some of the "sins" of liquid systems in that a flow control of some kind must be used. If this propulsion system were used during the descent, and had to throttle or start and stop, its design would be considerably more complicated than that of a uniformly burning engine which had no particular demands on it except reliable shutdown. These features would probably not be so necessary for the takeoff phase. It might be possible to "lock" them out of operation during takeoff, or at least minimize their use, since every moving part or extra element tends to influence reliability unfavorably.

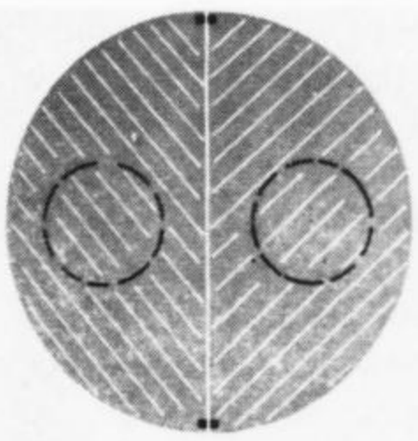
Solid rockets cannot be counted on for throttling or restart. However, an aggregate of solids could be used for the descent-ascent phase if the aggregate were so organized that units could fire in the descent to give a variable-thrust effect. The solids shine even more brightly for the takeoff maneuver. There is no question that solid units, proven by a rigorous static-testing program, can be depended upon to ignite and fire reliably, possibly with a greater chance for success than is possible with liquids, no matter how much they have been tested.

The solids also offer the added feature of greater over-all system-design simplicity—with no propellant slosh-damping needed, and no fragile tanks and pipes with flow controls, all of which can be damaged on landing. The man or men do not have to pressurize the propulsion system and check for leaks or the operation of flow controls. A relatively tried and proven propellant should be reasonably resistant to physical stresses, pounding, and cracking.

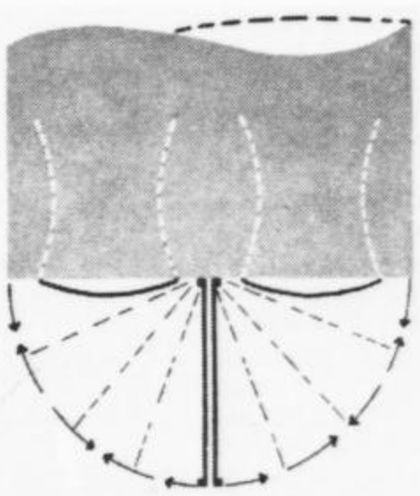
The matter of thermal influence on solid propellant is more serious, especially if the spacecraft has to remain on the lunar surface in the sunshine for some hours. This problem is not insurmountable, since the rate of heat transfer to the grain can be considerably reduced by even a small amount of radiation shielding against the sunlight; and there is, of course, little or no conductive heat transfer, so it would be many hours if not days before the propellant was "heat soaked" sufficiently to prejudice its burning. At any rate, a temperature rise even to the "spec" limits would act more favorably (by increasing the total impulse) than a severe temperature drop, this being also possible if the vehicle lands in the shadow of a lunar object.

The specific impulse of solid propellants, at present, may be considered to be substantially below medium-high-energy liquids. Still, improvements in solids may drive them into a specific-impulse domain presently preempted by some liquids, and by the time a lunar attempt is made we may have proven solids of high-

DETAILS OF AFT-END ENGINE PROTECTION "FLAPS"

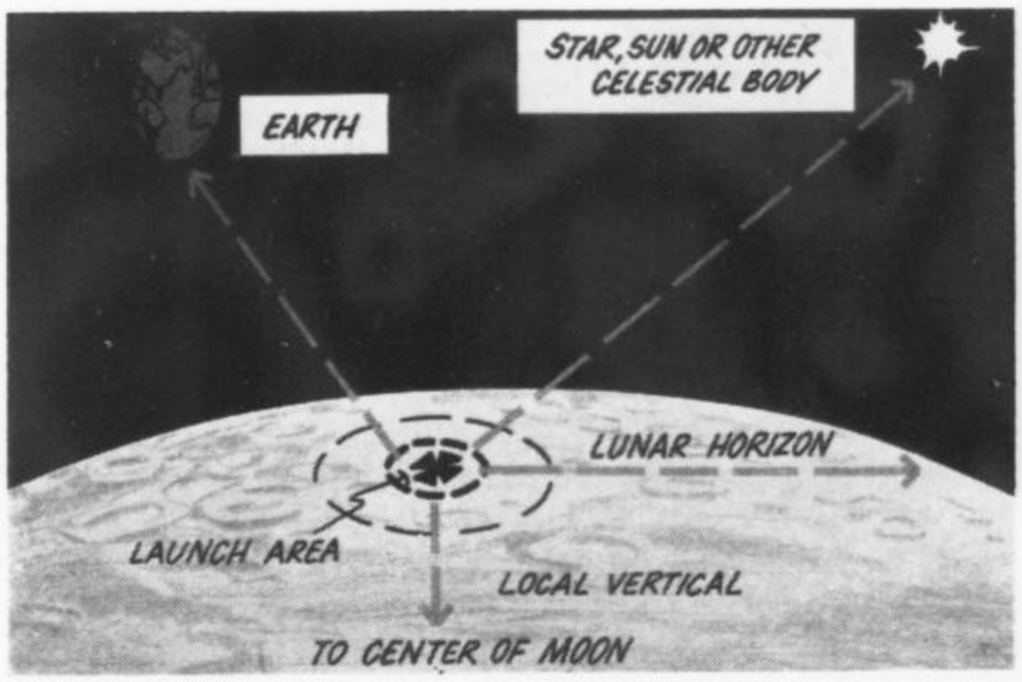


FLAPS CLOSE OVER ENGINE NOZZLES JUST BEFORE TOUCHDOWN & ENGINE OFF



HINGED FLAPS SPREAD OUT & UP FOR CLOSURE NORMALLY EXTEND "DOWNWARD." PROTECTED AGAINST EXHAUST BLAST.

GUIDANCE REFERENCES AVAILABLE TO PILOT



specific impulse, very low temperature coefficient, high strength and high density—excellent candidates for the lunar takeoff stages. Added to these virtues should be that of some simple, foolproof thrust termination.

Common to liquid and solid propulsion systems is a problem of steering. The liquid vehicle is usually steered by a gimbaled thrust chamber. The solid obtains thrust-vector control by jet vanes or some similar mechanical device or by fluid injection into the rocket exhaust. Generally, simplicity and predictibility tend to be on the side of small heat-resistant jet vanes, and it may be desirable to use such small jet vanes for either the liquids or the solids, particularly if new materials can be devised to withstand the erosion and heat flux.

The astronaut, then, must not only prepare the propulsion system to be ready to takeoff with all elements in a "go" condition, but he must also adjust his guidance system so that it can direct most or all of the ascent through the lunar-earth flight path. Considering the present state of guidance technology, it should not be too difficult to provide him with a simple lightweight system that can be adjusted by dials from the instrument control panel, much as an aircraft autopilot is now is set for heading, altitude, etc. However, to know how to reference the guidance system or to adjust its settings, some extraneous reference must be obtained. This could be the "local vertical" vector (the radius to the center of the moon) and reference to celestial bodies, such as the sun, the earth, a "fixed" star, or the horizon.

THE *man* in the guidance link may use some possible form of radio control from the earth-orbiting rendezvous vehicle. The initial "Doppler" radar approach-controller that was used for the descent may be used in reverse for the ascent, having reference to the lunar surface and giving altitude and rate of change of altitude at all times. Radio range and range-rate information, feeding into the guidance system, could be monitored and refined by the man.

Great guidance and control precision for the rate of pitch-over is necessary, as well as exact control of total impulse for the final velocity needed. Small gas jets or similar auxiliary propulsion devices would be needed for the trimming out of this velocity, as well as for terminal rendezvous control.

Lunar takeoff, we may conclude, challenges our imagination and technology in these several areas:

1. Some new approaches to rocket-vehicle preparation and launching must be found if one or two men are to leave the moon. "Packaged" high-energy liquids may provide the approach, with very simple flow-controls (if any; rupture disks could be used) or other moving parts such as turbopumps, unless these have had many hundreds of hours of testing and operational history. Solids have high reliability but are at least one-third heavier than liquids.

2. Structural innovations are necessary; lightweight sandwich, honeycomb elements are desirable. Ordinary tank and plumbing construction (or case fabrication for solids) will not do. Explosive forming of entire elements, such as tanks, would eliminate joints.

3. A very elaborate scheme of drop-testing and structural testing will be necessary to eliminate weak points in the vehicle. It must be presumed that the takeoff vehicle will suffer severe impact stresses on touch down; but these stresses must not result in detrimental strain or deformation of the vehicle.

4. Practice takeoffs from earth must be tried, with the higher "G" forces of earth considered. A useful experiment might be a takeoff from White Sands Proving Ground with "rendezvous" (really, approach to) a high-altitude jet aircraft.

5. A combination autopilot and manned pilot program might give a lightweight and reliable guidance and control system. But reliability of 100% in propulsion and guidance is impossible to attain. A relatively high risk factor might have to be accepted for the lunar takeoff.

6. With liquids, the landing and takeoff system could be the same, perhaps augmented by solids or other propulsion units previously landed on or near the touch down and takeoff site.

No matter what the approach, we have our work cut out for us in lunar takeoff. ♦♦

Lunar Takeoff Spacecraft Characteristics

Function	Ideal System	Next-best System	Comments
Propulsion	High - energy, high-mass-ratio solids.	99.8–99.9% reliable high-energy simple liquid system, "space-storable" on lunar environment; hypergolic, low corrosion.	The liquid is preferable if used for landing as well; start-stop and throttling are then required. Pitch-yaw-roll control might be exercised by auxiliary system, for liquid or solid propellant main propulsion.
Control	High - pressure gas, with small jets.	H_2O_2 or N_2H_4 monopropellant gas generator with control jets.	Can be used for final velocity "trim" or midcourse altitude control. Use of auxiliary sytem reduces complexity of main engine.
Guidance	Lightweight low drift inertial stable platform, pre-set at takeoff using celestial or horizon reference A man in the guidance loop will considerably ease the demands on the system if he can derive referencing intelligence from the horizon, radio, and gyro instruments.	Two-axis gyro system coupled to celestial or radio reference with manned link.	The guidance system has to do the following: 1. Sense acceleration (and velocity) and give command for propulsion cut-off and trim. 2. Establish correct pitch program into the moon-earth path, with proper injection vectors, into co-planar orbit with the earth-orbit vehicle. 3. Maintain correct altitude (including roll) control.
Prelaunch Vehicle Alignment	Extensible legs pneumatically adjusted for vertical vehicle position or other desired launch angle.	Takeoff "as-is," correction made for flight path with vehicle steering correction after takeoff.	If the vehicle is severely canted from the optimum launch angle an undue (and unacceptable) demand might be placed on the control system to align the vehicle properly.
Structure	Rigid, lightweight, high-strength; tankage (integral), resistant to propellants (if liquid); minimum of welded or other joints, especially for liquid system; liberal use of "styro-foam" desirable; many drop tests necessary to assure strength and integrity of vehicle.	There can be no compromise with "ideal" system.	It should be possible to achieve mass ratio of 0.92 with all the desirable features shown here. After takeoff with propulsion system functioning perfectly the legs, etc. could be jettisoned for further mass-ratio improvement. The legs, retained for the first hundred feet or so after launch, are a safety feature, if engine quits in that distance. The vehicle could then fall back to moon without a catastrophic crash, cushioned by the legs.

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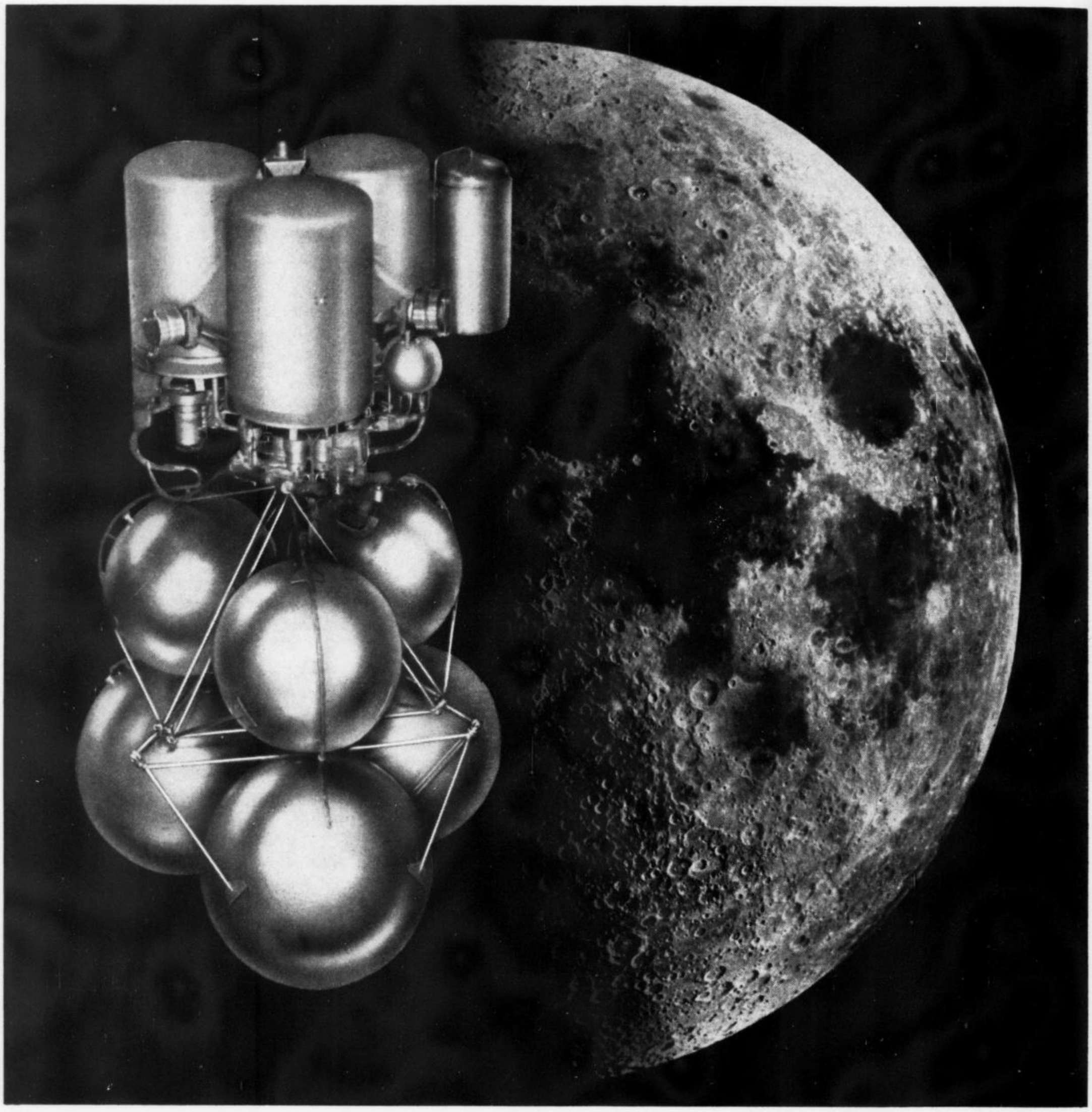
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A fuel cell for Apollo

This is a model of a fuel cell designed by Pratt & Whitney Aircraft—the company chosen to develop a fuel cell system for Apollo, America's first manned lunar craft. The Apollo spacecraft will be built for NASA by North American Aviation.

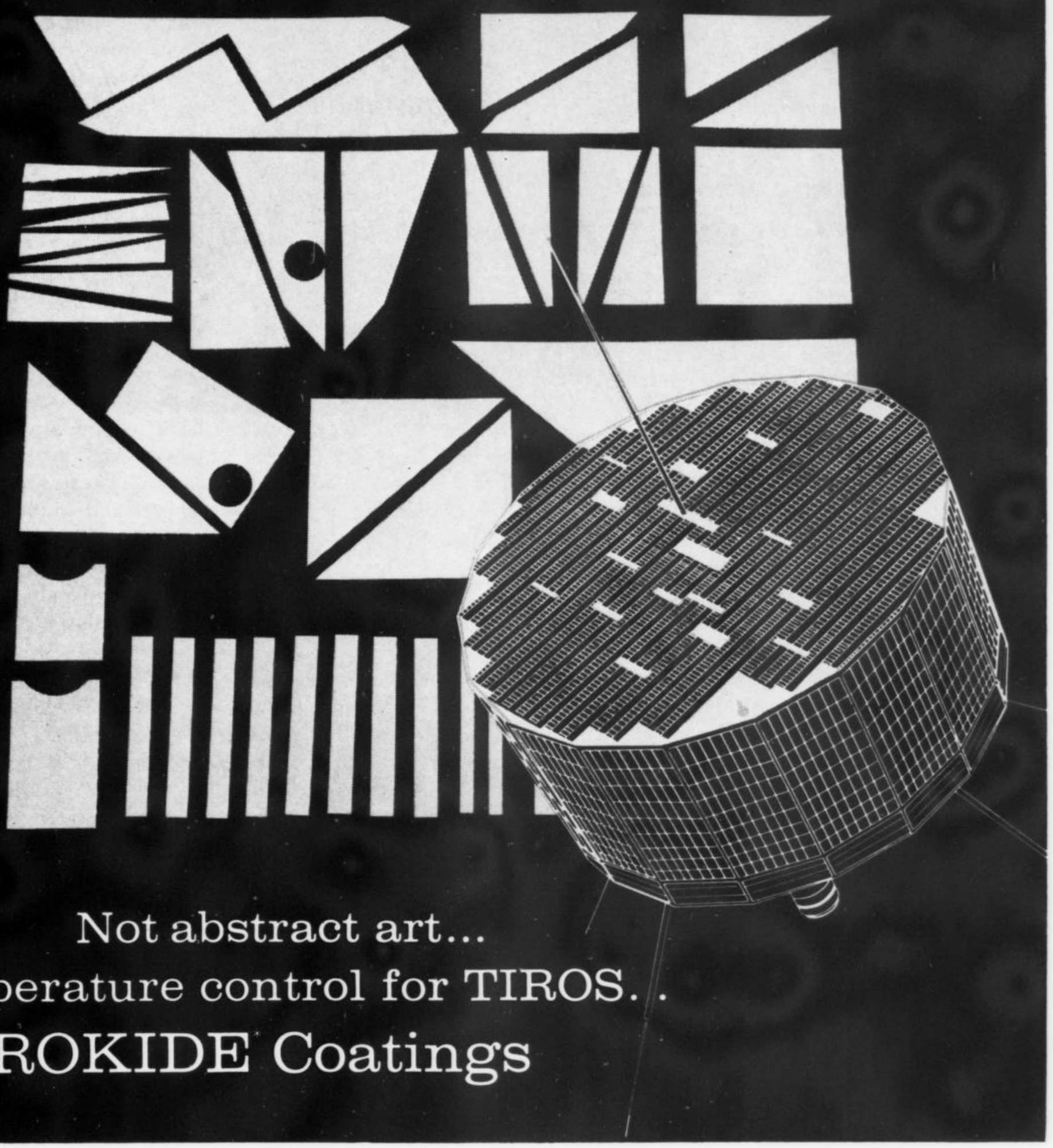
The hydrogen-oxygen cell will supply power for environmental conditioning, communication, instrumentation, and scientific equipment. In addition to generating electricity, the fuel cell will provide water for Apollo's three-man crew.

Pratt & Whitney Aircraft's fuel cell is far more efficient than conventional power systems. During tests, cells have demonstrated efficiencies of 70 to 80 per cent.

The fuel cell has a significant role in space. Moreover, it promises to be a significant power source on earth. Pratt & Whitney Aircraft is currently studying fuel cell power systems for such applications as remote-site power, vehicle propulsion, commercial power generation, and other industrial tasks.

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Crystallizing Ideas into Products



Not abstract art...
temperature control for TIROS..
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Actually, these geometrical figures do represent one form of modern art — the craftsmanship required to assure effective thermal balance in Tiros satellites.

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Ugly Duckling—VT 1105R Test Vehicle

Manned lunar-landing exercises may profit from its state-of-the-art propulsion and guidance

BY FELTON WILLIAMSON AND EARL YIM

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One of the engineering problems involved in placing a man on the moon is the soft-landing of the manned lunar module. In early 1959, the U.S. Naval Ordnance Test Station (NOTS) postulated that its variable-thrust propulsion system could be used for this mission.[1] Not long thereafter NOTS designed, built, and flight-tested an experimental vehicle which demonstrated conclusively that a variable-thrust propulsion system can be precisely controlled to soft-land a vertically descending craft.

The photo opposite shows this experimental vehicle, the 1105R. It was 8 ft high by 5 ft wide and weighed 700 lb fully loaded, including 300 lb of inhibited red-fuming nitric acid (IRFNA) and unsymmetrical-dimethylhydrazine (UDMH) that provided power for 75 sec through a 0- to 1300-lb variable-thrust (VT) engine. During experimental tests, the vehicle was restricted to vertical movements on four cables hung between a 150-ft tower and the ground.

This experimental craft tested both the rocket and an optical guidance system. Results were generally excellent. The Station has consequently proposed exploiting its state-of-the-art technology in a test vehicle for Apollo components. What follows describes in more detail the nature of the work leading to this proposal.

A VT-engine program began at NOTS in 1955 to meet various operational requirements. Since that time, a family of liquid-propellant VT engines of 0–10- and 0–3500-lb thrust have been designed, built, and tested.

In 1958, when serious thought was given by this nation to a lunar expedition, it became apparent that VT retro-propulsion was a natural method for soft-landing on the moon. But at that time there was considerable skepticism whether the NOTS variable-thrust engine could achieve the precise control and good frequency response necessary for softly landing a manned vehicle. Therefore, in 1960, it was decided to design and build a low-cost soft-landing vehicle, designated the 1105R, to demonstrate feasibility.

The fabrication of the vehicle was completed in June 1960, but flight-testing was postponed until April 1961. This vehicle used a 0- to 1100-lb VT-engine design which had already gone through a prototype development program resulting in 16 successful flight demonstrations. This engine, developed for a surface-to-surface weapon system feasibility demonstration, performed so well that it was used for retro-propulsion in the 1105R vehicle.

During this interim period, an optical sensing device was designed to provide automatic control for a soft-lander. With this device available, the 1105R program objective was modified to include testing of optical guidance and control.

In April 1961, we reached our first objective—demonstrating that the VT retro-engine could be precisely controlled to soft-land a vertically descending craft. Three more flight tests were made to provide additional data.

Since the 1105R vehicle was designed only for feasibility demonstration, it did not attain optimum design in terms of weight. It was designed for low cost of construction, ruggedness, and extreme reliability, and it looks a little odd—a kind of ugly duckling—because surplus hardware was used in it where possible.

We did not attempt to make a free-flight test vehicle because of the complexity and expense of an attitude-control system. Instead, we restricted its path and attitude with four vertical cables strung between the ground and the top of a 150-ft tower. The vehicle was free to fall in the vertical plane for demonstration of the retro-propulsion engine control.

Vehicle Characteristics. The following table outlines the 1105R's chief characteristics. The propellants, as mentioned, were UDMH and IRFNA.

WEIGHT	
Total vehicle (loaded), lb	700
Empty vehicle, lb	400
Propellant, lb	300
PROPELLANT PRESSURIZATION	
Nitrogen storage, psi	3000
Nitrogen regulated, psi	600
PROPULSION	
VT motor, lb thrust	0–1100 0–1300
Propellant tank pressure, psi	600
Chamber pressure, psi	400

The rocket fuel is located in four tanks, set 90 deg apart, which slope up to a spherical nitrogen-propellant-pressurization bottle at the top. Mounted on top of the nitrogen bottle are a movie camera, the optical-sensing device, and electronic controls. The oxidizer tank is in the middle of the vehicle. Mounted below the oxidizer tank is the VT engine. The four fuel tanks also form the landing gear. They terminate in four automobile overload coil springs and hydraulic shock absorbers.

Injector. The heart of the variable-thrust propulsion system was the NOTS variable-area injector,[2] views of which appear on the next two pages. The schematic drawings show a design with metal bellows seals and one with O-ring seals. The injector with the metal seals was designed, fabricated, and bench-tested successfully for leaks and response, but was never fired. The injector pintle response was 20% higher due to eliminating O-ring drag.

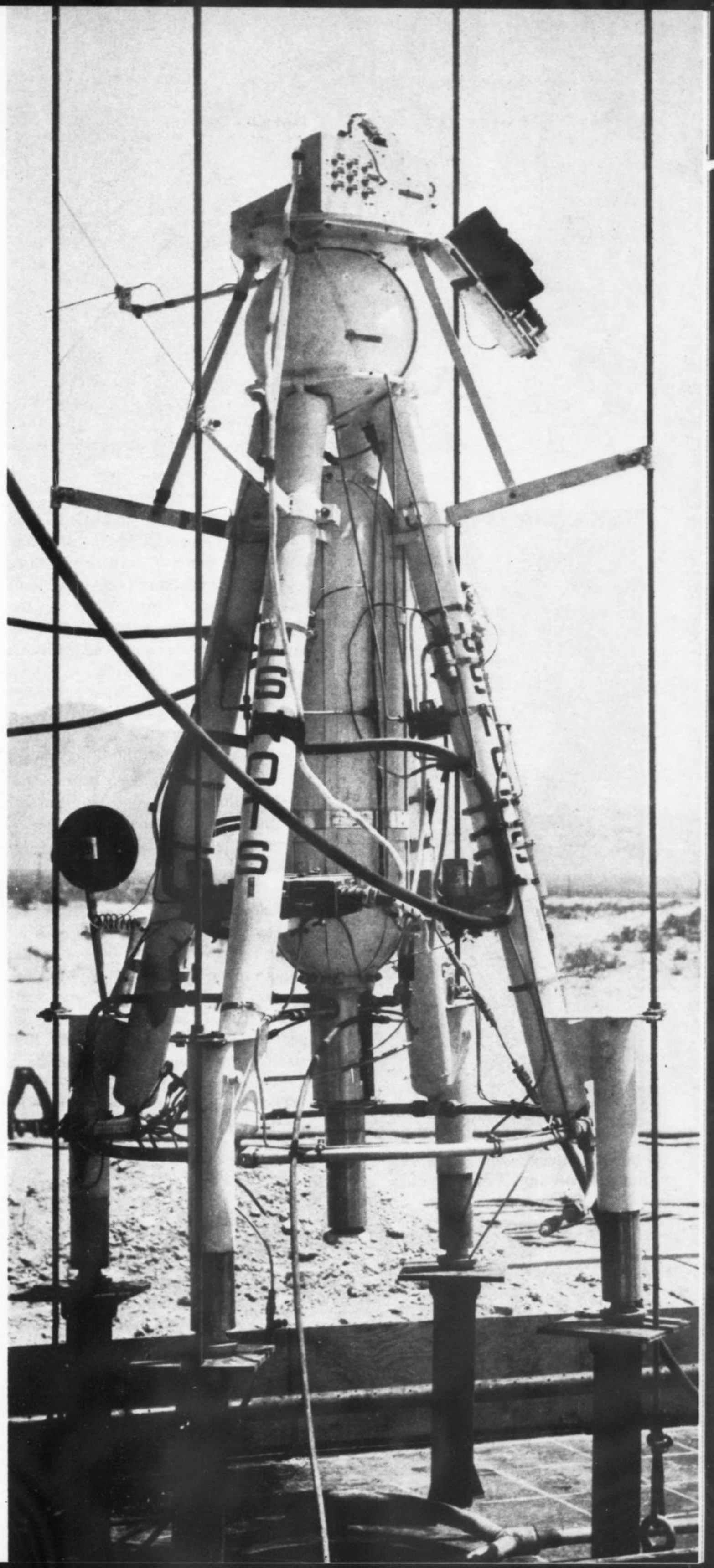
Thrust is controlled by a single moving part in the injector called the pintle. Positional change of the pintle varies the annular areas of both the fuel and oxidizer orifices at a constant ratio, thereby varying the amounts of propellant allowed to flow into the combustion chamber.

The pintle position was controlled by a hydraulic servo system, diagrammed at the top of page 45, in which the fuel was used as the pressurizing hydraulic fluid. This system employed an Atchley 310 four-way servo valve.

In the variable-area injector design, high-frequency response and high-precision thrust control are not compatible. Therefore, an injector designed for extremely high-frequency response would normally provide a lower degree of thrust control. Conversely, an injector designed for lower frequency response would normally provide more precise thrust control.

This injector was designed for medium response and good precision thrust control. The thrust-controlling element, the pintle, can be positioned within 1% of its full-travel movement of 0.090 in. A response to command signals up to 16 cps from zero to full thrust was obtainable with the injector. (Tests on an advanced experimental injector indicate that frequencies up to 30 cps can be obtained with good proportional thrust control.) With the design we measured characteristic exhaust velocity (C*) efficiency as high as 96% using UDMH and IRFNA.

Combustion Chamber. Phenolic-asbestos (Astrolite)-lined combustion chambers were used in the first two 1105R flight tests. This chamber provided approximately 1100 lb of thrust at 450-psi chamber pressure—not sufficient to allow the optical guidance to land the vehicle. It was determined after the first 1105R flight test that we would have to develop a combustion chamber which produced slightly higher thrust. This chamber was



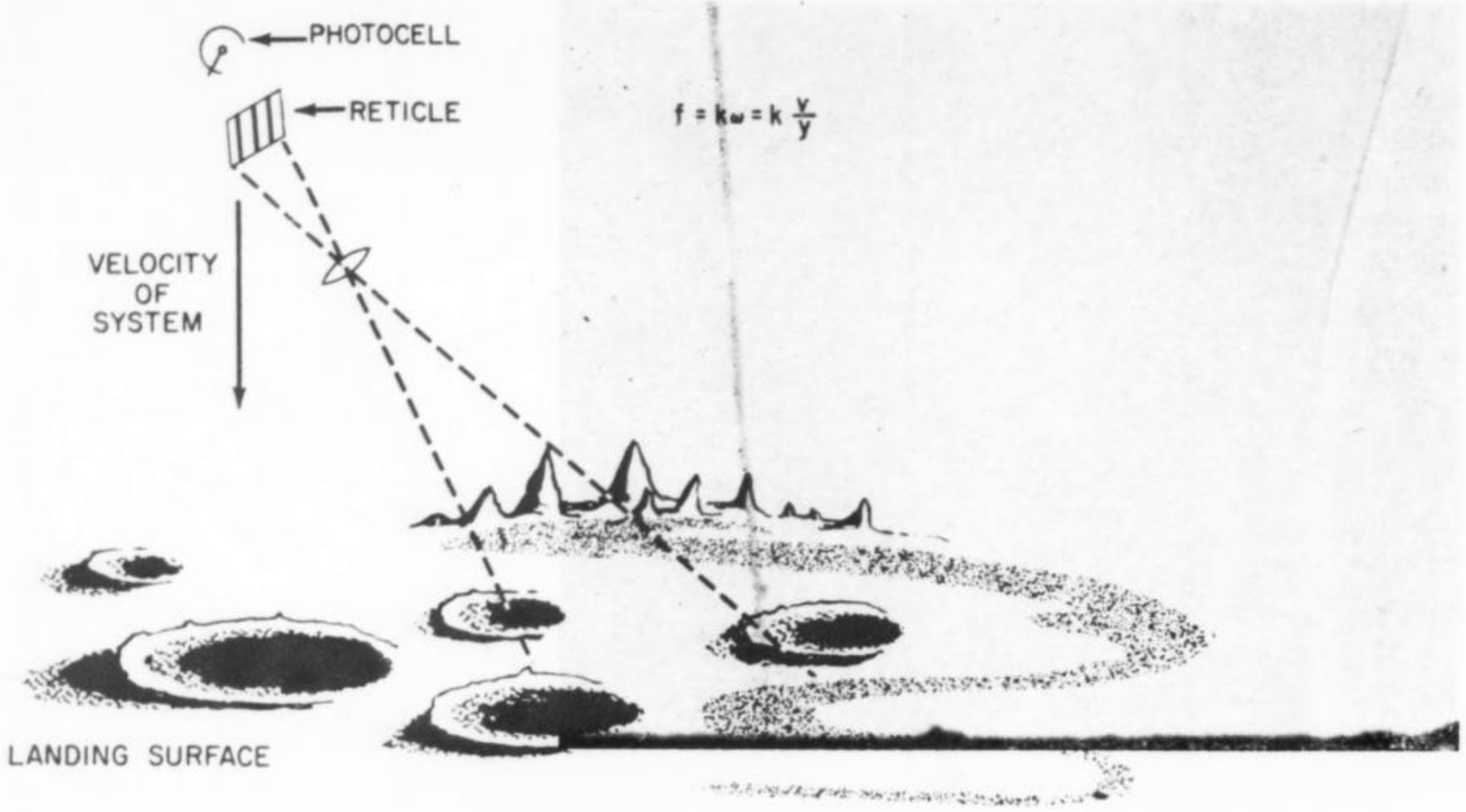
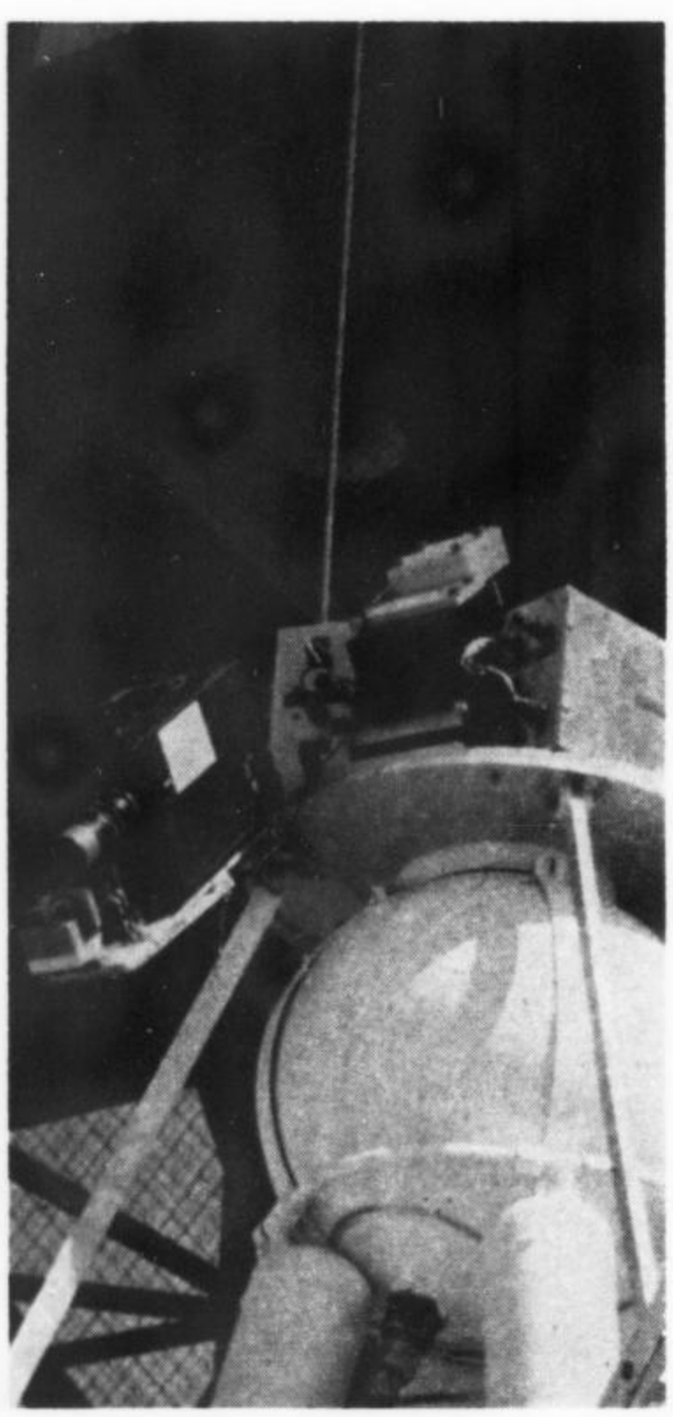


Diagram of an optical-guidance scheme superimposed on a photo of an actual desert background viewed by the optical scanner in a test. The scanner gave strong signals from this poor contrast.



Above, guidance equipment mounted on the 1105R.

graphite-lined and produced 1300-lb thrust at 300-psi chamber pressure. The same injector was used, since without modification it was capable of delivering enough propellant to the chamber. Our lowest touch-down velocity—3.8 fps—was achieved with this 1300-lb-thrust chamber.

Guidance. On the initial flight tests of the 1105R, the command signals to control the VT retro-engine were given by a pilot some 200 ft away from the vehicle. On the final test, the 1105R vehicle was controlled part of the time by an automatic onboard optical-scanning guidance system designed and developed at NOTS.

As can be seen in the photo at the left, the optical scanner and associated electronics mount at a fixed angle on top of the 1105R. As the vehicle moves toward the ground, the scanner sees objects move across its field of view. The images pass through a lens, through a reticle having alternate opaque and transparent bars, and onto a photosensitive transducer.

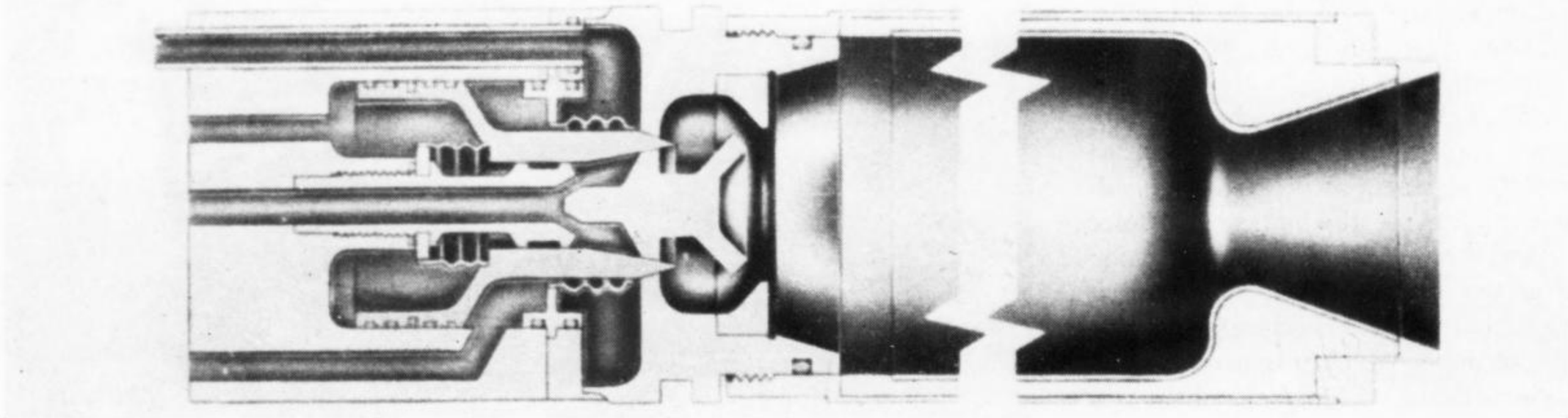
The images are chopped by the reticle; and consequently the signals from the photosensitive transducer are generated as frequencies. The signal frequency is independent of image size, shape, or number, but requires some optical contrast on the landing surface. The scanner requires very little optical contrast.

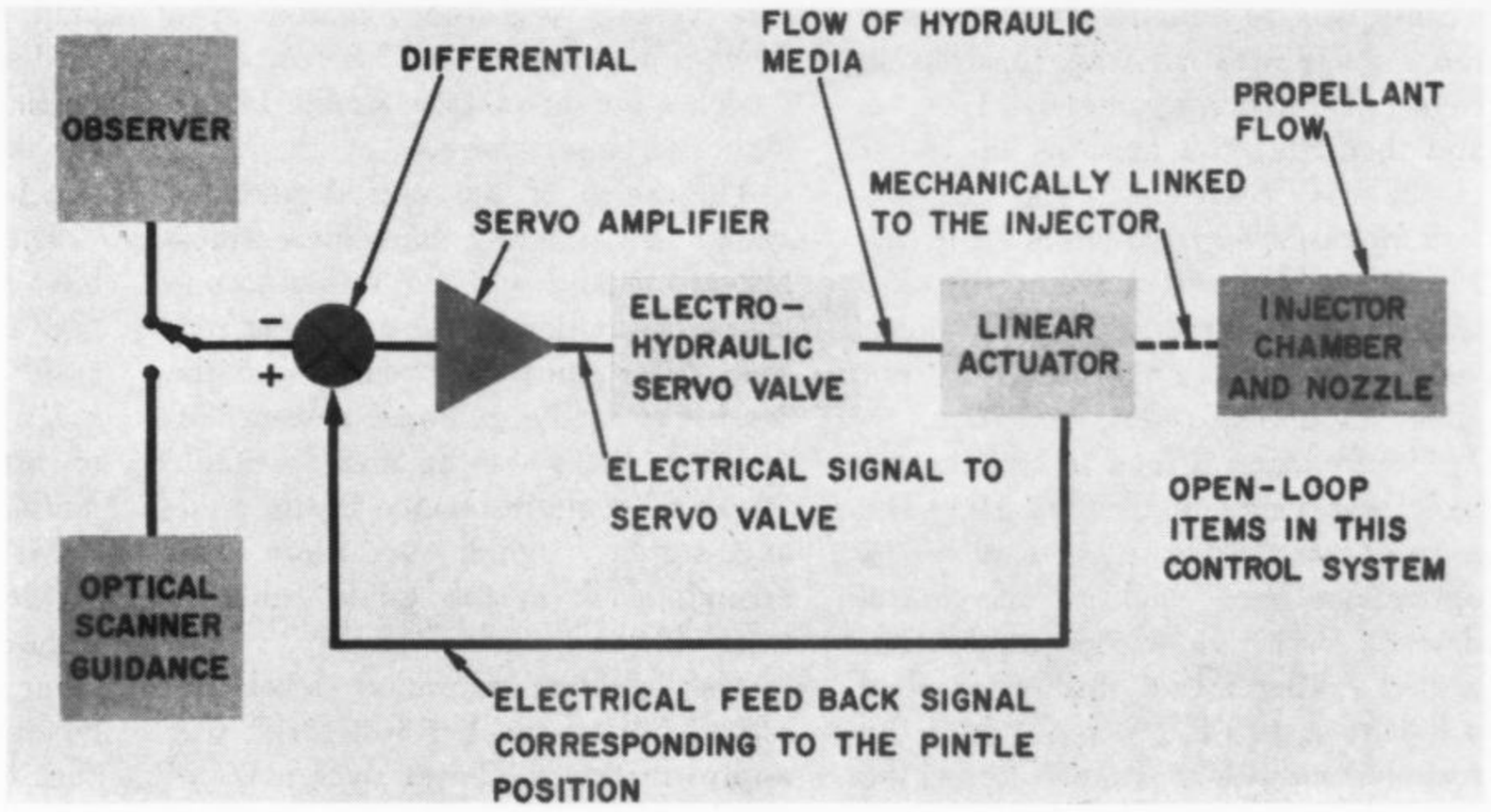
At the top here can be seen a diagram of the optical operation superimposed on the background viewed in a test. The optical scanner gave strong signals from this background.

The frequency output of the scanner is proportional to the ratio of velocity to height. Both the velocity and height of the vehicle can approach zero by varying the retro-thrust in such a manner as to cause the frequency of this signal to remain constant, thereby providing a soft-landing control.

By use of multiple scanners, the vehicle's attitude as well as descent rate can be controlled. Considering one plane and two scanners, the frequency-difference signals between the two scanners can be used to control attitude motors to align the velocity vector co-linear with the center of

Below, bellows-seal design of VT injector.





Servo System for the 1105R Test Vehicle.

the 1105R test vehicle.

Only one optical scanner was required for these tests, since the 1105R was guided by cables. A detailed description of the optical-scanner guidance system has been reported.[3]

Flight Tests

In the first feasibility demonstration (April 28, 1961), the 1100-lb motor raised the vehicle smoothly to a height of 60 ft, lowered and hovered at 30 ft, and finally softly landed at an estimated touch-down velocity of 5 fps. The rocket-powered rise and descent took 45 sec.

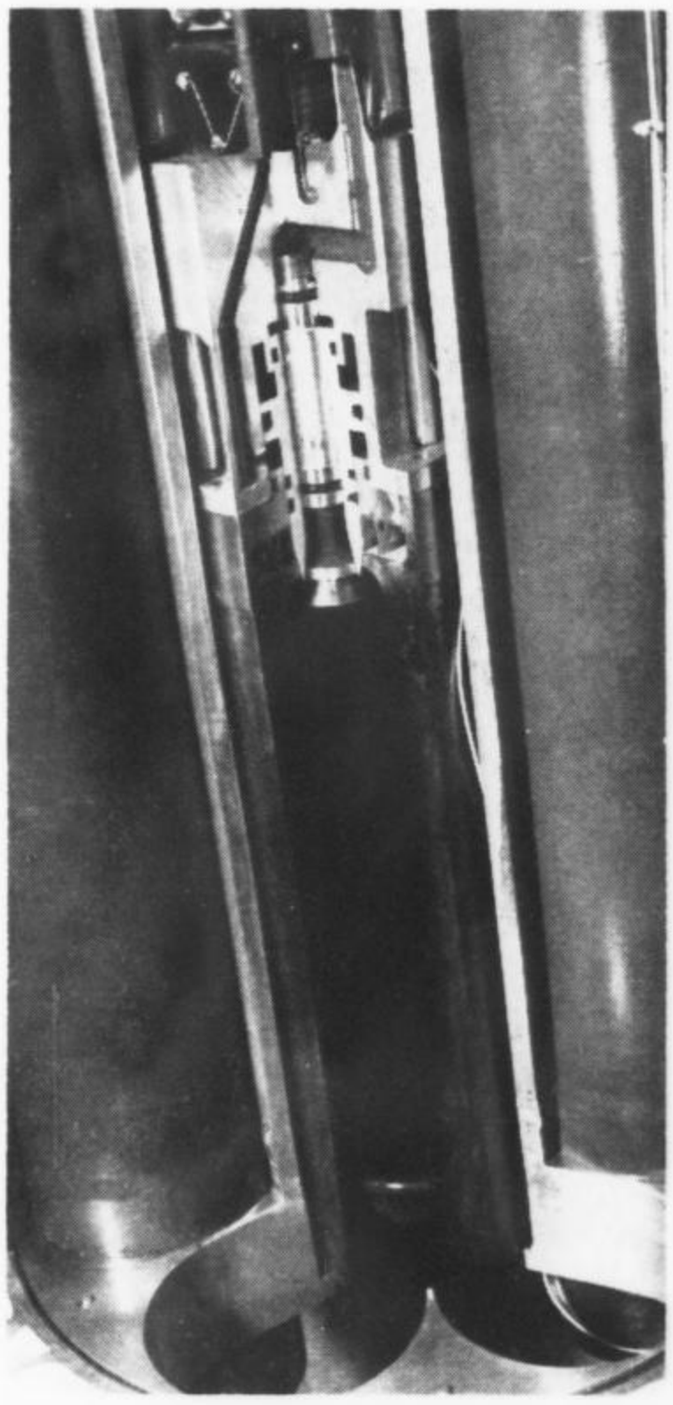
This test demonstrated the ability to control a VT-motor precisely enough to soft-land a vertically descending craft.

The second 1105R test, made June 5, 1961, was to determine the effect of engine vibrations on the operation of the optical-sensing device. The device's signal output was monitored on this test with the VT motor pilot-controlled from the ground. The 1105R rose to a height of 130 ft, descended to 70 ft, hovered, descended to 15 ft, hovered, and landed with a velocity at touch down of 8.3 fps. Flight time was 55 sec.

This test indicated that the engine's noise and vibration had little or no effect on the performance of the optical-scanner signal. The scanner performed satisfactorily during all phases of the flight in which the velocity-to-height ratio (v/h) exceeded the value of 0.1. During most of the descent the vehicle's velocity was held too low to cause the scanner to yield a signal. Flame and dust created by the engine didn't appreciably affect the scanner.

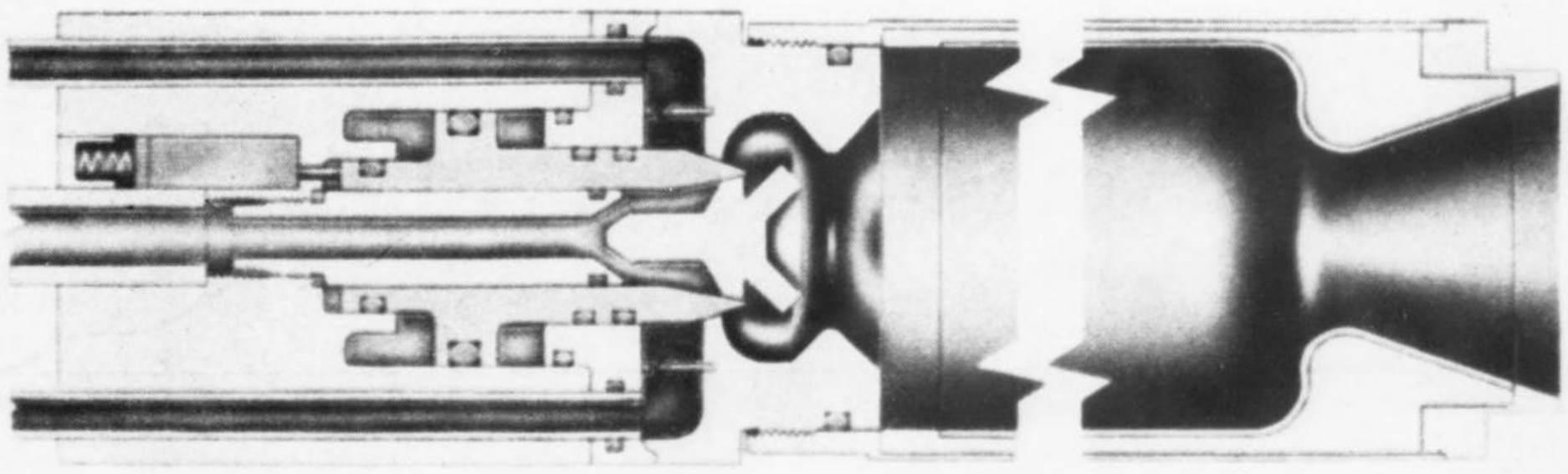
A third flight, made June 23, 1961, repeated the open-loop test on the optical scanner to make certain that a minor pulse-generator problem had been solved and to ascertain the extent of vibration of a new 1300-lb-thrust combustion chamber. Due to malfunctioning of an oxidizer vent valve, a small fire was started which caused a postponement of the test until September 14.

Then the test was successful. The vehicle was rocket-powered to 135 ft.



Above, sectional view of VT motor in experimental missile.

Below, O-ring-seal design of VT injector.



Thrust was terminated by the pilot, the vehicle was allowed to drop in free fall for approximately 1.7 sec, and then the pilot applied full thrust to the rocket engine. The fall was terminated at approximately 75 ft, the 1105R was hovered momentarily, and was then soft-landed at a touch-down velocity of 8 fps. Vibrations did not affect the optical-system operation.

The fourth and final test of the vehicle was made September 15. The purpose of this test was to allow the optical-guidance package to control descent. The vehicle was pilot-controlled during ascent until it reached a height of 146 ft (within 4 ft of the top of the tower). At this point, the thrust of the engine was reduced to zero and the control was switched from the pilot to the optical-guidance system. The vehicle, now on automatic control, continued its descent for several seconds, stopped, and then began to accelerate toward the top of the tower. It was necessary to switch back to pilot control to prevent the vehicle from running into the top of the tower.

A second attempt was made to allow the optical system to control the landing, but the results were identical with those following the first attempt. The vehicle was then landed at a touch-down velocity of 3.8 fps. The vehicle's height-vs.-time profile in this flight can be seen here.

The cause of the optical-guidance system commanding the vehicle to rise instead of land was due either to one or a combination of the following reasons: For some unknown reason the sensitivity of the guidance system had doubled; there was an unaccountable 50- to 60-cycle resonance in the guidance-system signal; or there was enough slack in the guide cable to translate the vehicle laterally.

The greatest vibration level observed during the last test series was approximately 4 G rms over a 2000-cps bandwidth. This corresponds to a spectral density of 8×10^{-3} G^2 cps. There was little difference in the maximum vibration level produced by the engine with the 1100- or 1300-lb-thrust chamber.

Results and a Proposal

In this work we attained the initial objective of demonstrating that a NOTS variable-thrust retro-engine could be precisely controlled to soft-land a vertically descending craft. It was also demonstrated that a man can control the variable-thrust engine to land himself. Feasibility of the optical-scanner guidance and control was partially demonstrated, although minor problems not anticipated prevented a conclusive demonstration.

The Naval Ordnance Test Station has recently proposed a free-flight 6000-lb soft-landing test vehicle for early testing of various Apollo vehicle components and for eventual training of astronauts in the control of soft landings.

Many other applications exist for soft-landing or hovering vehicles—for instance, an instrumented platform launched by a multistage booster to hover at extremely high altitudes, as suggested by Heineck.[4]

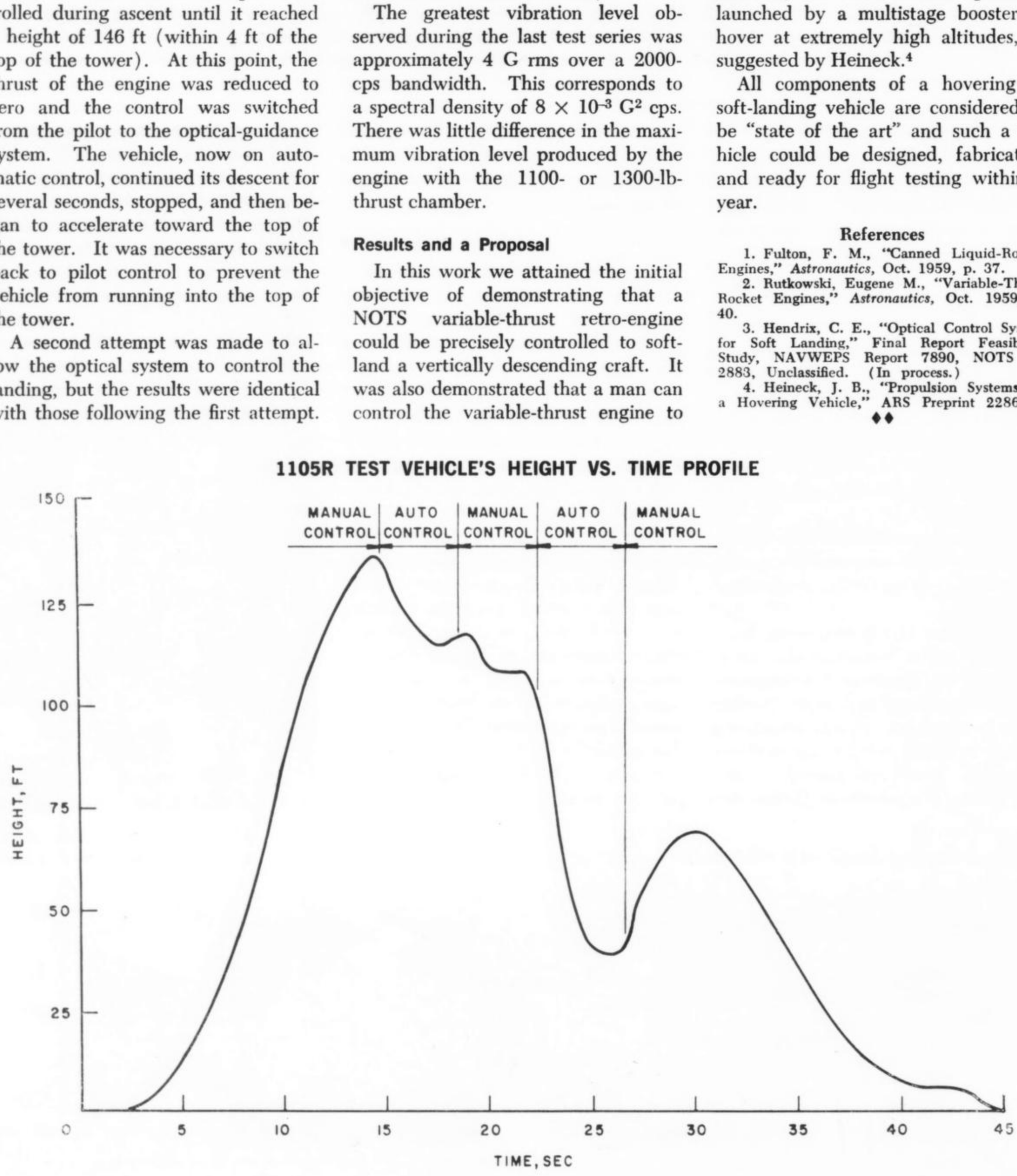
All components of a hovering or soft-landing vehicle are considered to be "state of the art" and such a vehicle could be designed, fabricated, and ready for flight testing within a year.

References

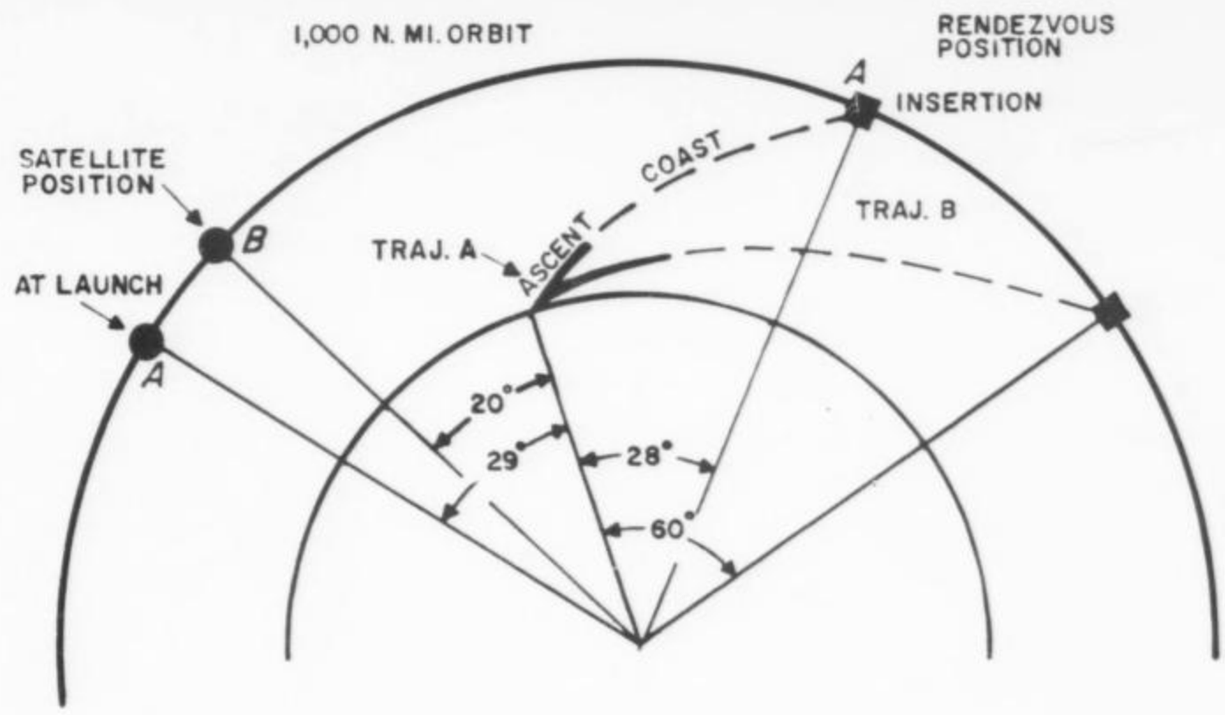
1. Fulton, F. M., "Canned Liquid-Rocket Engines," *Astronautics*, Oct. 1959, p. 37.
2. Rutkowski, Eugene M., "Variable-Thrust Rocket Engines," *Astronautics*, Oct. 1959, p. 40.
3. Hendrix, C. E., "Optical Control System for Soft Landing," Final Report Feasibility Study, NAVWEPS Report 7890, NOTS TP 2883, Unclassified. (In process.)
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1105R TEST VEHICLE'S HEIGHT VS. TIME PROFILE



TYPICAL DIRECT-ASCENT TRAJECTORY



FLIGHT TIME- TRAJ. A ≈ 1170 SEC.
TRAJ. B ≈ 1660 SEC.
Δt = 169 SEC.

Mistram and Rendezvous

This new tracking system should increase our rendezvous capability both near earth and on the moon

BY R. A. HEARTZ AND T. H. JONES

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MISTRAM (from missile trajectory measurement), a radio tracking system being installed near Cape Canaveral, is a precision instrument designed to provide data for the evaluation of missile guidance systems. It must provide position and velocity data at least an order of magnitude better than the radio or inertial guidance system being tested. This capability will support test programs to be conducted at the Atlantic Missile Range, and can greatly enhance future space activities, particularly rendezvous.

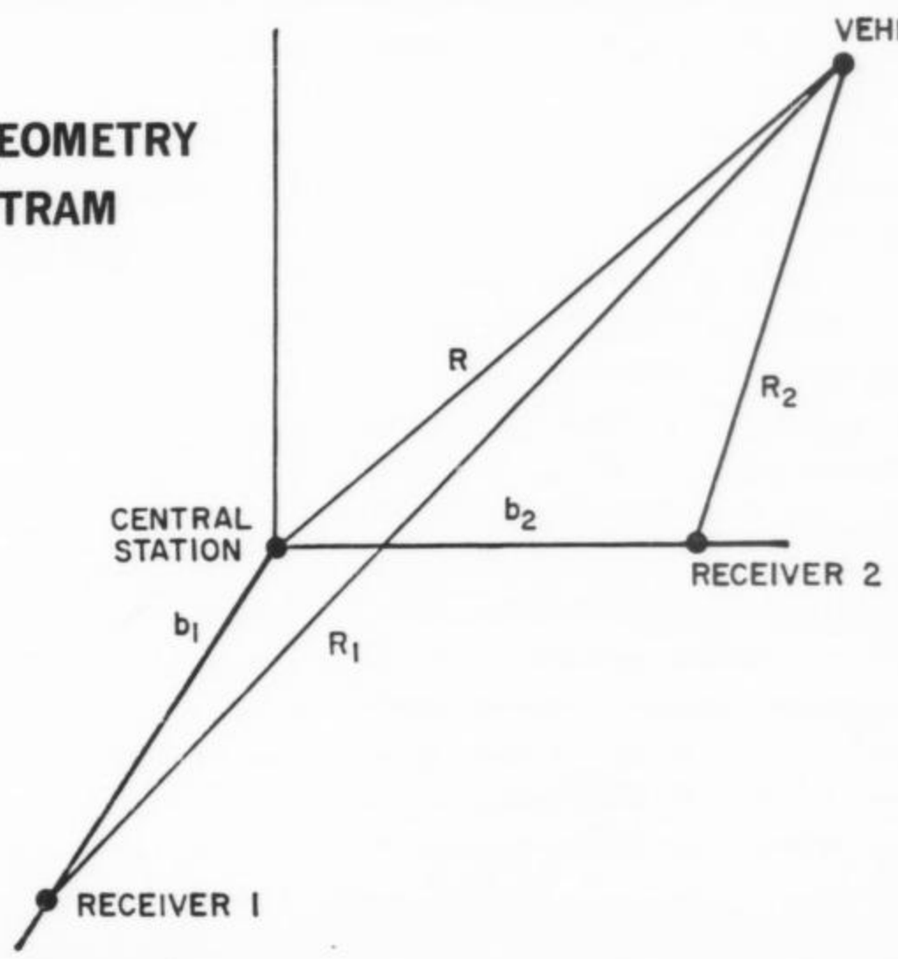
In this key mission, the goal is to join a vehicle from earth (the ferry) to a vehicle in orbit (the station). This is certainly not a simple maneuver. Successful achievement is made more difficult by several complex maneuvers that must be made in series. First, there is an ascent phase, where the ferry vehicle is guided and inserted into a trajectory whose apogee is at station altitude and time of apogee is precisely controlled relative to station position. Next the ferry is inserted into a close co-orbit with the station. Finally, the ferry acquires the station and is maneuvered to gentle contact with it.

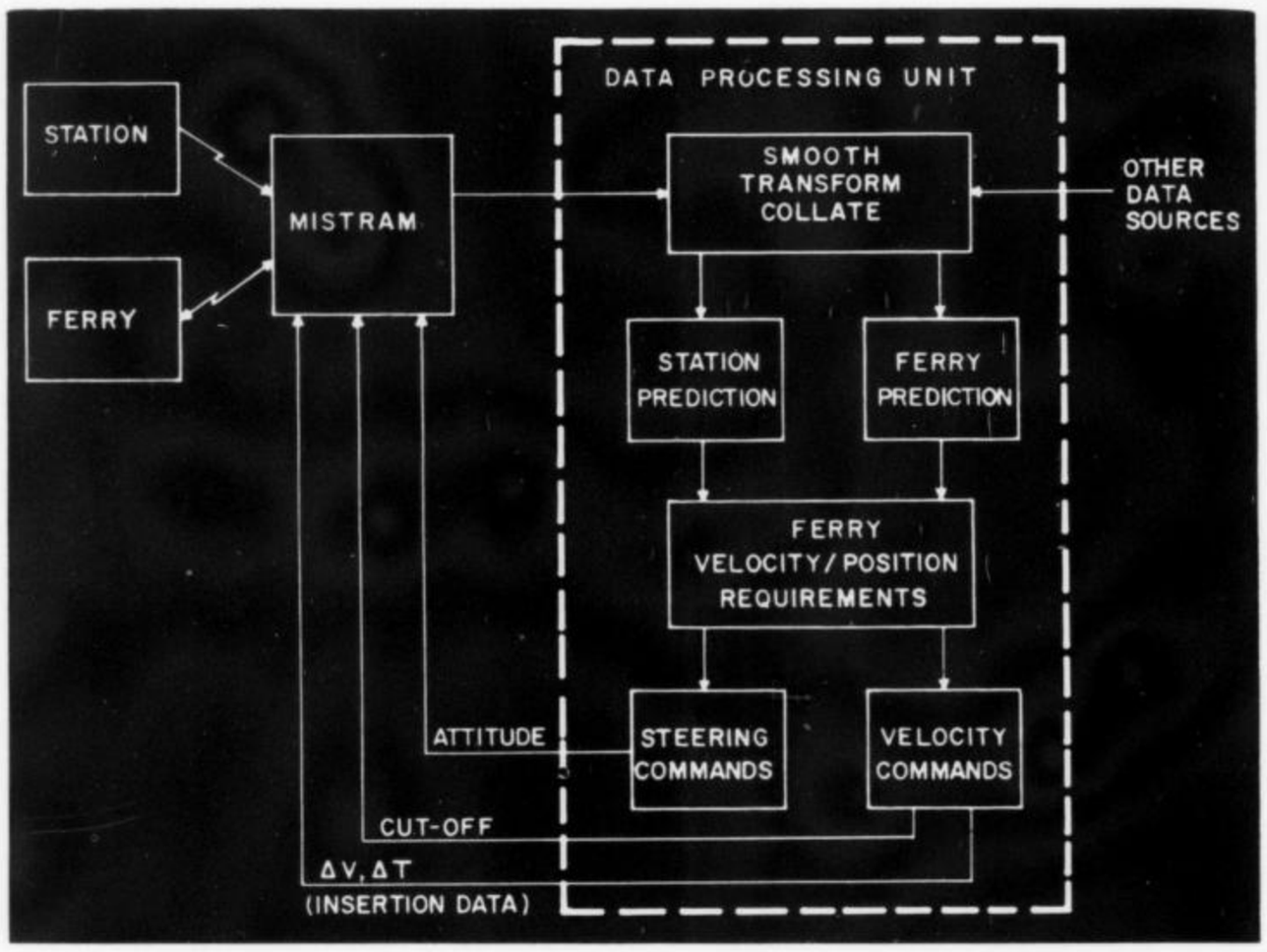
These three steps are basic, although there may be many variations of them, such as first inserting the ferry into a lower, higher-speed orbit and then at the proper time transferring the ferry to the station orbit.

Here we will emphasize the direct-ascent trajectory because it places the more stringent requirements on the tracking and guidance systems. In general, performance factors for a typical direct ascent can be readily transformed to represent other rendezvous maneuvers.

Ascent guidance must not only direct the vehicle to precise position and velocity at apogee, but must also select a trajectory that compensates for delays in launch, subnormal thrust,

BASELINE GEOMETRY FOR MISTRAM





Simple Guidance Loop with Mistram

and other time variants. While final approach and docking is a homing-type maneuver, where the ferry acquires the station (or vice versa) and dictates a maneuver which can compensate for insertion errors, success of this maneuver will be directly related to accuracy of ascent guidance.

This is evident when one considers that the complexity of equipment necessary to acquire another vehicle is a direct function of search position and velocity volumes. For example, a system that must search throughout an entire sphere at a velocity range of ±10 fps is bound to be more complex and thus must be less reliable (particularly airborne equipment) than one required to search a 10-deg solid angle with a velocity sweep of ±1 fps. The pilot's efficiency in acquiring a station and safely docking his vehicle will be related to the volume and velocity ranges he searches and to the error magnitudes that he must compensate.

Besides requirements to reduce onboard equipment complexity, there is also an energy constraint. Even with the crudest guidance systems, rendezvous could eventually be accomplished if unlimited energy were available. This is space billiards—a fascinating game but rather expensive.

Manned rendezvous missions will have three basic types of control, guidance, and navigation systems: first, the pilot; second, the vehicle-borne control and navigation systems; and, third, the tracking, data-processing, and command link of the ground-support system. The major question to be resolved is not whether control should be a pilot, radio, or inertial function, but rather, How can the unique features of these basic systems best be combined to assure mission success? How can we design the system that will have optimum capability to sustain the mission or provide safe recovery even though some failures occur?

A complete answer to this question involves a detailed study of specific missions and requirements. However, much can be accomplished if one hypothesizes a typical mission, selects equipments and performance characteristics, and then evaluates how these might perform.

Let us do just this. Our system will be the present Mistram tracking equipment augmented by a data-processing unit and command link.

Precision radars can give 1–10 ppm position accuracy, consistent with our present knowledge of the speed of light.[1] This accuracy is based on three-dimensional determinations with samples supplied at high data rates (20 or more per second; for most applications this corresponds to real-time measurement). The radars that will produce these results are long-baseline, microwave, continuous-wave systems using interferometer measurement techniques. The graph on the opposite page shows a typical baseline geometry. Measuring three ranges (R, R1, and R2) completely determines the position of the vehicle. The precision of the measurements depends on how accurately the ranges are measured and how accurately the three stations are known with respect to some fixed frame of reference.

In space work, where ranges are great, a transponder invariably is used in the vehicle to provide adequate signal strength for tracking. The transponder replies to signals received from the ground transmitter. The replies are also received at each of the two outlying stations where the total time delay in each case is equivalent to the total path (central station–vehicle–outlying station).

Using interferometer techniques, range can be measured to a fraction of a wavelength at microwave frequencies. This amounts to errors of less than a foot. The effects of the troposphere on radio propagation (effects of the ionosphere are rendered practically negligible by the use of microwave frequencies) can cause range errors of hundreds of feet, but these errors can be reduced to a few feet by careful compensation. The uncertainty in the speed of light in free space causes an additional error in range of a few parts per million. The foregoing statements apply to total range-measurement accuracy; incremental range can be measured to hundredths of a foot or better.

The angle measurements are more important, or at least the required ac-

curacy of a few parts per million (one microradian) is usually more difficult to achieve. It turns out that radars having very long baselines are required to attain this accuracy because of the propagation errors arising in the troposphere.

Although this method of measurement is not new, either in theory or in practice, the unique manner in which these techniques are implemented in the Mistram system permits measurement of vehicle flight parameters with a degree of precision and accuracy not hitherto obtainable in other long-baseline trajectory measurement systems. To a large extent, this is accomplished by a unique method of transferring intact the phase information in the signals from outlying stations to the central station. A two-way transmission path on each baseline is used to cancel out uncertainties due to variance in ground geometry and temperature.

The Florida Mistram station has 100,000-ft baselines. Its expected performance will be as follows:

Range of Operation:

Velocity	0 to 50,000 fps
Acceleration	0 to 750 fps^2
Azimuth	360 deg
Elevation	5 to 85 deg
Range	20 to 1000 mi.

Measurement Uncertainties (Rms):

Range	0.4 ft
Range Difference	0.3 ft
Range Rate	0.02 fps
Range Rate Difference	0.002 fps

(The last two quantities involve one-half second of smoothing.)

These are measurement accuracies expressed in Mistram system coordinates. They tell nothing unless associated with a specific geometry between a spacecraft and the Mistram station. The table shown below presents a typical geometry and the conversion of the figures just given to vehicle position and velocity measurement accuracy. They refer to a typical condition that might be related to insertion of a satellite, a rendezvous maneuver, or insertion to a lunar mission. These are near real-time accuracies (less than 0.5 sec of smoothing), but must be converted to a trajectory correction and delivered to the vehicle.

The measurement accuracies of Mistram will be a function of the geometry between the station and the space vehicle. For elevation angles greater than 10 deg we expect measurement uncertainties in position to be less than 10 ft and in velocity to be less than 1 fps. These are real-time accuracies and apply over all ranges of velocities and distances encountered for near-earth rendezvous maneuvers. But they are also only the absolute radio-tracking uncertainties. Guidance and control of a rendezvous mission will involve many other sources of error, such as thrust cutoff and unpredictable geodetic anomalies (atmospheric drag, surveying, computation uncertainties, etc.).

As our knowledge of space environment improves, these accuracies will be achievable. They are now achievable for a final rendezvous maneuver where both station and ferry are in sight of a Mistram station. Here ferry and station have roughly the same geometry; relative measurements become most important, absolute position and velocity of little concern. Under these conditions, Mistram can measure relative position and velocity between station and ferry to accuracies much better than ± 10 ft and $\pm 1/2$ fps. As these measurements are almost in real time, a ground-based computer can derive corrective maneuvering commands so that docking the ferry will be well within the capabilities of a pilot.

We can expect that many rendezvous maneuvers will be accomplished under less favorable conditions. Also, guidance accuracy is only one area of concern—energy constraint is another major problem. In general, whether direct ascent or intermediate co-orbit is used, it is the ascent guidance phase that will make or break a rendezvous mission.

First, precision guidance is a must. While the final phase of a rendezvous maneuver can compensate for ascent guidance errors, this costs fuel; and fuel cuts payload capacity.[2] Second, and perhaps most important, the ascent trajectory must be shaped to compensate for launch-time delays and subnormal boost thrust. Finally, it is during the ascent phase that energy constraints are most likely to be exceeded. When this occurs, a safe recovery path must be derived and commanded.

The diagram on page 47 provides a sample of how launch delays can be compensated in a direct-ascent rendezvous maneuver. In this example, if launch or other delays exceed 169 sec, then the mission cannot be accomplished, energy constraints have been exceeded, and a recovery maneuver must be initiated.

Techniques for ascent guidance are now far from an established art. The diagram on page 48 shows a rather simple example of this guidance loop. Fundamentally, the vehicle is first guided to a condition that gives a proper apogee altitude and then the ferry is steered on a constant-apogee altitude trajectory until position constraints are satisfied and apogee occurs somewhere between points A and B of the trajectory diagram. At this time, the Δv required for close co-orbit is computed and transmitted to the ferry. If rendezvous is beyond station range, this Δv is acquired by calibrated inertial onboard equipments.

An indication of the complexity of the task confronting the data-processing unit can be seen by briefly considering some of the functions it must perform. In addition to storing, retrieving, and smoothing data, it must execute coordinate transformations, predict vehicle trajectories, compute launch-vehicle cutoff conditions, and generate guidance commands. And

MEASUREMENT ACCURACIES FOR TYPICAL PARKING-ORBIT INSERTION

Insertion Parameters	Measurement Uncertainties	Orbit Uncertainties
$x = 1.13 \times 10^6$ ft (east)	$\Delta x = 4.9$ ft	Period, $\Delta t = 0.2$ sec
$y = -1.721 \times 10^6$ ft (north)	$\Delta y = 5.09$ ft	
$z = 0.583 \times 10^6$ ft	$\Delta z = 10.0$ ft	Eccentricity, $e = 2.7 \times 10^{-5}$
$\dot{x} = 20{,}651$ fps	$\Delta \dot{x} = 0.10$ fps	
$\dot{y} = 12{,}633$ fps	$\Delta \dot{y} = 0.10$ fps	Altitude, $\Delta h = 1400$ ft
$z = -978$ fps	$\Delta \dot{z} = 0.355$ fps	

INSERTION ACCURACIES FOR DIRECT-ASCENT TRAJECTORY

Ascent Cutoff Parameters	Measurement Uncertainties at Cutoff*	Propagated Uncertainties at Apogee*
$x = 0$ ft (cross range)	$\Delta x = 5.4$ ft	$\Delta x = 185$ ft
$y = 1.119 \times 10^6$ ft (down-range)	$\Delta y = 0.6$ ft	$\Delta y = 30$ ft
$z = 0.426 \times 10^6$ ft	$\Delta z = 14.5$ ft	$\Delta z = 1350$ ft
$\dot{x} = 0$ fps	$\Delta \dot{x} = 0.11$ fps	$\Delta \dot{x} = 0.15$ fps
$\dot{y} = 25{,}213$ fps	$\Delta \dot{y} = 0.04$ fps	$\Delta \dot{y} = 0.10$ fps
$\dot{z} = -717.5$ fps	$\Delta \dot{z} = 0.62$ fps	$\Delta \dot{z} = 0.73$ fps

* A 0.5 probability ellipsoid.

this must be done very rapidly, accurately, and reliably.

One simplified example of the equations to be solved concerns the prediction of station position and velocity. Based on the station's orbital eccentricity (e) and semi-major axis length (a), its geocentric altitude, true anomaly and velocity are given by

$$R = a(1-e\cos E)$$

$$\theta = \frac{\cos E - e}{1 - e\cos E}$$

$$V = \sqrt{\mu\left(\frac{2}{R} - \frac{1}{a}\right)}$$

where the eccentric anomaly (E) is determined from Kepler's equation: $M = E - e \sin E$ and the mean anomaly (M) is a function of the semi-major axis, the earth gravitational constant (μ), and the time.

The station position and velocity are used to determine desired ferry position and velocity values, which in turn are employed in the computation of the required launch-vehicle cutoff conditions. Consider the two-dimensional case where the ferry apogee velocity (V_a), altitude (R_a), and angular position (θ_m) are given. The required cutoff values of altitude, velocity, and path angle result from

$$R_c = \frac{V_a^2 R_a^2}{\mu(1-e\cos\theta_m)}$$

$$V_c = \sqrt{2\mu\left(\frac{R_a - R_c}{R_a R_c}\right) + V_a^2}$$

$$\beta_c = \sin^{-1}\left(\frac{R_a V_a}{R_c V_c}\right)$$

This is a basis for deriving guidance commands, but the actual determinations are extremely complex because they must account for constraints on energy, turning rates, vehicle attitude, and many other physical limits. A complete error analysis is a very complex task requiring specific trajectory and vehicle parameters. This is far beyond our scope here. However, we can expect that it will be imperative that the measurements supplied to the data-processing unit should be as precise as possible.

As an example of measurement uncertainties alone, assume a Mistram located at Cape Canaveral and a trajectory directed southeast with cutoff altitude at 75 n. mi. and range 180 n. mi. Apogee altitude will be 500 n. mi. In the table at top here Column 1 gives typical ascent cutoff parameters and Column 2 gives the cutoff measurement accuracies.

The tracking uncertainties, at ascent cutoff, propagate throughout the ballistic midcourse trajectory, resulting in a larger error volume at the initiation of orbital insertion. There are numerous techniques for analytically propagating these errors. One of these has been applied to a representative direct-ascent trajectory, and the results are shown in Column 3 of the table at top here.

Assuming no further ground-based data, the insertion into a near coorbit is accomplished by onboard navigation equipment. Using state-of-the-art inertial equipments (a 0.5 deg attitude horizon scanner reference and 1×10^{-5} accelerometers) calibrated by radio data after ascent cutoff, final insertion errors can be held to less than 10 fps in velocity, 1 n. mi. in position, and 0.1 deg in velocity angle. Thus the final acquisition and docking maneuver is within the capabilities of a pilot.[3]

The mission can be enhanced if final rendezvous can be accomplished within range of a Mistram station. As mentioned previously, measurement accuracies will be less than ±10 ft in relative position and less than ±0.5 fps in relative velocity. These are real-time accuracies. Thus, homing data can be computed, transmitted, and displayed to the pilot should some failures occur in onboard navigational equipment.

These accuracies also apply in many orbital transfer maneuvers. Suppose there are two vehicles in different period orbits with nearly equal inclination angles. It is very likely that one Mistram station can measure both of these orbits with almost identical geometry. Thus, station and ferry ephemerides can be predicted to a high precision, and the optimum transfer time and ferry Δv can be precisely determined. The velocity required for transfer could be of the order of a horizontal Δv of 100 fps. This transfer can be achieved accurately with relatively crude onboard equipment if calibrated by a ground-support station.

In conclusion, let us briefly look at a possible next step. Assume that by rendezvous we have assembled a manned vehicle destined for a soft landing on the moon.[4] Typical lunar insertion parameters are velocity = 35,080 fps, altitude = 300 n. mi., and angle relative to local horizon = 14.2 deg. The accuracies given on page 49, assuming a typical insertion geometry, can be converted to a velocity-magnitude accuracy of ±0.14 fps and a velocity-angle accuracy of ±0.001 deg. Assuming no control or geometry errors, the lunar C.E.P. would be less than 10 n. mi.

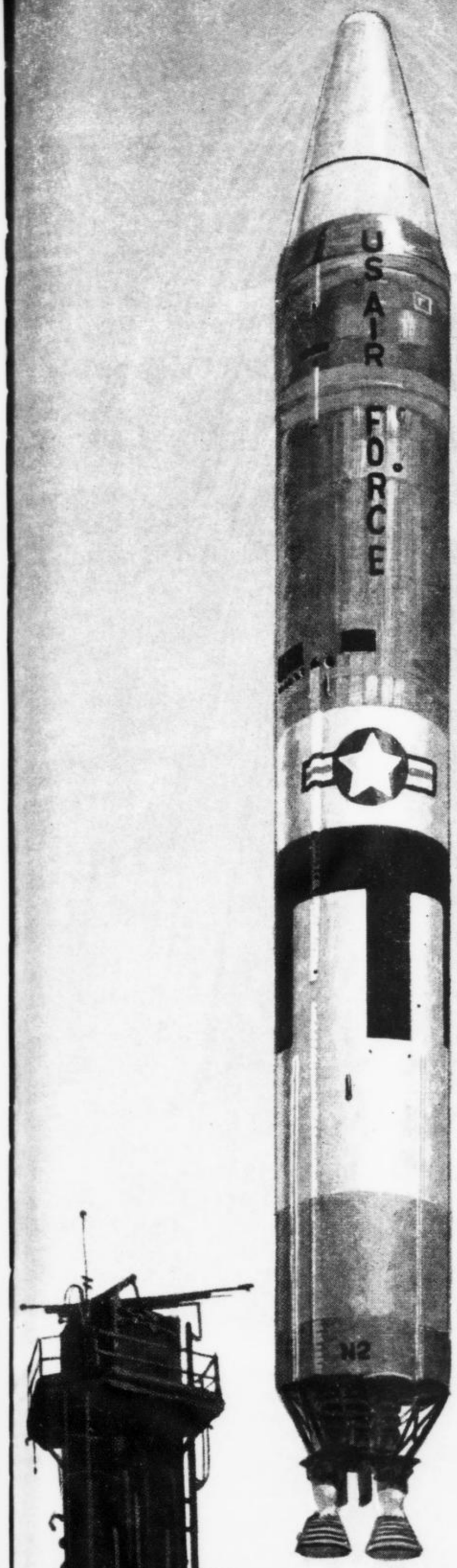
Moreover, the position of the moon relative to the earth is known to an accuracy of roughly 50 n. mi. The position of a Mistram beacon on the moon relative to an earth station can be measured to an accuracy of $^1/_2$ n. mi. There is much we can learn through a precision measurement system and a transponder in space.

References

1. "Precision Radio Tracking of Space Vehicles" by C. R. Woods and E. B. Mullen, ARS Guidance and Control Conference, 1961.
2. "A Guidance Technique for Achieving Rendezvous" by Fellman and Sears, MIT, presented at ARS-IAS Manned Space Station Symposium, 1960.
3. "Visual Control of Rendezvous" by Brissenden and Lineberry, presented at IAS 30th annual meeting, 1962, Paper No. 62-42.
4. "Electronic Support for Flight Crew Safety on Manned Lunar Missions" by R. S. Grisetti, H. Lehmann, and R. A. Heartz, presented at IAS 30th annual meeting, 1962. Paper No. 62-77. ♦♦







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On the calendar

1962

July 12–13	12th General Assembly, NATO Advisory Group for Aeronautical Research and Development, Paris, France.
July 17–19	**ARS Lunar Missions Meeting, Pick-Carter and Statler-Hilton Hotels, Cleveland, Ohio.**
Aug. 8–10	1962 Standards Laboratory Conference, National Bureau of Standards Boulder Laboratories, Boulder, Colo.
Aug. 13–16	7th Symposium on Ballistic Missile and Space Technology, U.S. Air Force Academy, Colorado Springs, Colo. Sponsored by USAF and Aerospace Corp.
Aug. 13–17	Conference on Lunar Exploration sponsored by NSF, NASA Langley Research Center, and Virginia Polytechnic Institute, VPI, Blacksburg, Va.
Aug. 14–16	International Conference on Precision Electromagnetic Measurements, National Bureau of Standards Boulder Laboratories, Boulder, Colo.
Aug. 14–16	Cryogenic Engineering Conference, Univ. of California, Los Angeles, Calif.
Aug. 15–17	**ARS, ANS, IAS Nuclear Propulsion Conference, U.S. Naval Postgraduate School, Monterey, Calif.**
Aug. 15–17	3rd International Electronic Circuit Packaging Symposium, Univ. of Colorado, Boulder, Colo.
Aug. 21–24	IRE Western Electronics Show and Conference, Los Angeles, Calif.
Aug. 21–24	International Symposium on Far Infrared Spectroscopy, Sheraton Gibson Hotel, Cincinnati, Ohio. Sponsored by Air Force Systems Command, Materials Central, Aeronautical Systems Div.
Aug. 27–29	AIME Technical Conference on Advanced Electronics Materials, Benjamin Franklin Hotel, Philadelphia, Pa.
Aug. 27–31	4th International Symposium on Space Technology and Science sponsored by Japanese Rocket Society, Nippon Toshi Center, Tokyo.
Aug. 27–Sept. 1	3rd International Congress, International Council of the Aeronautical Sciences, New Congress Hall, Stockholm, Sweden.
Aug. 27–Sept. 1	2nd International Congress on Information Processing of International Federation of Information Processing, Munich, Germany.
Aug. 28–30	4th Conference on Maintainability of Electronic Equipment, Electronic Industries Assn. Univ. of Colorado, Boulder, Colo. Sponsored by Electronic Industries Assn., with Dept. of Defense cooperation.
Sept. 10–14	National Conference on Applied Meteorology, Chamberlin Hotel, Hampton, Va.
Sept. 20–23	Rocketry and Astronautics, Koblenz on Rhine, W. Germany, sponsored by German Rocket Society.
Sept. 23–29	**XIIIth International Astronautical Congress, Sofia, Bulgaria.**
Sept. 25–28	**ARS Space Power Systems Conference, Miramar Hotel, Santa Monica, Calif.**
Oct. 8–10	18th Annual National Electronics Conference and Exhibition, McCormick Place, Chicago, Ill.
Oct. 10–12	**ARS Ions in Flames and Rocket Exhausts Conference, Palm Springs, Calif.**
Oct. 26–27	17th Midwest Quality Control Conference on American Society for Quality Control, Denver Hilton Hotel, Colo.
Oct. 29–31	Symposium on Dynamics of Manned Lifting Planetary Entry, Philadelphia, Pa. Sponsored by General Electric MSVD, Valley Forge Space Technology Center and AFOSR.
Oct. 29–Nov. 2	International Symposium on Basic Environmental Problems of Man in Space, Paris sponsored by IAF and IAA with UNESCO, International Atomic Energy Agency, and World Health Organization.
Nov. 5–7	Symposium on Protection Against Radiation Hazards in Space, Gatlinburg, Tenn. Sponsored by Oakridge National Lab and NASA.
Nov. 13–18	**17th Annual Meeting and Space Flight Exposition, Pan Pacific Auditorium, Los Angeles, Calif.**
Dec. 4–6	1962 Fall Joint Computer Conference, Sheraton Hotel, New York, N.Y. Philadelphia, Pa. Sponsored by American Federation of Information Processing Societies.
Dec. 26–31	**Space Physics—AAAS, Philadelphia, Pa.**

1963

Jan. 22–24	9th National Symposium on Reliability and Quality Control, Sheraton-Palace Hotel, San Francisco, Calif.
April 17–19	AIEE/IRE International Conference on Nonlinear Magnetics, Shoreham Hotel, Washington, D.C.
May 20–23	International Symposium on Humidity and Moisture—Measurement and Control In Science and Industry, Sheraton-Park Hotel, Washington, D.C.

This summer one of the most versatile scientific experiments ever assembled will be flown as the Mariner P-37 and P-38 spacecraft in

Venus Mission—1962

BY ROBERT C. WYCKOFF

JET PROPULSION LABORATORY, PASADENA, CALIF.

THIS SUMMER, under NASA sponsorship, the Jet Propulsion Laboratory plans to send the first of a series of scientifically instrumented spacecraft to the planet Venus. For reliability and coverage, this Venus-probe mission will comprise two identical spacecraft—Mariners P-37 and P-38—which will be capable of making a close approach to the planet. The mission has three primary objectives:

- Launching a spacecraft to the vicinity of Venus.
- Communication with the spacecraft in the vicinity of this planet.
- Performing a Venus-oriented scientific experiment and others oriented toward interplanetary space.

Experiments fall into three areas:

1. Close to Venus, to give information about it and its atmosphere.
2. In the vicinity of Venus, to give information on its environment out to about 10 or 20 planetary radii.
3. Between earth and Venus.

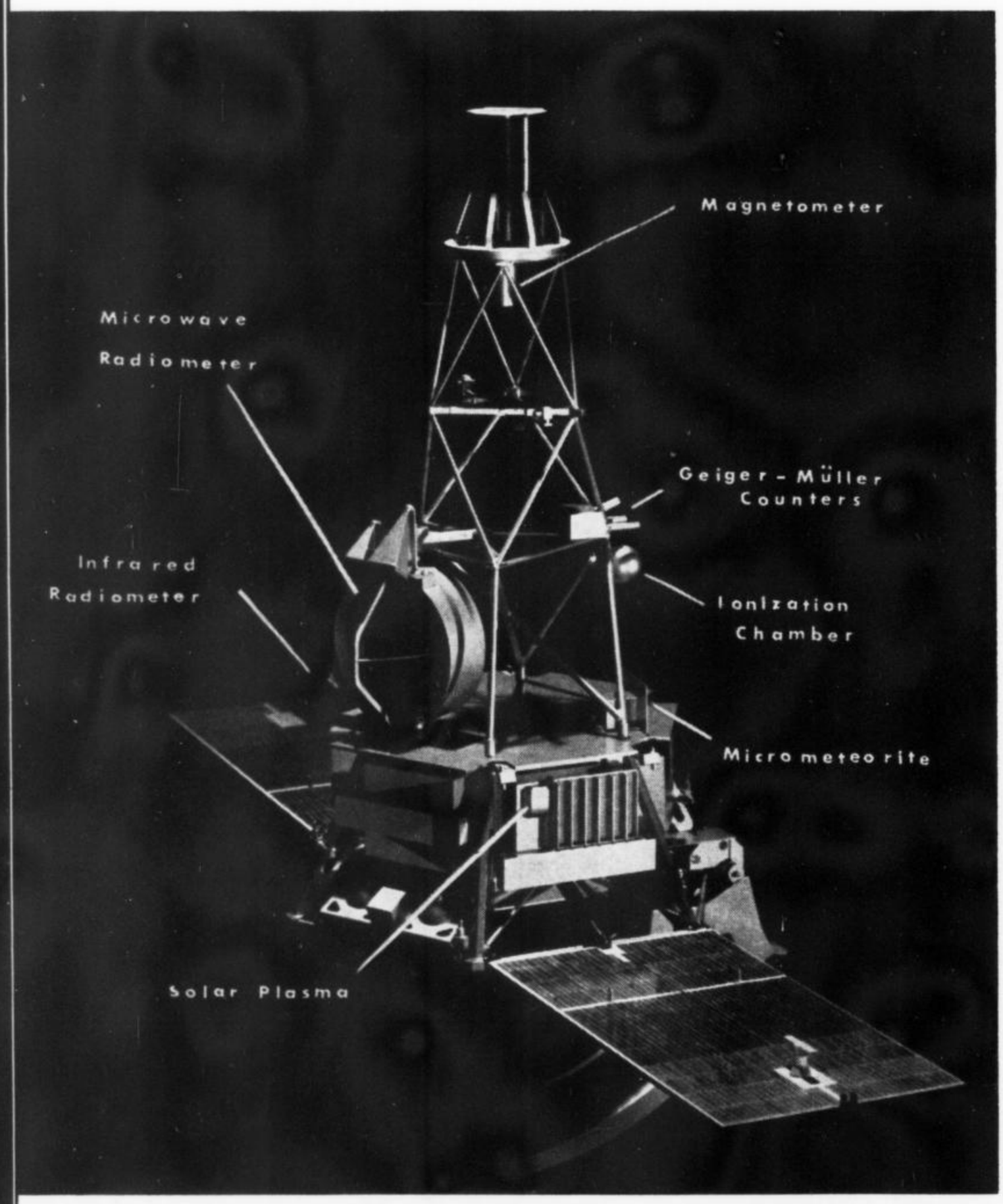
Area 1 experiments involve a microwave and an infrared (IR) radiometer. Areas 2 and 3 involve a magnetometer and various instruments to measure the flux of charged particles and the spatial and temporal density of cosmic dust.

Dynamic range of the interplanetary experiments will permit investigation of phenomena caused by solar disturbances, besides the quiescent interplanetary environment.

In addition, since the mission will extend over a radial distance of some 0.3 A. U., there will be the opportunity to measure any radial variation of the interplanetary magnetic field and charged-particle flux. The possibility of making simultaneous measurements of these quantities on two spacecraft widely separated in space, and at varying distances from the sun and at different solar longitudes, is extremely interesting scientifically. The results of such measurements may well play a crucial part in understanding the origin of these phenomena, the mechanism of their propagation, and their spatial and temporal variations.

Seven distinct scientific experiments will be flown in the mission, as called out on the Mariner model on this page. They have been proposed by and are under the direction of scientists from the Army Ordnance Missile Command, the Univ. of California-Berkeley, CalTech, NASA Goddard SFC, Harvard Observatory, State Univ. of Iowa, JPL, MIT, State Univ. of Nevada, and NASA Headquarters.

Placement of experiments on Mariner for this summer's Venus flyby.



As might be imagined, the most important are the radiometric experiments, designed to give data on the planet and its atmosphere.

Microwave Radiometer. Venus' surface temperature and the nature of its atmosphere stand high among the most interesting and puzzling questions in the entire field of planetary astronomy. Direct experimental evidence bearing on them is meager and in certain respects contradictory. Experiments that may resolve these questions were considered first.

Temperature measurements of Venus have been made from earth by both IR and microwave techniques. The microwave measurements give consistently higher values. The combined graph and table at the right summarize results of these observations over the wavelength range 0.4 to 21 cm.[1-14]

The IR radiometric observations of Petit and Nicholson,[15] in the 8- to 13-micron terrestrial window, and of Sinton and Strong[16] indicate a temperature near 235 K, which presumably refers to a region near the top of Venus' cloud layer.

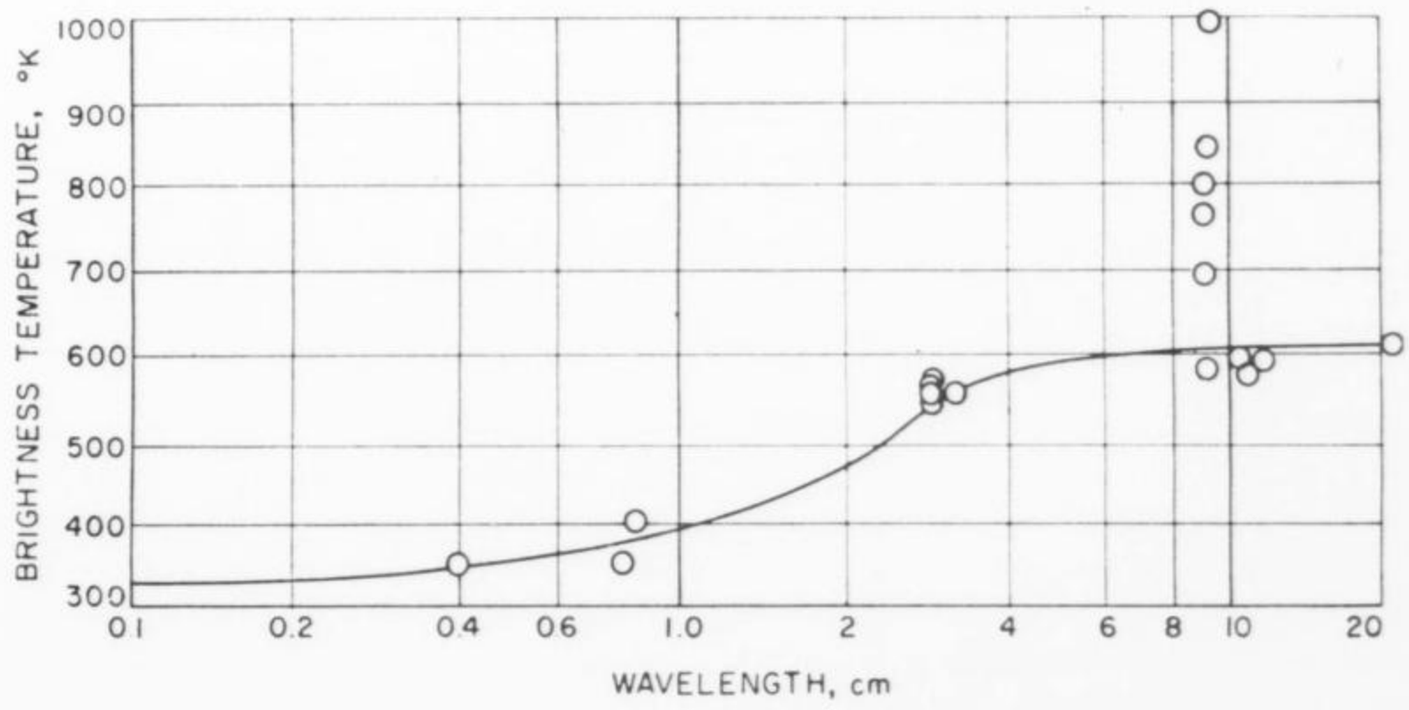
The temperature from the spectroscopic rotational band analysis of the 7820 Å CO_2 band is about 285 K, based on Chandrasekhar's radiation-transfer theory.[17] A direct application of the Boltzmann theory gives a temperature of over 300 K.[18] These temperatures probably refer to the top of the visible cloud layer or below. The microwave data, which give temperatures hundreds of degrees higher, obviously refer to quite a different region, most probably Venus' surface.

The IR temperature measurements indicate a very small difference between the dark and light portions of the planetary disk, but there is strong evidence that this does not hold for microwave measurements. At the same inferior conjunction, some investigators have found a distinct phase effect, while others have not. Even more puzzling, the same investigators have found a phase effect at one conjunction but not at another. Moreover, the Russians find a day-to-day variation of as much as 100 to 150 K.[11]

All-in-all, the question of Venus' surface temperature and atmospheric composition is in great turmoil; and a number of atmospheric models have been formulated. The Mariner microwave and IR radiometric experiments should allow either a distinction among existing atmospheric models or formulation of the correct one. The surface temperature of Venus is of most popular interest. It is hoped that this, in addition to other knowledge of the nature of our mysterious neighbor, will be gained.

MICROWAVE BRIGHTNESS-TEMPERATURE MEASUREMENTS OF VENUS

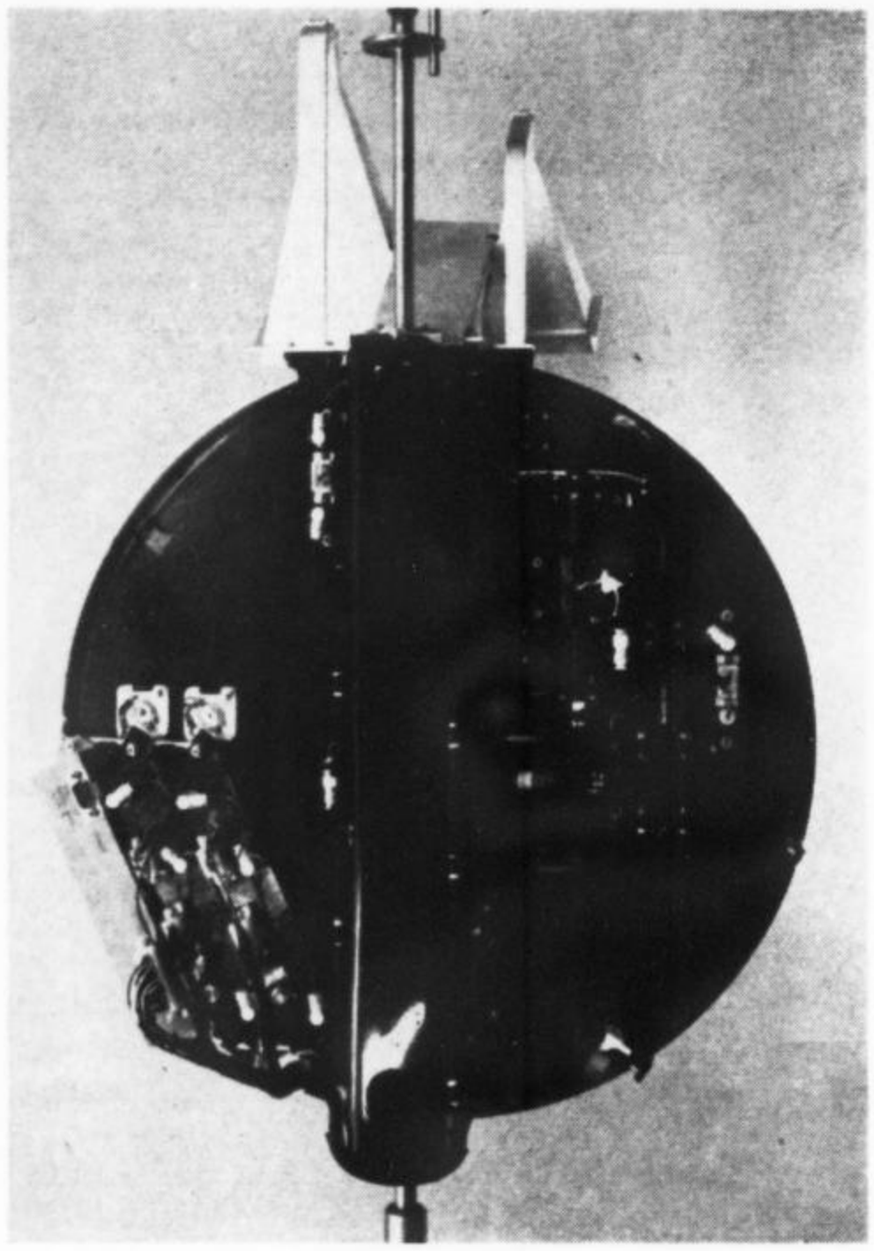
Wavelength, cm	Brightness Temp., K	Date of Observation	Reference
3.15	560 ± 73	May 5–June 23, 1956	1, 2
9.4	580 ± 160	June 24–July 27, 1956	1, 2
0.86	410 ± 160	Jan. 29–Feb. 5, 6, 11, 1958	3
3.4	575 ± 60	Feb. 12–March 5, 1958	4
3.37	575 ± 58	April 18–April 19, 1958	5, 6
0.80	3.5 ± 70	Sept. 18, 1959	7
3.75	573 ± 28	July 7–Oct. 4, 1959	8
10.2	600 ± 65	Sept. 17–Oct. 10, 1959	4
0.4	350 ± 50	1961	9
3.15	550 to 620	April–June 1961	10
9.6	850 ± 50	April 3, 1961	11
—	1000 ± 150	April 4, 1961	11
—	700 ± 100	April 5, 1961	11
—	775 ± 70	April 21, 1961	11
—	800 ± 50	April 22, 1961	11
10.2	580 ± 636	April–July 1961	12
12.5	590 ± 200	1961	13
21	630 ± 130	March 8, 9, 10, 13, 1961	14

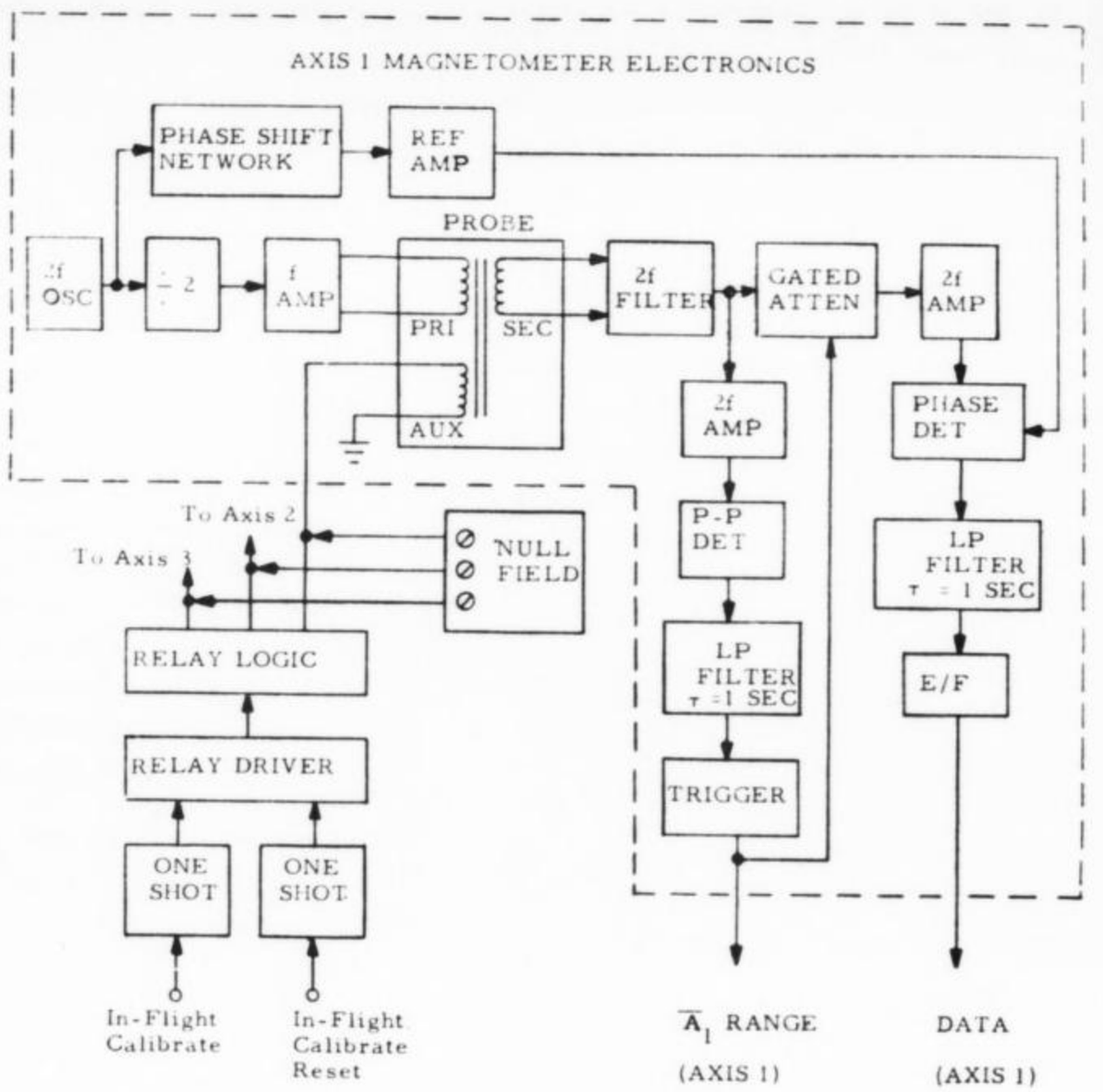


IDEALLY WE should make microwave measurements at as many wavelengths as possible, so as to determine the form of the wavelength-vs.-temperature curve in the transition region from short-mm to short-cm wavelengths (see graph with table at top here). Sufficiently small angular resolution, coupled with an appropriate scan pattern, will allow the planetary disc to be scanned across the terminator. Thus any phase effect can be determined, as well as any changes in temperature and emissivity over the surface. It is expected that the longer of two wavelengths selected—13.5 and 19 mm—will get through the atmosphere from the surface. Weight and power limitations do not allow the inclusion of more than these two wavelengths.

The photo on page 56 shows a rear view of the microwave radiometer, a crystal video type, which does not tie up weight in RF mixers or IF amplifiers. This instrument should give an rms noise level less than 3% of the expected antenna temperature.

One antenna will operate simultaneously at both wavelengths. It will be calibrated through a secondary standard in the form of a noise discharge tube, combined with a cold space reading. The antenna beam widths are 2.2 and 2.5 deg, respectively, at the 13.5- and 19-mm wavelengths. Sidelobe power due to energy from the sun will be negligibly low compared with the planet's. The output signal can range between +1 and +6 v DC with the zero temperature level set at +1 v and the +6-v level corresponding to a temperature of 1000 K. The voltage fluctuations





NOTE: Functions in phantom are triplicated.

If all goes well, results from the spacecraft's microwave and infrared radiometer experiments will give the true surface temperature of Venus and allow a sounder hypothetical description of the planet. Left, the microwave radiometer as seen from the rear; and right, a block diagram of its electronics.

at the output correspond to about 50 K peak to peak.

This radiometer will begin to operate a few hours before the spacecraft's closest approach to Venus. It will first run a searching pattern 60 deg above and 60 deg below a plane defined by the earth, spacecraft, and the sun—a plane approximately parallel to the ecliptic and perpendicular to the spacecraft-sun vector. The initial scan rate will be a degree a second. As the spacecraft approaches the planet, the microwave-radiometer antenna beam will contact the near planetary limb. Then the scan rate will drop to 0.1 deg/sec; and when the antenna beam has passed 5 deg off the limb, the scan direction will reverse. This reduced and "locked-on" scan pattern then continues until the planetary disc is lost through the motion of the spacecraft.

If the planetary disc is accidently lost during this slow scan mode, provision is made for a return to the initial fast scan-search mode until the disc is again acquired. Thus a sinusoidal-like path will be scanned on both the light and dark parts of the planetary disc, the number of periods of which will depend on the distance the spacecraft passes the planet.

IR Radiometer. This completes the experimental package designed to obtain information on Venus' radiation. IR radiation can come from the planetary surface, clouds in the atmosphere, or a combination of both. Two wavelength regions will be investigated—8 to 9 microns and 10 to 10.8 microns. A higher angular resolution will be possible with this experiment than with earth-based ones, and this should help detect any fine cloud-layer structure above a certain minimum.

Earth-based measurements indicate a Venus temperature in the 8- to 13-micron region of about 235 K, with a short-term (daily) fluctuation.[16,19] In the 8- to 9-micron region, the common gases are fairly transparent at temperatures of 200–300 K. A CO_2 absorption band that has been detected in Venus' spectrum centers at 10.4 microns.

The two wavelength channels observe the same area on the planet.

If radiation comes entirely from the cloud tops, the effective temperatures derived from the two channels will be the same, after appropriate corrections for any CO_2 above the cloud layer. A 1% break in a 235-K cloud cover over a 600-K surface will change the energy in the 8- to 9-micron channel by a factor of 2, while the CO_2 absorption in the 10- to 10.8-micron channel will lead to a smaller energy change.

The IR radiometer attaches rigidly to the microwave radiometer antenna, with optic and antenna axes aligned parallel, and so follows the scan pattern of the microwave radiometer. It will be turned on at the same time as the microwave radiometer. Its angular field of view is a 0.9-deg square. The detectors are uncooled, germanium-immersed thermistor bolometers with a sensitive area of 0.15 by 0.15 mm. The $f/2.4$ optical system utilizes a germanium objective. The incident beam is chopped at a frequency of 20 cps, which alternately allows the detectors to see the planet and free space through a similar optical system but with its axis displaced 45 deg from the other.

After being chopped, the beam is split into two perpendicular beams by a dichroic filter. Appropriate filters then define the two wavelength regions. A schematic diagram of the instrumentation appears on page 57. At the end of each complete fast-scan sweep, the IR detectors view a plate at a known temperature on the spacecraft superstructure and thus can be calibrated.

Magnetometer. There is practically no direct experimental evidence of a magnetic field for the planet Venus. The most commonly accepted explanation of the origin of a planetary magnetic field involves fluid motion in a fluid planetary core. Detecting a magnetic field for Venus would play an important part in determining the origin and nature of the planetary interior. Moreover, the properties and dynamics of the atmosphere in relation to charged particles, magnetic storms, and auroras depend heavily on knowledge of any magnetic field.

Whether Venus has a magnetic field can be established by observing a transition region from interplanetary space to the immediate vicinity of the planet. This transition, called the magnetopause, separates a planetary magnetic field from the ionized component of the interplanetary medium. It is thought that a planetry magnetic field, owing to the so-called "solar wind," will be distorted in the radial direction to the sun, being compressed toward the sun and elongated away from it.[20-23] Thus a planetary magnetic field appears to be confined to a sort of streamlined cavity inside the interplanetary gas. Observation of such a boundary would constitute evidence of a planetary magnetic field. In addition, the magnitude inside such a boundary and the distance from the planet would permit an estimate of the magnetic field at the surface, assuming a known origin.

The Venus-probe magnetometer will allow direct measurements to be made of the interplanetary magnetic field, its variations with distance from the sun, short-term variations caused by solar activity.

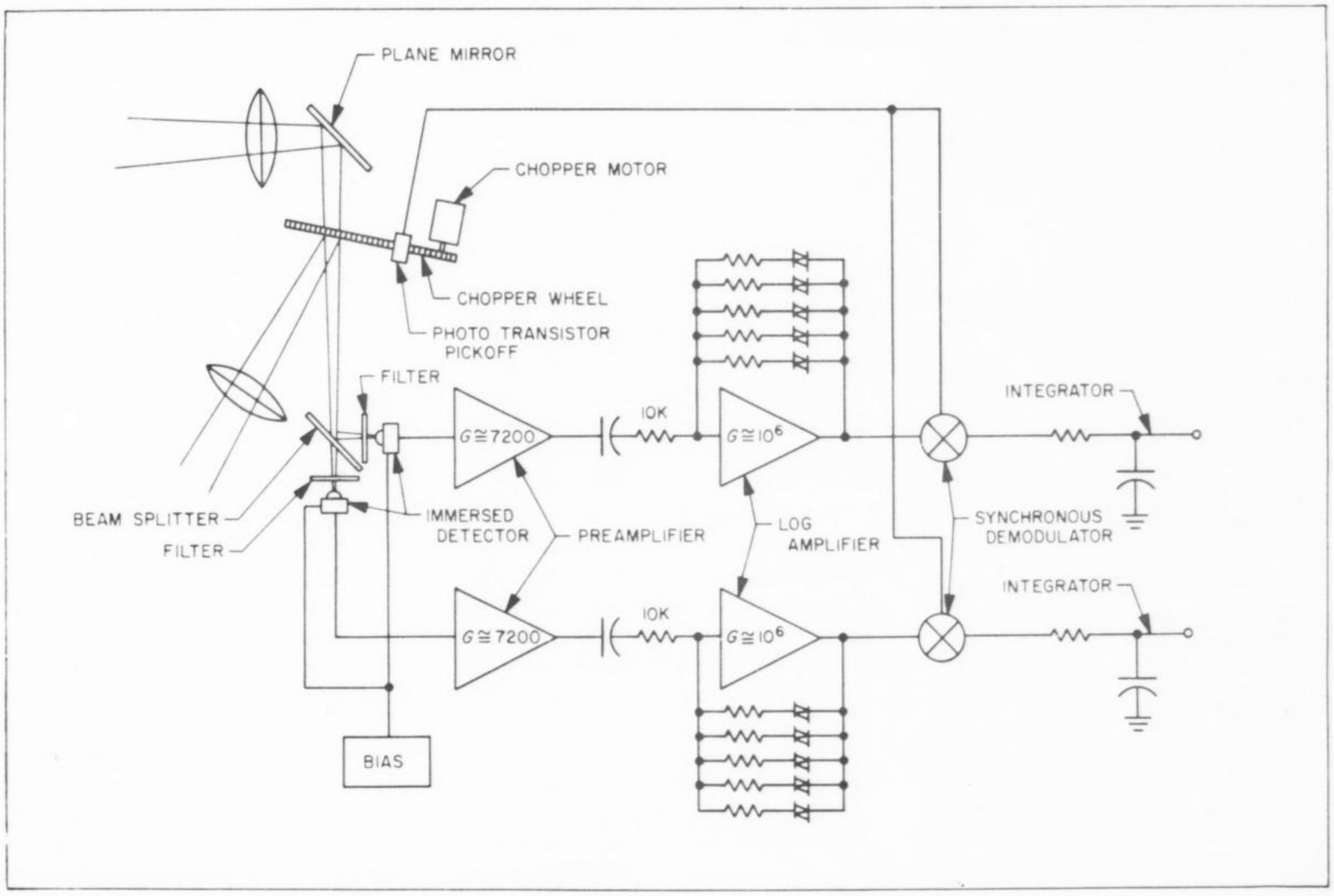
SHOWN DIAGRAMMATICALLY on page 56, magnetometer, is a triaxial fluxgate type. The sensing element is a magnetic core containing primary and secondary windings. An alternating current of 20 kc/s is applied to the primary winding sufficient to saturate the core material. Any external magnetic field with a component parallel to the axis of the core then induces a signal in the secondary winding, which contains the second harmonic of the signal impressed on the primary winding. The amplitude of this second harmonic component is proportional to the magnitude of the external magnetic-field component.

The noise appearing in the magnetometer is equivalent to a fluctuating magnetic field of approximately 0.25 gamma (1 gamma = 10^{-5} oersted). There are two scale ranges, 0 to ±64 gamma and 0 to ±320 gamma. On the low range the sensitivity is about 0.6 gamma. A system of coils surrounds each sensor, by which the component of any induced or permanent field of the spacecraft can be counteracted. These coils can "compensate" for a magnetic field component up to 100 gamma.

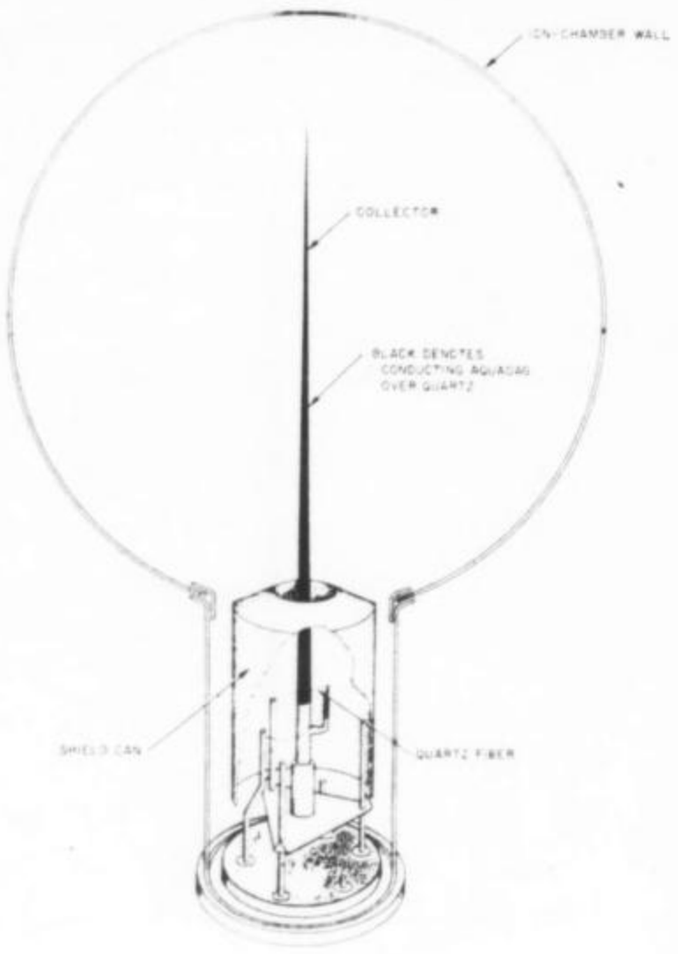
Charged-Particle-Flux Experiments. These experiments will allow measuring high-energy radiation for a long time over a significantly varying distance from the sun. They will be helpful in understanding the nature, origin, and behavior of this radiation. Three specific areas of interest will be investigated.

1. Variation with distance. This spatial variation of cosmic rays depends on the mechanism by which the sun's activity modulates both the frequency and intensity of this radiation

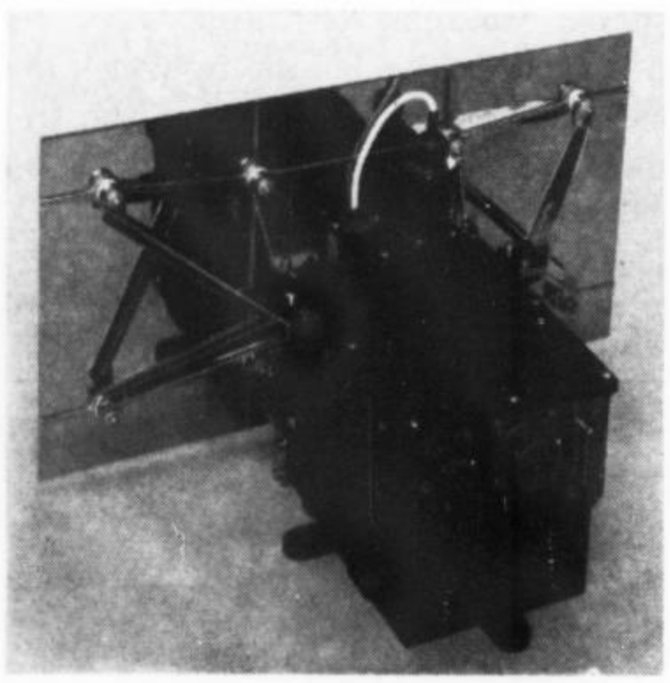
SCHEMATIC DIAGRAM OF THE INFRARED RADIOMETER



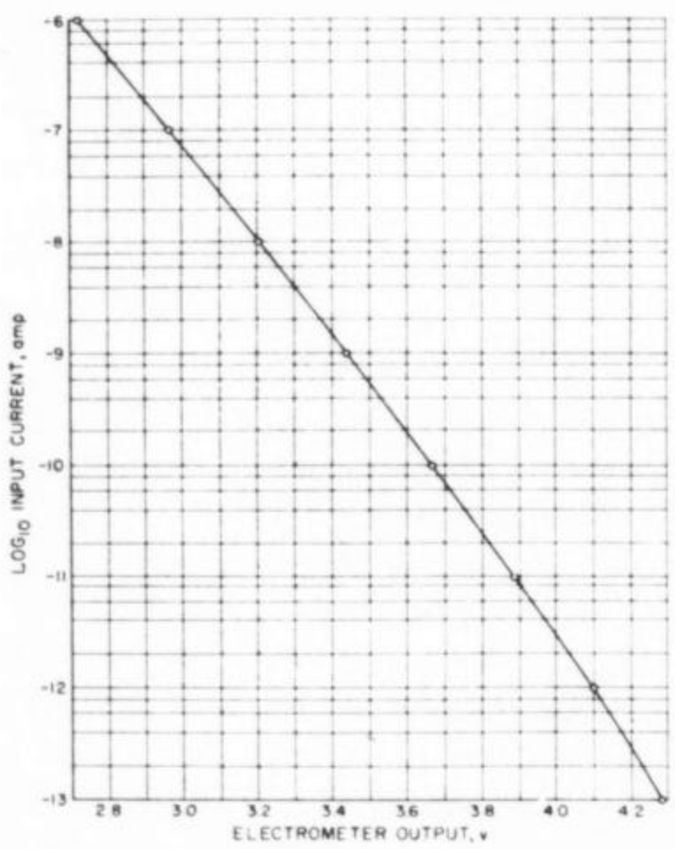
IONIZATION CHAMBER



MICROMETEORITE DETECTOR



ELECTROMETER CALIBRATION CURVE FOR SOLAR-PLASMA EXPERIMENT



and condition of the interplanetary medium.

2. Variation with time. The cosmic-ray intensity will vary at the spacecraft and at the earth during the same period of observation. This variation and the energies of the particles depend on the distribution of the magnetic field and plasma between the earth, the spacecraft, and the sun.

3. Any radiation trapped near Venus. This would depend on origin of the radiation and magnitude of any magnetic field of Venus.

A. *Ionization Chamber.* This instrument is of the Neher type and consists of a volume of argon gas considered in a spherical metal shell. An insulated collector extends into the gas as shown in the figure at top left. A potential is established between this collector and the shell. Any radiation penetrating into the gas produces ionization in the argon gas. Ions collect at the insulated collector and the shell, gradually reducing their potential difference. When the collector has been discharged to a certain level, it is automatically recharged.

Thus the number of times the collector recharges in any specified interval measures the rate of ionization of the argon gas. The collector is recharged after about 10^{-10} coulombs have been collected from the gas. The shell can be penetrated by protons of 10-Mev energy or greater and by electrons with energy greater than 0.5 Mev. For alpha particles the value is about 40 Mev. Electrons with less energy may still be detected through the bremsstrahlung process, with an efficiency depending on their energy.

The ionization of the gas is related to the recharging pulse frequency by the equation $I = k/\Delta t$ where k is a constant and Δt is the time between pulses. The instrument obeys this equation for a time region $5 \times 10^4 > \Delta t > 0.05$ sec to within about 2%.

The instrument will give measurements with the Δt as small as 0.01 sec. Ionization due to galactic cosmic rays probably lies between 100 and 1500 ion pairs $cm^{-3}sec^{-1}atm^{-1}$. The ionization may rise to more than 400,000 ion pairs during a solar flare. Corresponding values of Δt are 3600, 240, and 0.9 sec.

B. *Geiger-Mueller Counters.* In contrast to the ionization chamber, these well-known devices produce a current pulse every time a charged particle traverses any part of their sensitive volume. The pulse rate is thus proportional to the number of charged particles encountered. Triggering the counters will be primary particles that penetrate its walls, secondary particles produced in its walls and gas, and secondary particles produced in the adjacent material of the spacecraft.

Two RCL 10311 G-M counters and one Anton 213 are being flown on this mission. The RCL 10311's are shielded so as to detect protons with energies of 10 Mev and 0.5 Mev for electrons. Differently shielded, these two counters will allow a distinction to be made between protons and electrons through the bremsstrahlung effect in each tube. It is expected that the galactic cosmic-ray background will produce about 15 counts/sec. The RCL counters have a maximum counting rate of 45,000 sec^{-1}.

THE ANTON 213 G-M counter, an end-window type, admits electrons with energies greater than 40 Kev and protons with energies greater than 0.5 Mev. A shield defines the solid angle of entrance to the window. The remainder of the tube is shielded so as to admit electrons with energies greater than 1 Mev and protons with energies greater than 20 Mev. The normal galactic cosmic-ray count with this tube should be about one count every 5 sec. Its maximum counting rate is 20,000 sec^{-1}, which corresponds to a maximum resolvable rate of about 10^7 true counts per sec. This tube is mounted so that the window cannot view the sun.

Cosmic Dust Experiment. A knowledge of spatial and temporal density of cosmic dust between earth and Venus will be of great importance both for design of future manned and unmanned spacecraft and for understanding the sources and dynamics of these interplanetary particles. This experiment aims to measure cosmic dust as a function of direction, distance from the sun, and momentum with respect to the spacecraft. In addition, it is desired to investigate any concentration of these particles into streams. Pronounced time variations of the particle flux near the earth have been reported.[24,25] Concentrations of cosmic dust are thought to be dispersed by the Poynting-Robertson and other drag effects, as well as by the cumulative effects of small differences

in the orbital elements of the individual particles. Thus any large concentration of particles will probably be of relatively recent origin.

The instrumentation consists of a crystal-transducer microphone attached to the center of a flat rectangular plate. The microphone is tuned to 100 kc/s, with an over-all gain of 100 db. A binary counter records this amplifier's pulse rate. A second binary counter receives its input from a point in the amplifier of 20-db-less gain. The threshold sensitivity of the detector varies as a function of the impact location on the plate, and lies between 0.9×10^{-4} and 1.1×10^{-4} dyne sec over 99% of the exposed area of the plate, with the heater sensitivity at the center over the microphone. The flux values measurable lie betwen 1.5 and 2.8 impacts m^{-2} sec^{-1}.

Solar Plasma. This experiment is designed to measure the flux and energy spectrum of the *positively charged* component of streams of solar plasma which may be moving radially outward from the sun. The existence of this solar plasma, or "wind," has been of course a fairly recent discovery and the mechanism of its origin and the dynamics of its movement are of the greatest importance. The results from the magnetometer experiment must be considered in the analysis and interpretation of this experiment.

The instrument is a charged-particle spectrometer with a logarithmic response covering the range of energies from 240 to 8400 ev for protons.

The plasma analyzer consists of a pair of curved plates, electrically charged with respect to each other, that selects the charged particles of desired energy, a Faraday cup which collects the charge of the particles traversing the electrostatic field between the plates, an electrometer circuit for measuring the current due to this collected charge, and a high-voltage generating system which applies voltages in sequence to the analyzer plates. The plates have an angular length of 120 deg with radii of curvature of 3.97 and 4.50 in.

The analyzer has, effectively, a 10-deg angular resolution and a 12% energy resolution. The high-voltage supply is programmed to apply 10 progressively greater deflecting voltages to the plates. The electrometer circuit, utilizing logarithmic feedback, can measure currents from 10^{-6} to 10^{-13} amp—a fair dynamic range.

A typical calibration curve appears on page 58. The linearity of the response over this dynamic range is remarkable. Provision is made for a "zero current" measurement by holding both collecting plates at zero voltage, as well as for a calibrating current of 10^{-10} amp fed directly to the electrometer input through a constant-current source.

We will always want to fly more equipment, and more complex equipment, than circumstances permit. For the Mariner mission to Venus this year we have designed a logical, integrated payload with the emphasis allocated according to the importance of the scientific questions to be asked, and the expectation of getting the answers. Mariners P-37 and P-38 represent one of the most versatile scientific experiments ever assembled.

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Acknowledgment

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People in the news

ARS President **William H. Pickering,** director of the Jet Propulsion Laboratory in Pasadena, Calif., was selected for membership in the National Academy of Sciences, April 24, 1962. The National Academy of Sciences is a private agency, founded in 1863 by Abraham Lincoln, whose members are distinguished scientists from all branches of the natural sciences. It is dedicated to the furtherance of science and its use for the general welfare.

John E. Masterson, ARS member and technical consultant for meteorology at the Pacific Missile Range, has been named to the National Academy of Sciences' Space Science Board's new High Altitude Rocket and Balloon Research Committee.

Rodney D. Stewart, an ARS member, has been designated project manager at the Marshall Space Flight Center for NASA's Liquid Hydrogen/Liquid Oxygen M-1 rocket engine. Prior to this assignment, he was project engineer on the F-1 rocket engine at MSFC.

Raymond L. Bisplinghoff, ARS member and formerly professor of aeronautical engineering at MIT, has been appointed director of NASA's Office of Advanced Research and Technology. In other appointments, **John R. Biggs,** former director, procurement, NASA Lewis Research Center, has been named to head NASA's new on-site management unit at the Space and Information Systems Div., North American Aviation-Downey. **George A. Lemke** becomes Apollo project office representative at Downey for NASA's Manned Spacecraft Center and **Donald Bowden,** Saturn project office representative for Marshall SFC.

Donnell Rhody has been promoted from manager to director, project planning, Aircraft-Missiles Div., Fairchild Stratos.

J. A. Jamieson has joined Aerojet-General as manager of research, Astrionics Div.

John Stack, former NASA director of aeronautical research, has joined Republic Aviation as vice president and director of engineering. **Alexander Kartveli,** an ARS Senior Member and one of the original members of Republic when it was known as the Seversky Aircraft Corp., retired June 1 from his position as vice president, research and development, ending a career of more than three decades during which Kartveli-designed combat planes were front-line weapons in WW II and Korea.

Donald T. Perkins, an ARS member, has been named scientific adviser and chief of research and technology at Lockheed-California Co.

Donald N. Griffin, an ARS Senior Member, has been appointed director of engineering, Pelmec Div. of Quantic Industries, Inc.

H. W. Jamieson, an ARS Senior Member, has been named chief executive officer and board chairman of the newly formed Jamieson Industries, Inc., Van Nuys, Calif. **E. J. Rehfeldt,** founder and former head of Transonic, Inc., has been appointed president.

F. C. Gorey and **W. L. Parker** have been named directors of engineering and marketing, respectively, Northrop's Nortronics Div.

Charles L. Bernier has been appointed director of the Armed Services Technical Information Agency (ASTIA).

Herbert Sukenik has been named chief of space medicine, Life Sciences Dept., Martin's Space Systems Div.

William W. Seifert, associate professor, electrical engineering, MIT, has been appointed to the new post of assistant dean of the School of Engineering.

Julius Lukasiewicz, chief, von Karman Gas Dynamics Facility, ARO, Inc., has been appointed an alternate member of the AGARD Fluid Dynamics Panel.

Wen Tsing Chow has been appointed manager, computer products, Arma Div., American Bosch Arma Corp.

Frederick J. Milford has been appointed assistant director, technical development, Battelle Memorial Institute.

Gerhard H. De Witz has been appointed chief engineer, Magnetic Research Corp. He formerly was manager, advanced systems engineering, Telecomputing Corp.

Charles S. Rockwell, an ARS member and president and general manager, Ford Instrument Co., has been elected president of the New York post, American Ordnance Assn. **Angelo Montani** has been named assistant to Rockwell.

Charles W. Newhall Jr., formerly president, Flight Refueling, Inc., has been appointed assistant to the president of Marquardt Corp.

Samuel Koslov, an ARS Senior Member and former professor of physics, Stevens Institute of Technology, has been appointed chief, physical sciences, Allied Research Asso-

(CONTINUED ON PAGE 63)



Stewart



Bisplinghoff



Rhody



Stack



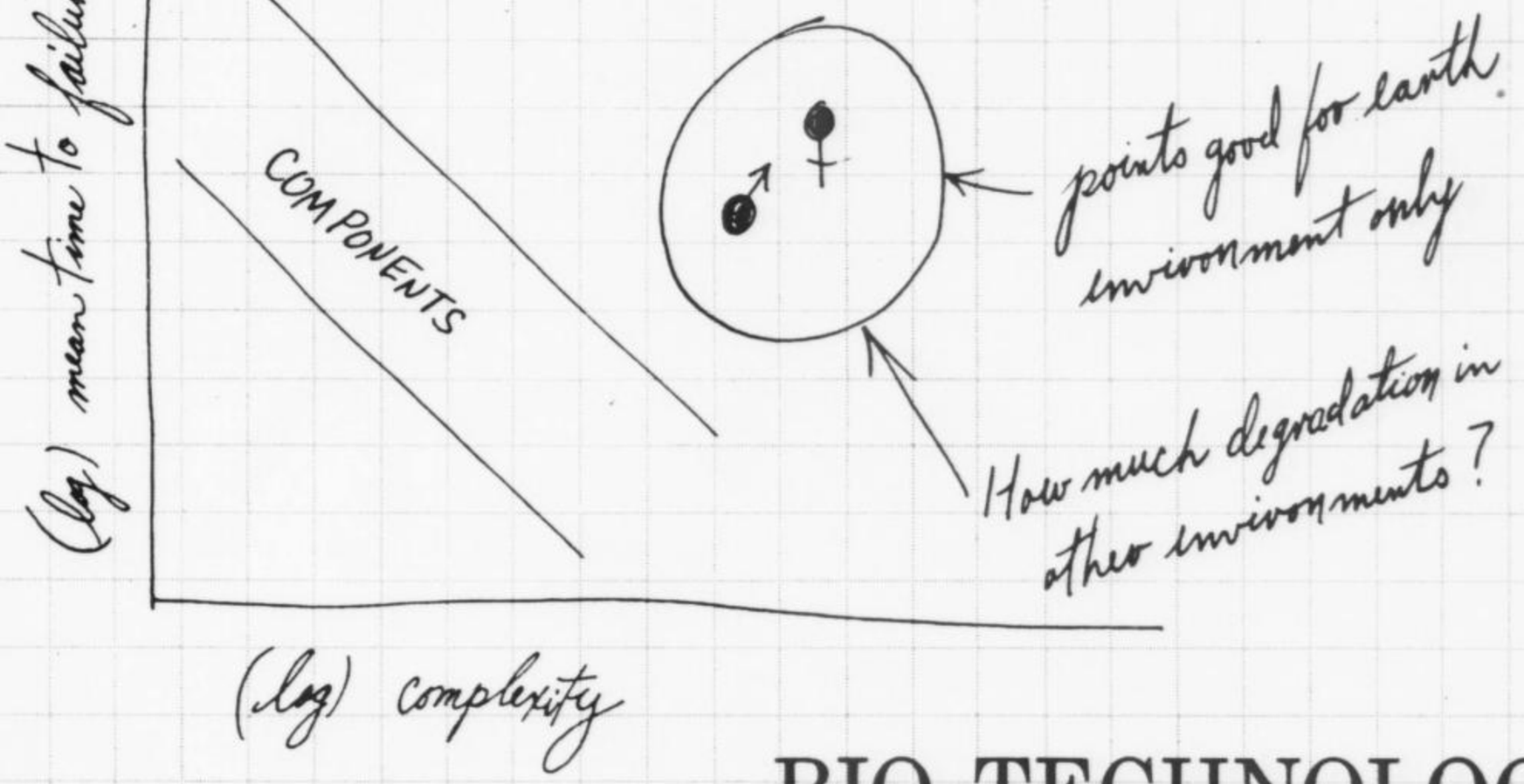
Kartveli



Griffin



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- Techniques for producing artificial environments and evaluating their biological effects;
- Learning and teaching machines, remote handling systems, and display and control techniques to support space operations.

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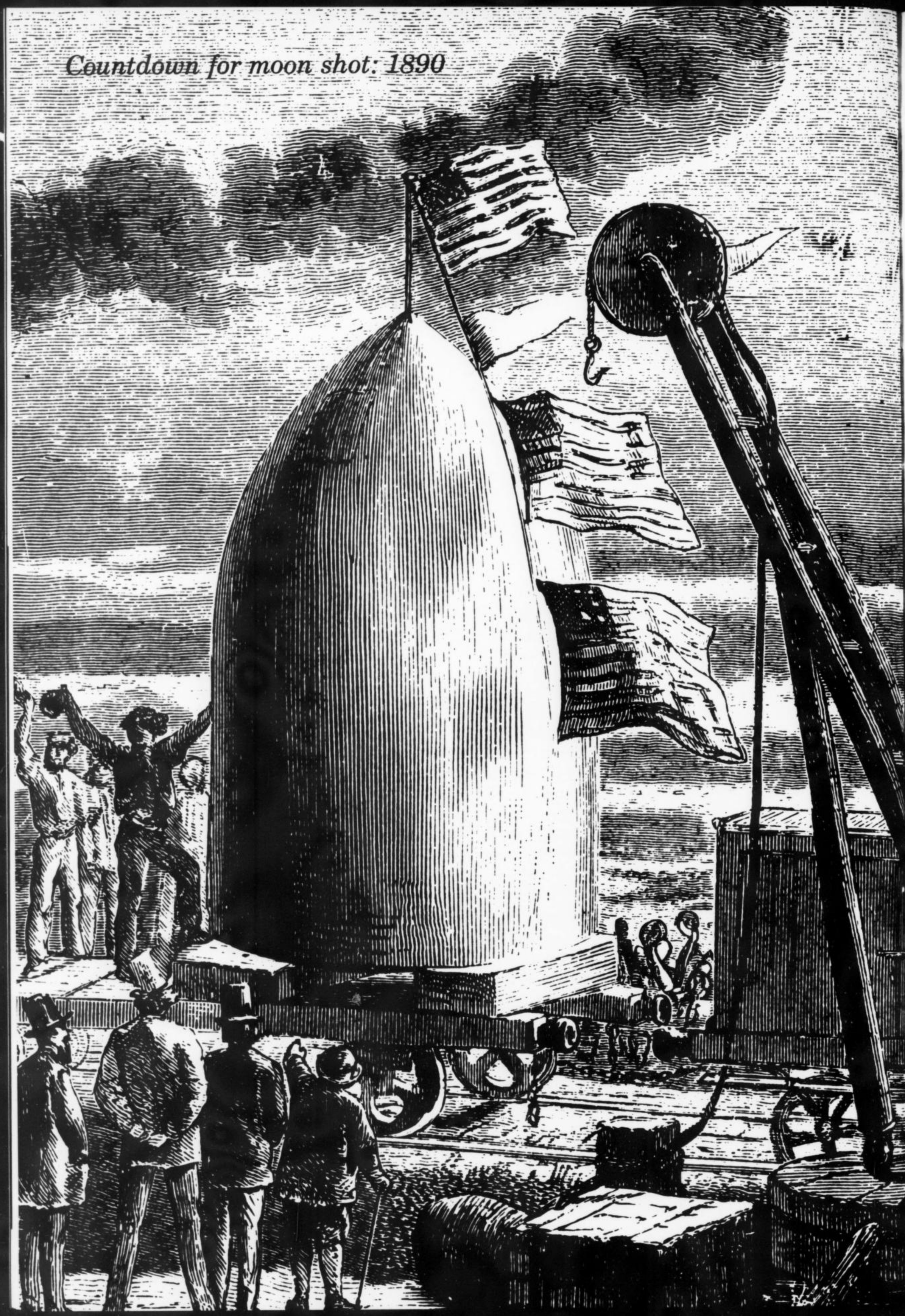
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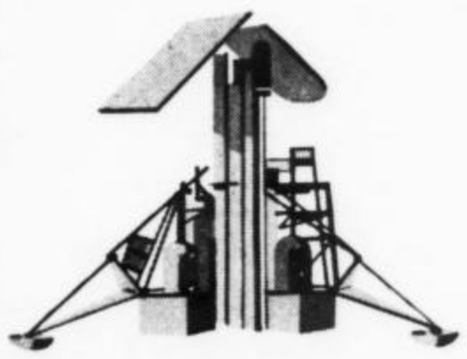
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*In Verne's 1890 novel, "From the Earth to the Moon," his spaceship, "Columbiad," was launched from Tampa, Florida—just 120 miles from Cape Canaveral! After missing the moon, the craft returned to earth at 115,200 miles an hour. It plunged into the sea, popped to the surface—and the three men inside were found "playing at dominoes."

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ciates, Inc. **Raymond E. Zelenka** has been made chief engineer.

Gordon S. Humphrey, former assistant vice president and general manager, Raytheon's Santa Barbara operation, has been named general manager, Leach Corp. Controls Div.

Joseph W. Wiechowski, an ARS member, has been appointed Western operations manager, Studebaker-Packard Corp.–CTL Div.

Robert Spencer Bradford has joined Minnesota Mining and Mfg. Co. as research manager, Mincom Div.

William P. Senett, formerly principal scientist, General Dynamics Electronics Div., has joined Leesona Moos Laboratories as director of advanced technology.

Arthur J. Minasy has been appointed vice president for operations in charge of production and engineering of Belock Instrument Corp. **Jeremy Taylor** has been named executive assistant to the president.

Ralph E. Willison has been upped to manager, engineering and development, of the new Electronics Div., Research-Cottrell, Inc.

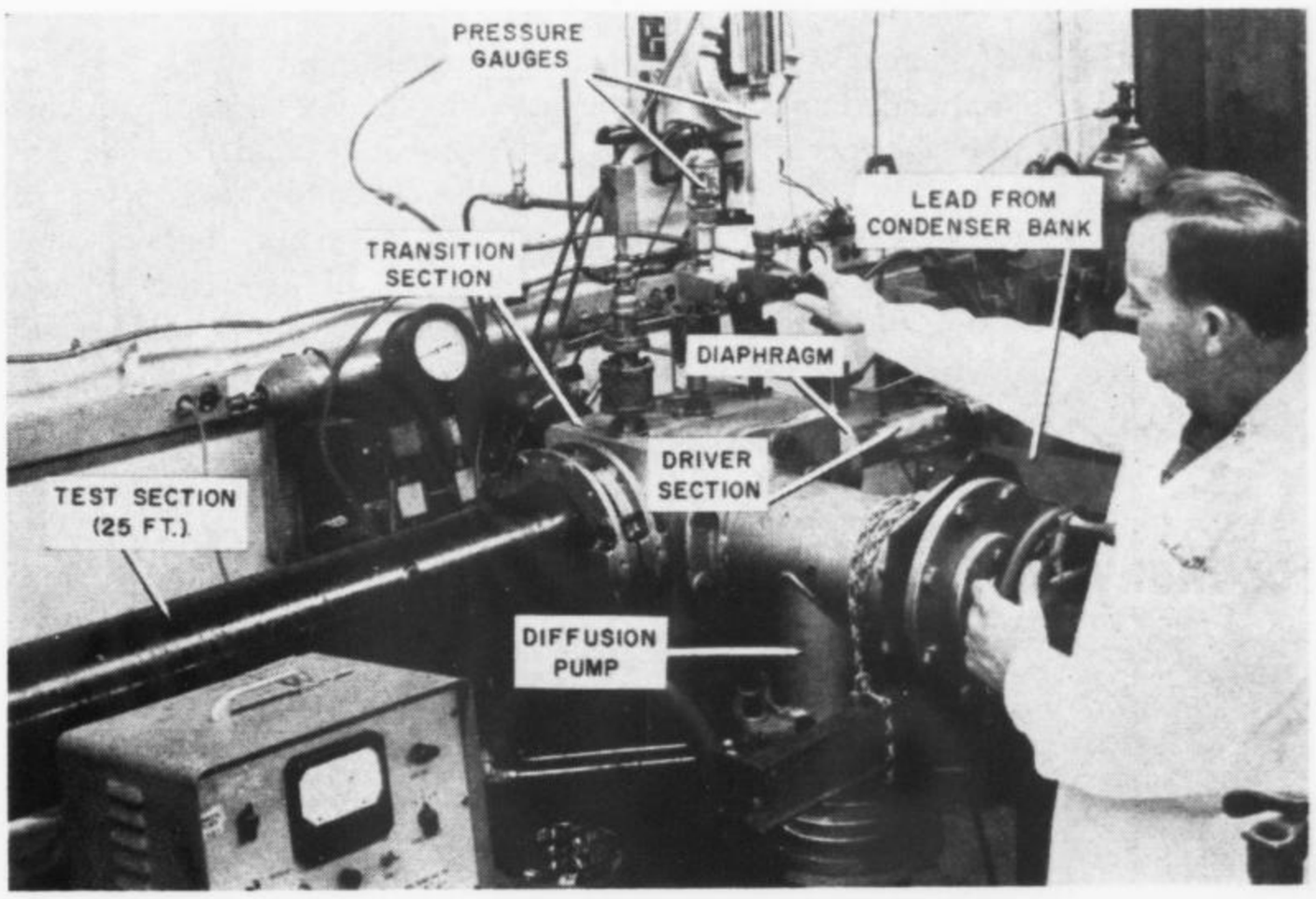
R. M. Gramling has been appointed project manager of Pan American's management role of the Rocket Research Facility at Fort Churchill.

Arnold R. Sabel has been appointed engineering planning manager for integrated electronics applications at Motorola's Military Electronics Div.

HONORS

Charles Stark Draper, an ARS Fellow Member, founder and director of the MIT Instrumentation Laboratory and head of the Dept. of Aeronautics and Astronautics at MIT, has been awarded the 1962 National Society of Professional Engineers Award for his "outstanding contributions to the military affairs of the country, his beneficial influence on public welfare . . . and for his profound teaching and counsel. . . ."

G. Stuart Patterson Jr., a senior engineer, Advanced Reactor Systems Section, Martin's Nuclear Div., has been awarded a $5000 company fellowship to continue doctoral studies at the Johns Hopkins Univ. ♦♦



Avco to Design and Build Apollo Heat Shield

The Apollo heat shield, expected to be made of charring plastics, will be designed and built by Avco's Research and Advanced Development Div. under a NASA contract expected to exceed $8 million. Part of the shield development will be conducted by Avco in a new research facility at Wilmington housing an MHD shock tube and a molecular-beam shock tunnel to accelerate gases to 60,000 fps for radiative heating study. The photo shows the helium-driver shock tube developed by Avco-Everett under NASA and Air Force contracts to study heat pulses up to 90,000 F. This machine will add to the Apollo study.

Nuclear Propulsion Meeting Program Set

The program for the ARS, ANS, and IAS Nuclear Propulsion Conference, to be held at the U.S. Naval Postgraduate School in Monterey, Calif., August 15–17, has been announced by Program Chairman Robert W. Bussard.

The meeting, organized jointly by the NASA/AEC Space Nuclear Propulsion Office, ARS, ANS, and IAS, will feature papers on the development of nuclear-propulsion hardware. Although classified papers will make up the bulk of the meeting, new and original material, which is pertinent but classified, will also be presented.

SESSION SCHEDULE

Wednesday, August 15

9:00 a.m. Opening Session—The Rover Program, The Pluto Program, and the Orion Program

2:00 p.m. Reactor Criticality—Theory and Experiment
Engine and Vehicle Design

Evening Banquet

Thursday, August 16

9:00 a.m. Radiation Levels and Analysis
Materials Research I

2:00 p.m. Flight Safety of Nuclear Propulsion Systems

7:30 p.m. Reactor Test Operations and Facilities

Friday, August 17

9:00 a.m. Heat Transfer and Fluid Flow
Propulsion Reactor Control

2:00 p.m. Engine Structures and Component Development
Reactor Engineering Design

SECTION NEWS

Arizona: At a dinner meeting in May, guest **James Burke,** manager of JPL's Ranger project, discussed this program and its lunar mission with the aid of a sound movie and slides. A model of the Ranger spacecraft and other project equipment were on display at the meeting.

—Dean Later

Arrowhead: Fifty members and guests of the Section attended an April meeting held at the Officers Club, Norton AFB.

Guest speaker was **Col. William J. Campbell,** Titan I and II Weapons Systems Support Manager at San Bernardino Air Material Area, Norton AFB, who described Titan I and II and their performance. Through the use of slides, Col. Campbell traced the development of the hardened silo complexes housing not only the missiles but the myriad GSE necessary to sustain them and the launch crew. Also, a film was shown on the Titans I and II.

—Lou Crider

Central Indiana: The April meeting, with 62 members and guests attending, heard guest speaker **B. B. Belant** of Aerojet-General discuss "Large Segmented Solid Rockets," including the assembly and firing of large segmented rocket boosters. A film was shown of the assembly and static firing of a 100-in.-diam solid motor. Belant showed a well-documented film concerning the use of computers in internal-ballistic and grain design for solids.

—Caroll B. Adams

Chicago: In April, the Section held a special meeting on the campus of the Illinois Institute of Technology. Guest speaker was ARS President **W. H. Pickering,** who reviewed the lunar program at JPL, and then discussed the role of the professional society in the U.S. today.

—John F. Wendt

Columbus: Officers for the term beginning in July will be as follows: Donald E. Hall Jr., president; Robert F. Badertscher, vice-president; Joseph I. Schwartz, corresponding secretary; Gerald M. Gregorek, recording secretary; and Carl F. Speich, treasurer.

—K. W. Greenlee

Delaware: Section officers for the current term are as follows: Raymond J. Goskowski, president; R. Joseph Goldblatt, vice-president; Don G. Zuck, secretary; and F. William Jahns Jr., treasurer.

—Don G. Zuck

Detroit: In April, the Section sponsored a luncheon seminar titled "Space Flight Report to Detroit." This meeting, the first midday event in the Section's history, was attended by approximately 120 persons representing local firms engaged in space activity, local governmental officials, the military services, and the press. The meeting arrangements were handled by Section director Richard J. Egger of Burroughs Corp. Chairman for the meeting was Richard Morrison of the Univ. of Michigan Aeronautical School.

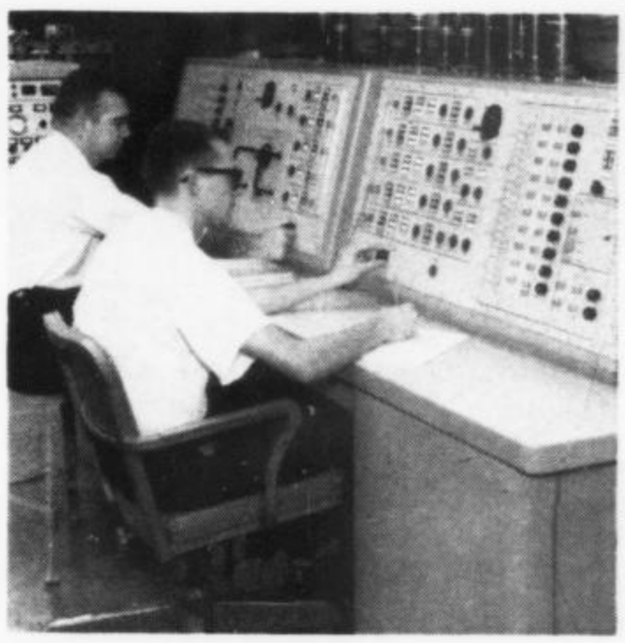
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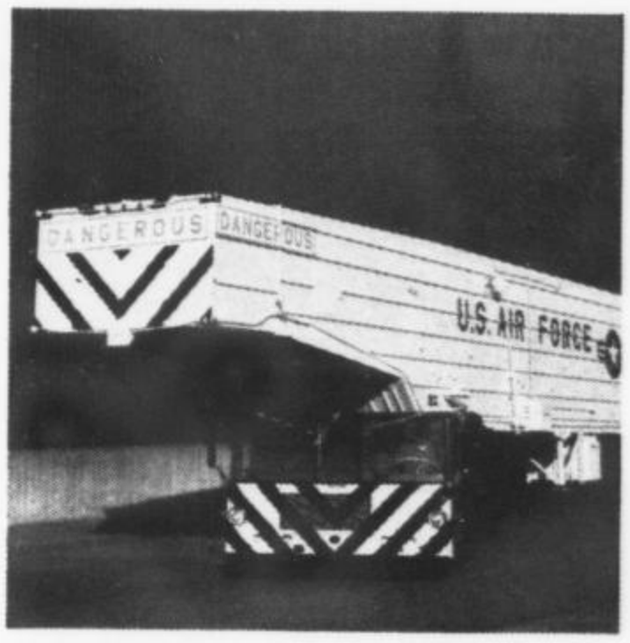
Col. Prentice Peabody, USAF, a founder and president of the ARS Florida Section, who recently transferred from AFMTC to California, receives a plaque from the Section in appreciation of his many contributions to ARS activities. Section President Harry Pfeiffer makes the presentation following a farewell luncheon. From left, Maj. Walter Flint, Eugene Wise, Pfeiffer, Col. Peabody, Charles Carroll, K. M. McLaren and R. E. Nugent, all members of the Section's Board of Directors. Col. Peabody is vice-chairman of the ARS Test, Operations, and Support Committee.



Complete missile test programs



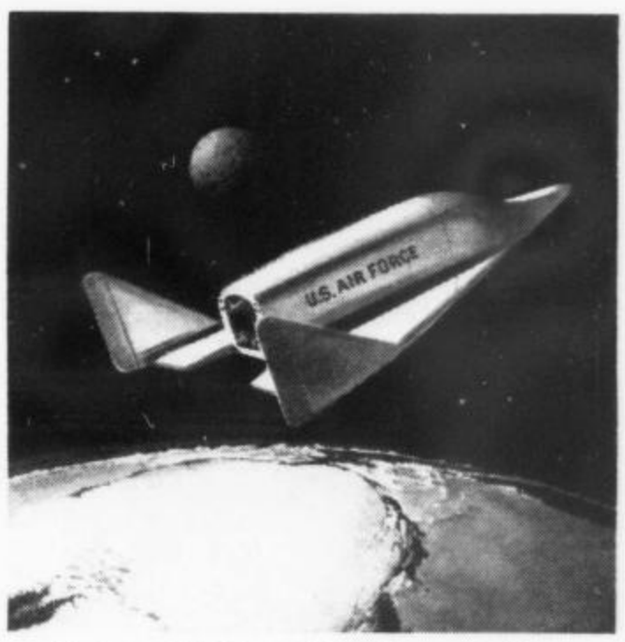
Electronics engineering and manufacture



Ground support systems



Management techniques (PERT)



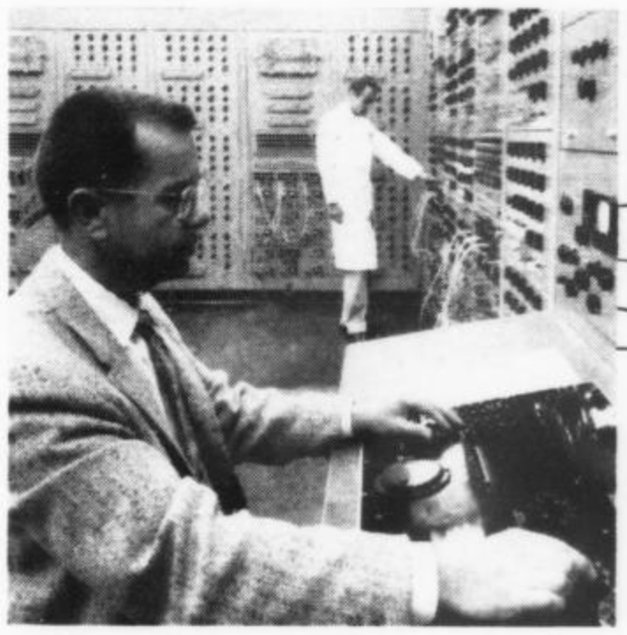
Space vehicle and systems design



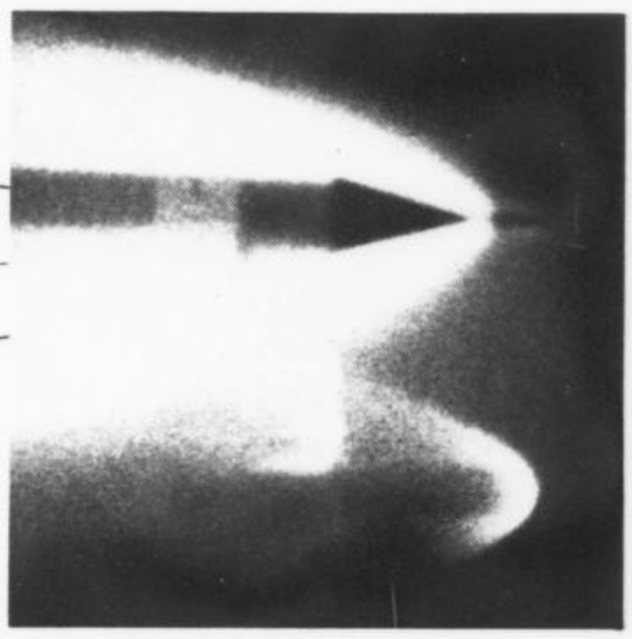
Quality-controlled manufacture



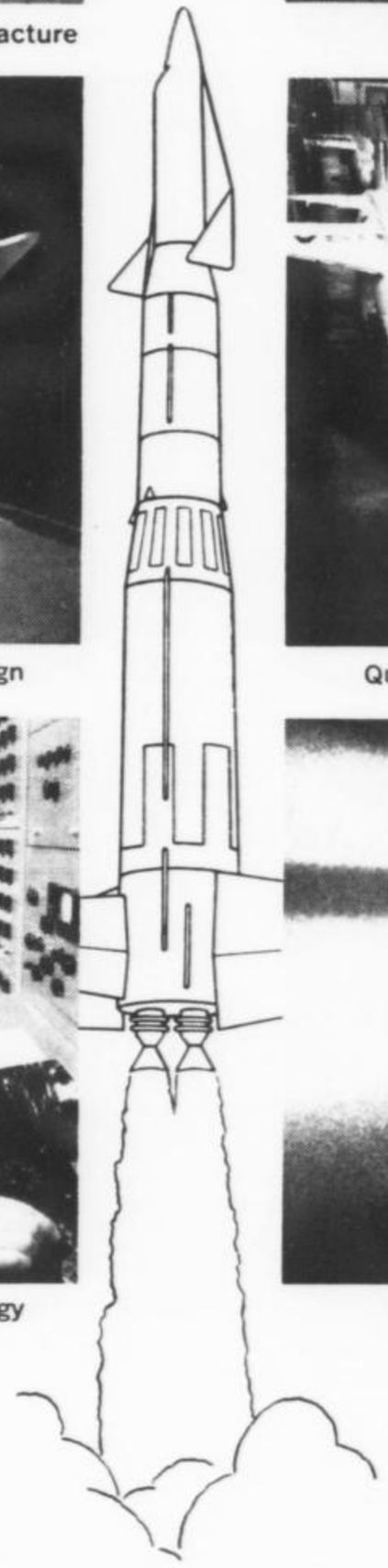
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BOEING

AERO-SPACE DIVISION

The meeting heard several speakers. **Paul S. Mirabito,** vice-president for defense contracts of Burroughs, spoke on "Small Boosters for Space Vehicles" with emphasis on the Atlas booster and the Burroughs contribution to the guidance system. **Lovell Lawrence Jr.,** director of Chrysler's Advanced Projects group, discussed "Large Boosters for Spacecraft" and some of the study work that has been accomplished for the Saturn and Nova programs. **Russell D. O'Neal,** vice president for engineering of Bendix Corp., gave a report on "Communications Satellites." He included the work that Bendix has done for such projects as Advent. "Interplanetary and Lunar Vehicles" was the subject of an excellent presentation by **Donal B. Duncan,** general operations manager of Aeronutronic's Space Systems Operations. He covered the work currently underway in the Ranger project in detail. **William A. Fleming,** NASA's director of technical programs, provided a comprehensive and sequenced review of the various NASA programs —past, present, and contemplated.

The consensus was that this was an outstanding program.

—J. M. Dutton

Florida: Cape Canaveral will continue to be the heartbeat in the life cycle of lunar and planetary launches, **William H. Pickering,** ARS president, told the Canaveral Council of Technical Societies in a meeting hosted by the ARS Florida Section.

Dr. Pickering talked about today's trend of merging professional societies, and discussed the Ranger, Surveyor, and Prospector unmanned lunar programs.

Dr. Pickering said the future includes such exciting projects as attempts to reach Venus and Mars and eventually manned travel to the planets as well as the moon. An attempt will be made by this country—and possibly by the Russians—to hit Venus with an instrument package this summer, he said (see page 54).

Dr. Pickering said he favored the proposed merger of ARS and IAS and other proposed professional mergers to avoid overlapping and duplication and to provide a broad base with interests for larger groups of professionals.

—H. E. Wise

Long Island: Guest speaker for the May meeting was **Robert Stroupe,** program manager for NASA's Orbiting Astronomical Observatory, shown here at the right examining a star tracker with Ross Renninger, general manager of Kollsman Instrument Corp., which produces trackers for the OAO. Stroupe reviewed the OAO program and its many technical and scientific ramifications.



—Hoshen R. Lu

New England: At our May meeting, **C. Stark Draper** discussed the growing debate over human vs. automated guidance systems for lunar and interplanetary missions. Dr. Draper told an audience of about 100 that MIT's Instrumentation Laboratory was planning a "composite" approach to the guidance system for the Apollo lunar vehicle. This approach would involve inertial-guidance systems for takeoff and landing sequences and star-tracking for midcourse guidance.

The inertial systems would be automated, while the star-tracking system would make use of human sightings, integrated with automatic computations. "The human eye is better, by an order of magnitude or more, than the best available optical systems, for this purpose," Dr. Draper said. "We should take advantage of everything we've got—every available resource." He added that radio and radar links with earthbound control stations would also be included in the Apollo guidance system.

—Winston Markey

Sacramento: In an April meeting, the Section heard a discussion of "The Effects of Radiation in Man" by guest speaker **John W. Gofman,** professor of medical physics at the Univ. of California-Berkeley. Dr. Gofman began by stating that we actually know very little about radiation. Radiation does two things in man in a broad sense. It does something referred to medically as the "acute way": 50% of people exposed to 700 roentgen in a short time will die in a period from a few hours to 30 days. In low doses, radiation over long periods may produce leukemia in 10 yr. Or it may produce bone cancer or a hereditary change. Three questions uppermost regarding long-term effects of radiation are whether life-shortening occurs, whether cancer or leukemia occurs, and whether hereditary changes occur and by what mechanism. Data indicate these effects do occur.

In normal life the human body at sea level absorbs $^1/_6$ to $^1/_{10}$ unit of radiation per year. We have no real studies of large populations of humans

Space Flight Report to Detroit



Mrs. Jean Pearson of the Detroit Free Press inspects a model of the Ranger spacecraft along with participants in the ARS Detroit Section's luncheon meeting, "Space Flight Report to Detroit," held in April. The meeting drew about 120 members from local space firms, government, military services, and the press. **Left** to right, Donal Duncan, general operations manager for Ford's Aeronutronic Div., who discussed Ranger and the lunar program; Mrs. Pearson; Paul Mirabito, vice-president for defense contracts of Burroughs Corp., who spoke on "Small Boosters for Space Vehicles"; NASA's William Fleming, director of technical programs, who reviewed the U.S. space program; and Brig. Gen. Cecil Lessig, USAF, Commander of the Fifth AF Reserve Region, Selfridge AFB, a guest.

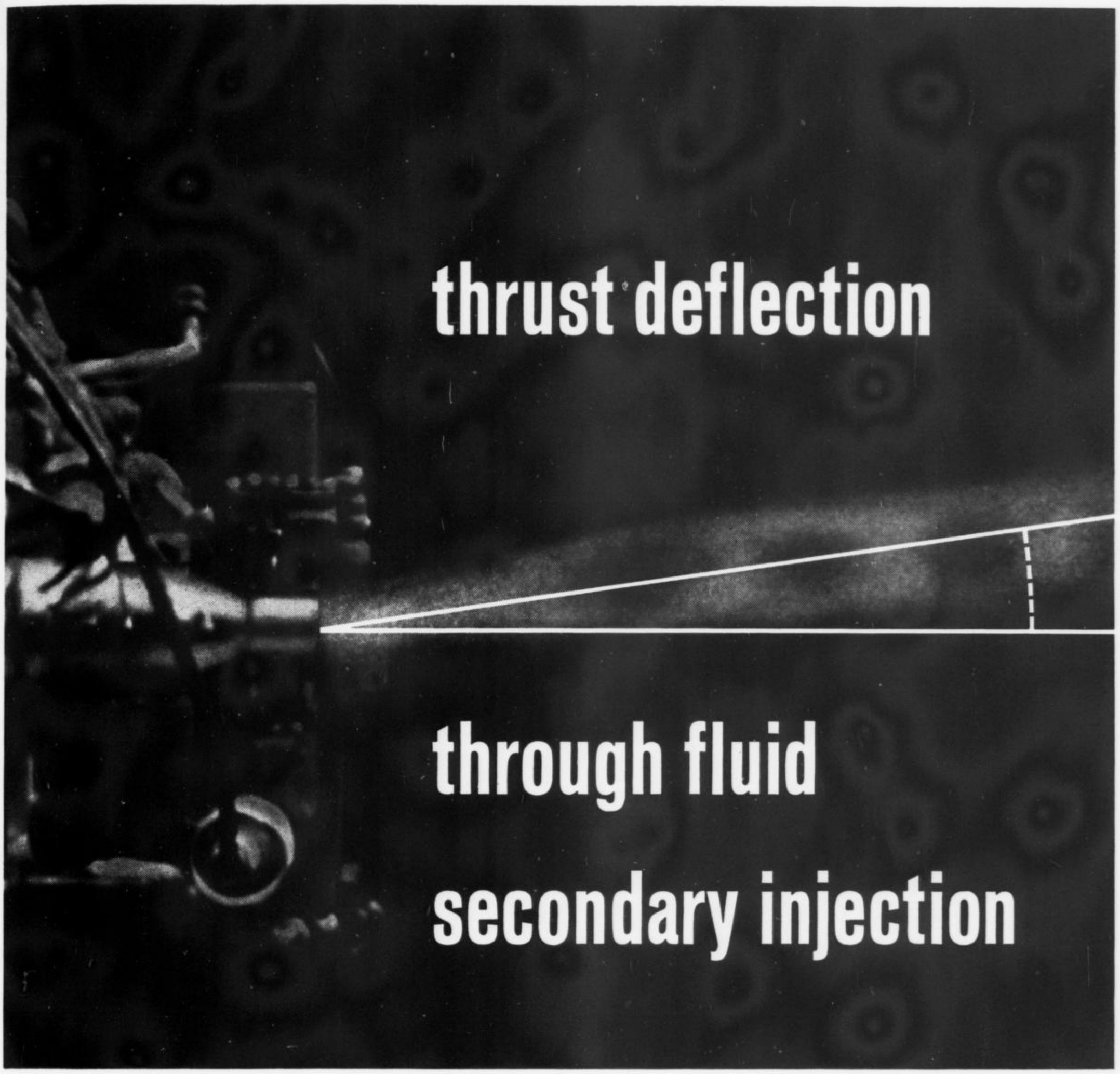


Photo of test conducted at AiResearch

AiResearch is now conducting laboratory tests utilizing various fluids in secondary injection systems for missile thrust vector control.

These tests show many advantages over present vectoring methods; faster response, moving parts are virtually eliminated, and high temperature problems are minimized. In addition, the average vectoring system weight is less as the fluid is expended at burn-out.

AiResearch, with many years of experience in systems management, research and production in the components involved, is prepared to help solve your steering and vector control problems. Direct requests for information to the Los Angeles division.

GARRETT **AIRESEARCH MANUFACTURING DIVISIONS** • *Los Angeles 45, California • Phoenix, Arizona*

Systems and Components for:

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exposed to low doses of radiation over long periods of time, but studies of animals subjected to this condition show a definite life-shortening effect. Concerning hereditary effects of radiation, Dr. Gofman gave a detailed account of the effects of DNA.

Radiation, he pointed out, can cause a break in the chromosome strand. Once a strand breaks, it has a high tendency to recombine with something. This means it would heal abnormally with a piece added or a piece missing in the strand. One break per cell can be seen from 20 roentgen.

In closing, Dr. Gofman said that the field to watch in the future for effects of radiation is cytogenetics, the study of the cells.

—Ethel Smith

STUDENT CHAPTERS

Academy of Aeronautics: In our Chapter's continuing program on astronautics, this month we will be seeing the films "Packaging Rocket Power" and "Nike-Hercules" and making a field trip to the Hayden Planetarium in New York City. Next month we will view a film on inertial navigation.

—Martin Steinmetz

Boston Univ.: At the meeting in May, at the College of Industrial Technology, the Chapter heard **Prof. Carl Peterson** of MIT and Goodrich-High Voltage Astronautics discuss rocket propulsion, including nuclear, arcjet, and ion rockets in some detail, with the aid of slides and analytical notes.

Back in January, 25 members toured Avco's Research and Advanced Development Div. in Wilmington, Mass. After a warm reception, we were taken into the laboratory where we saw an arcjet engine in operation.

—William Krasnow

Newark College: Each year, our Chapter presents a certificate and a subscription to *Astronautics* to the student who shows the best space project at the Greater Newark Science Fair. This year's award went to Bernie Brien of Springfield, N.J., for



his "Experimental Rocket." The photo here shows Brien and his rocket at the right and Albert L. Papp Jr., left, who presented him with the certificate of merit.

—Albert L. Papp Jr.

Boeing Building Metrology Lab

The Boeing Co. has begun construction of a large, modern metrology laboratory in Seattle. When completed in November, the building will house some 80 persons in offices, shops, and labs, which will be controlled to within one-quarter of a degree.

Raytheon Expands

Plans to add a 100,000-sq-ft building to its Bedford, Mass., engineering and development laboratories were announced recently by Raytheon Co., to provide more room for its Missile and Space Div.'s engineering.

Plasma Facility for Republic

Republic Aviation says it will build an advanced plasma physics research facility at a cost of $1.5 million and will incorporate the laboratory into the company's Paul Moore Research and Development Center. The new facility is scheduled for operation next spring. President Mundy I. Peale said that the addition "is needed to handle the company's growing contract work in plasma propulsion and other areas of magnetohydrodynamic research."

Superconductivity at Westinghouse

Westinghouse Electric Corp. has established a Superconducting Materials Dept. at its Materials Manufacturing Div. for the development, manufacture, and marketing of superconducting materials.

Space-General Moves Into New Ultra-Modern Space Center

Space-General Corp., a subsidiary of Aerojet-General, recently occupied the first of three buildings at its new multimillion-dollar space center under construction at a 30-acre site at El Monte, Calif. The two-story 167,000-sq-ft building houses administration and engineering personnel and laboratories previously located at plants in Glendale and Azusa, Calif.

The other two buildings are a systems-evaluation facility scheduled for completion this month and a cafeteria for which the foundation has been started. The sketch below shows the completed administration and engineering building in the foreground, the systems-evaluation facility, right rear, and the cafeteria in the center.



CHANGE-OF-ADDRESS NOTICE

In the event of a change of address, it is necessary to include both your old and new addresses, as well as your membership number and coding, when notifying ARS Headquarters in order to insure prompt service. If you are moving or have moved, send the following form to Membership Dept., American Rocket Society, 500 Fifth Ave., New York 36, N.Y.

Name_____

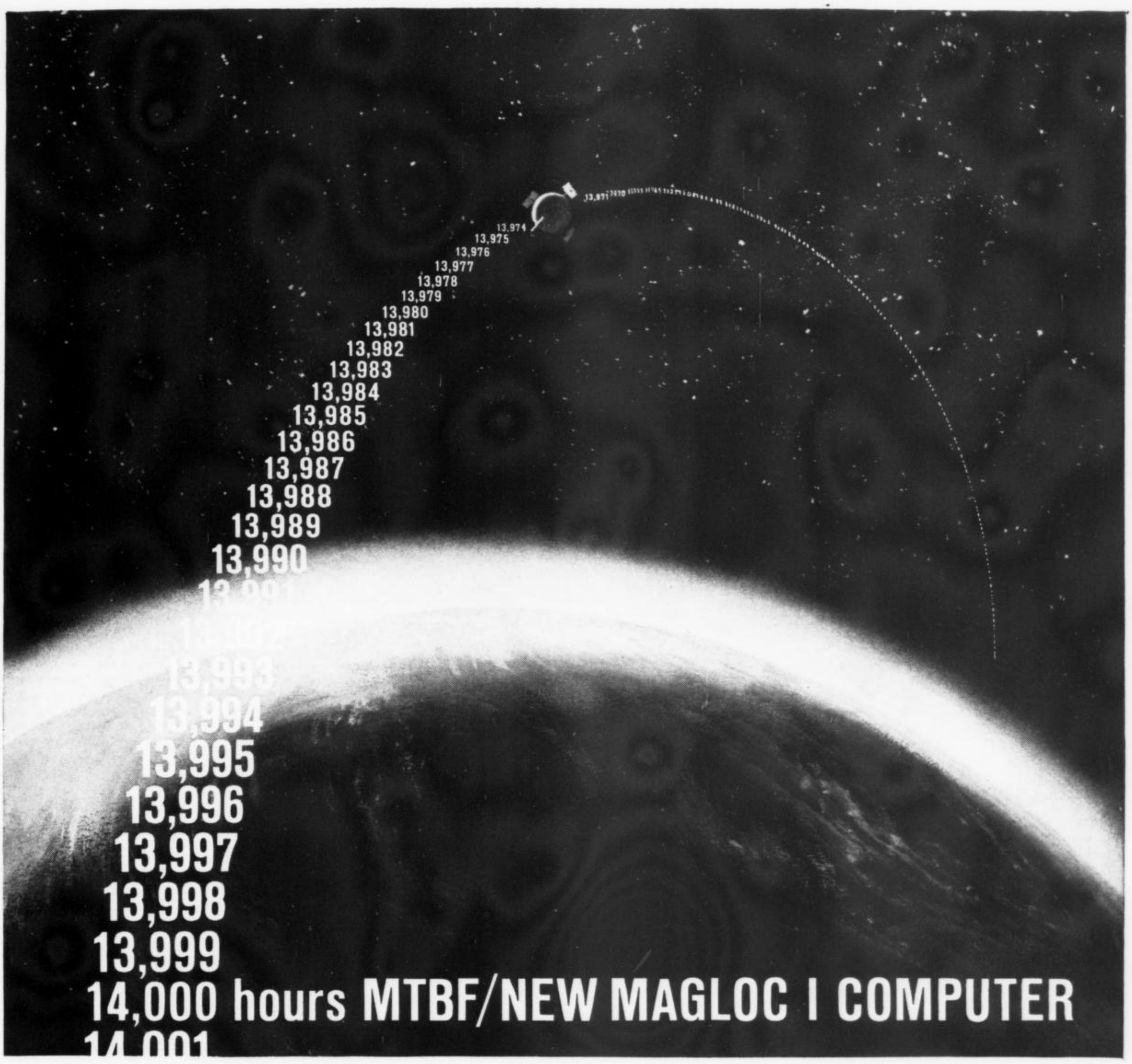
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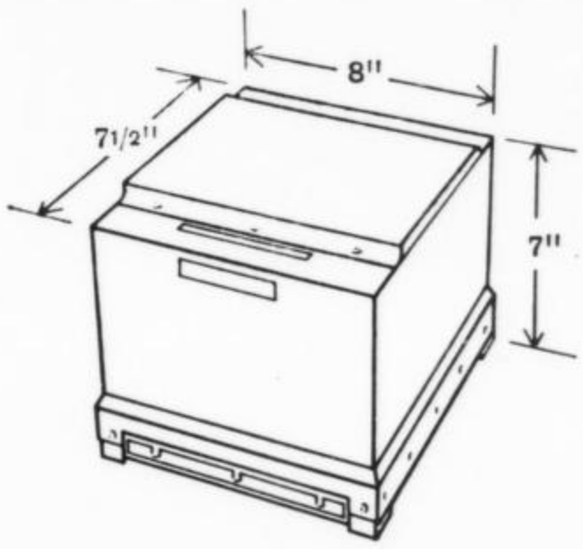
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SPERRY

An operating model of Magloc I—a new logic computer employing advanced magnetic techniques for maximum aerospace reliability—will soon be delivered to Aeronautical Systems Division, Air Force Systems Command, USAF. Its reliability target is 14,000 hours mean-time-before-failure, under extremes of environment.

Developed by Sperry under ASD sponsorship, Magloc I uses the high reliability inherent in non-active magnetic components for its logic, drive and memory circuits. Extensive design study and test breadboarding have resulted in a significant reduction in the number of fail-prone semiconductor components such as transistors and diodes . . . in a replacement of these components by magnetic components . . . and in an overall reduction of total components.

For example, the active components required in a 24-stage shift register was reduced by a ratio of 24-to-1, and the total component count by a ratio of 9-to-1. Unique, high-density, encapsulated welded packaging—using functional building block techniques – further enhances the inherent reliability of the new logic computer.

Magloc I features a biaperture ferrite non-destructive readout, and electrically-alterable program memory operating from −55°C. to 125°C. without compensation. Effective clock rate is 300 kc. Designed for long-duration interplanetary missions, Magloc I offers distinct advantages in cost, size, weight, and radiation resistance. Inquiries are invited.

AIR ARMAMENT DIVISION, SPERRY GYROSCOPE COMPANY · DIVISION OF SPERRY RAND CORPORATION, GREAT NECK, N.Y.

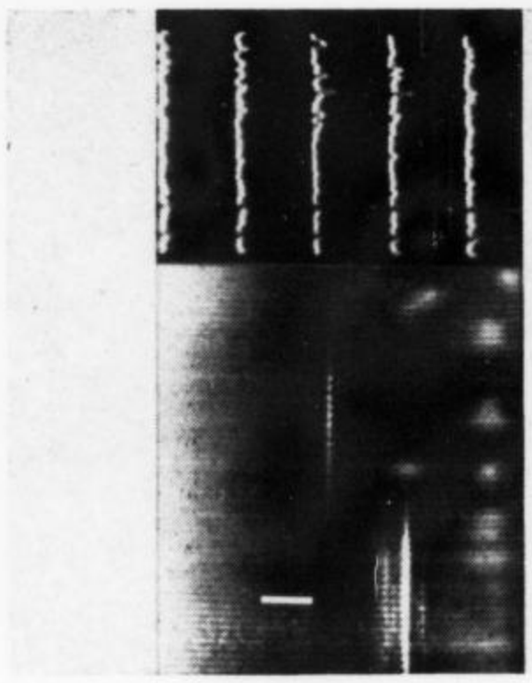
DESIGNS FOR TOMORROW

Additional information on the products listed in this section may be obtained by using the number at the end of the item with the Reader Service Card on page 97



Foamed-Plastic Structures

This chair and "igloo" were formed from a plastic developed for building lightweight structures in space. Forms for the two structures were covered with thin discs that "sudsed" into a hardened mass after exposure to solar rays in a space chamber. This represents part of a study of such structures by Hughes. Their work led to a sterically hindered isocyanate (as well as a solid diol and triol, both melting below 200 F) which foamed in vacuum without resulting foam weighed 2 to 5 lb/cu ft, depending on processing conditions, and had compressive strength of 15 to 40 psi, and on being compressed the material did not shatter. The maximum height of foam which could be obtained was 4 in. The foamed material showed good strength at 300 to 350 F. The gummy nature of the diols and triols was overcome by developing a prepolymer plastic when hot and brittle when cold, and so grindable to a powder. It was pelletized, using a plastics-preform. Hughes Aircraft Co., Culver City, Calif. (89)



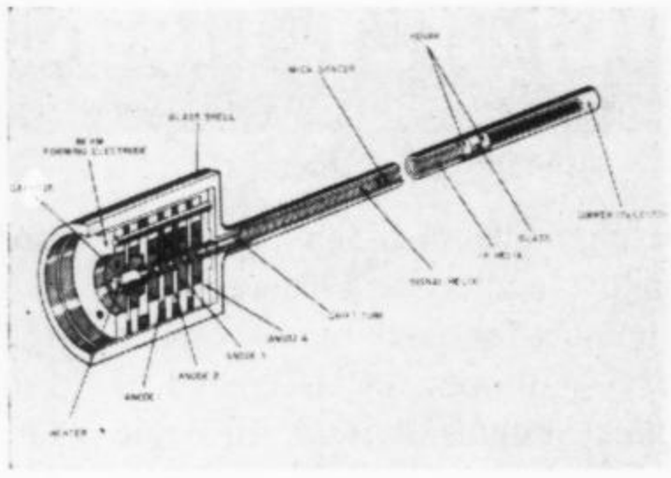
TPR Radar Recording

Thermoplastic recording (TPR) of video signals from a new airborne radar has allowed the sampling of a very large amount of information at a resolution sufficient for examination of the radar's performance in an individual cell equal to a pulse width. Some 45 ft of tape, GE reported, held a sample of usable radar video information 30 times larger than obtainable with an oscilloscope and high-speed-camera set-up; and the recording as projected made clearly visible pulse-to-pulse echo-intensity information (see photo, which composes oscilloscope reading, top, and TPR, bottom). GE engineers say that the TPR technique is applicable wherever there is a requirement for a permanent record of the type of data now displayed by means of oscilloscopes. Work is also underway at LMED to apply TPR to electrostatic latent image photography, random access digital data storage, and the recording of composite analog signals provided by such sensors as side-looking radar, infrared, and television. GE Light Military Electronics Dept., Utica, N.Y. (90)



Meiseng Design System

This system, the brainchild of R. C. Meissner, shown here with a data-conversion tube, produces engineering designs from instructions by an engineer or computer expert, as follows: Design data on punched cards are fed into an IBM 1620 system for analysis and computation. Results are expressed in plotting instructions on cards. These translate into binary instructions on magnetic tape through an IBM 1401 magnetic-tape system which has positioning-language equipment. A GD/Electronics S-C 4020 computer-recorder then translates the data—using electron beams—to plot the drawings at speeds up to 15,000 characters/sec. Form projection (company symbols, logotype, etc) simultaneously superimposed over the design. Drawings are recorded on 35-mm microfilm. This is processed at 96 drawings per minute on a Fulton film processor. Completely dimensioned drawings up to 24 × 36 in. on ordinary paper are made on a 24C Copyflow in 10 sec. The unit can also print on vellum or offset master. Meissner Engineers, Inc., Chicago, Ill. (91)



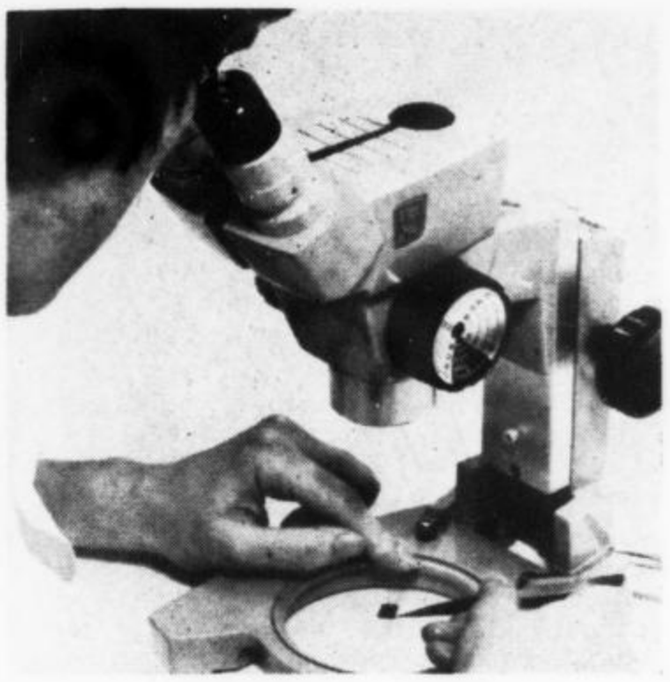
TW Tubes for Space

The sketch shows an experimental X-band version of a traveling-wave mixer tube combining four stages in an 8-in. envelope. This Sperry study, for the Air Force, ultimately envisions a 55-Gc mixer and a two-tube amplifier chain acting as the major active components of a spaceship-to-spaceship radar-communication system. (The sektch does not show input or output couplings or a double-gap feedback cavity around the tube which would produce the local oscillator signal.) The amplifiers are expected to put out 50,000-watt peak power at this frequency with an input of only 1 mw—a gain of 77 db. The company has already demonstrated generation of 1700 w at 32 Gc with its STV-128 power amplifier and has built a 10-Gc experimental tube of the unique mixer design. The two new transmitter tubes (STV-197 and STV-198) are being designed to operate in tandem as an amplifier chain, with the STV-197 as a driver and the STV-198 as the output tube of the space system. Sperry Electronic Tube Div., Great Neck, N.Y. (92)



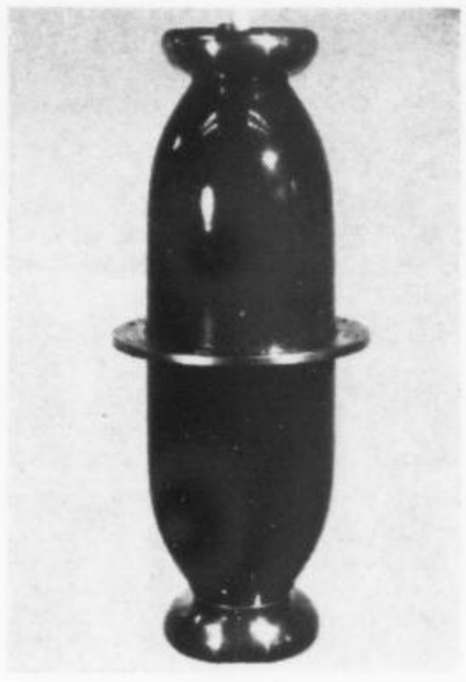
Infrared Detector

This IR detector responds to sources as faint as one millionth of a micro-watt. About the size of a lipstick, it has an active element of indium antimonide cut from a crystal (not thin film) that operates in the photoconductive mode and can be stored for extended periods without changes in characteristics. The device, sensitive to the intermediate region of the spectrum from 1 to $5^1/_2$ microns, delivers a signal of 1000 v per watt of 500-K blackbody radiation. This contrasts sharply with the 1/10-v signal delivered by other typical detectors, according to the company. The signal voltage is 50 billion times higher than the noise voltage when 1 watt of 5-micron IR strikes it—i.e., detectivity is $D^*(5.0\mu, 1000, 1) \geq 5 \times 10^{10}$ cm $(cps)^{1/2}/watt^{-1}$. Designed to operate at 77 K, it is being manufactured in a variety of Dewar configurations. It is available in several element sizes and shapes. The company expects the device will expand IR military applications. Its time constant is near 1 microsec. Minneapolis-Honeywell, West Los Angeles, Calif. (93)



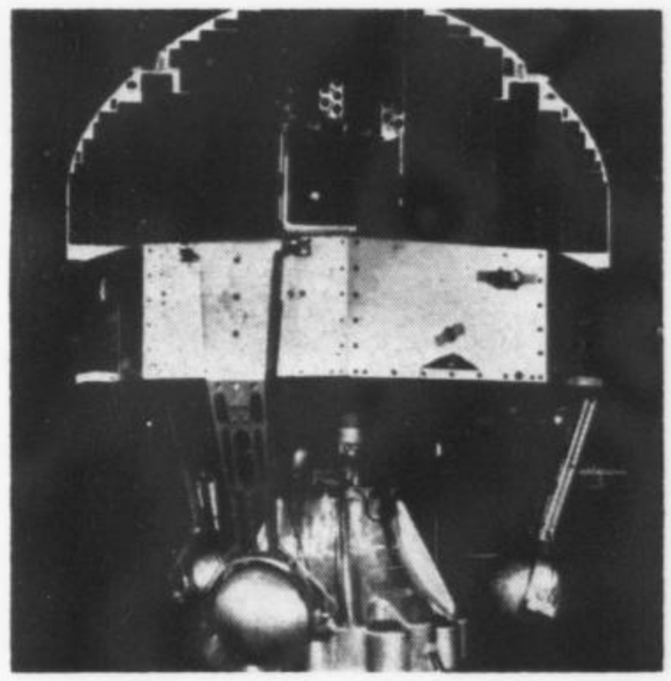
Semiconductor Strain Gauge

Having a single semiconductor element, this gauge offers inherent self compensation to ±1 microinch/inch/F—performance equivalent to selected-melt or special self-compensated wire or foil gauges—for materials with expansion coefficients ranging from zero to 20 parts/million/F. Gauges have been standardized for 6, 9, and 13 parts per million expansion materials. These gauges afford good stability, fatigue resistance, and low hysteresis. Two basic types are available: standard and temperature-compensated gauges which have nominal resistance values of 120 and 350 ohms. They are available as free-filament or Bakelite-backed units with three lead-exit configurations. All have an over-all filament length of about one quarter in. and an active gauge length of 3/16 in. Backed gauges are supplied with integral nickel-plated-copper ribbon leads; unbacked units are supplied with gold wire leads. The gauges can be mounted on a curve whose radius is as small as 1/8-in. Baldwin-Lima-Hamilton Electronics Div., Waltham, Mass. (94)



Cast-Epoxy Isolator

This cast-epoxy isolation bushing successfully withstood an operating test of 650 kv peak, 60 cps power, thus indicating the feasibility of such components for half-million-volt DC service. The bushing was tested for a high-voltage transformer unit that will become part of a large klystron development facility at Stanford Univ. Operating in an oil-to-oil environment, the bushing will carry 24-v AC filament power from one steel tank containing the filament transformer to another housing the klystron mounting base and cathode connections to a 350-kv input. Being only half as large (31 in. long) as a porcelain bushing for the same service, the new unit offers the possibility of substantial economies in space and size and the cost of auxiliary structures and enclosures. In addition, a IPI Series 400 feed-through bushings cover the operating range from 20 to 200 kv DC in five models. Special units also provide multi-conductor feed-through arrangements for such applications as filament leads to rectifiers, etc. Isolation Products Inc., Mountain View, Calif. (95)



Fibreglass Bottles

Important operational components of OSO-1, shown above, include four filament-wound fibreglass pressure bottles, which hold nitrogen at 3000 psi for attitude control. Two principal assemblies comprise the structure of OSO-1—a nine-sided drum and a fan-shaped structure. Three of the 160-cu-in. bottles are mounted on arms which extend outward from the spinning drum, and, by exhausting the pressurized nitrogen through small jet nozzles, permit the drum to spin at a constant rate of 30 rpm. The fourth bottle carries the gas supply for jets mounted near the top of the fan-shaped structure; these jets implement gyroscopic stabilizing action. The bottles are produced by a patented process, developed by Apex, in which a continuous filament of fibreglass is spread with resin and wound around a hollow spherical core. Similar Apex bottles have been prepared for Mercury spacecraft and Saturn boosters and will appear on deep-space vehicles. Apex Fibre-Glass Products Div., White Sewing Machine Corp., Cleveland, Ohio. (96)



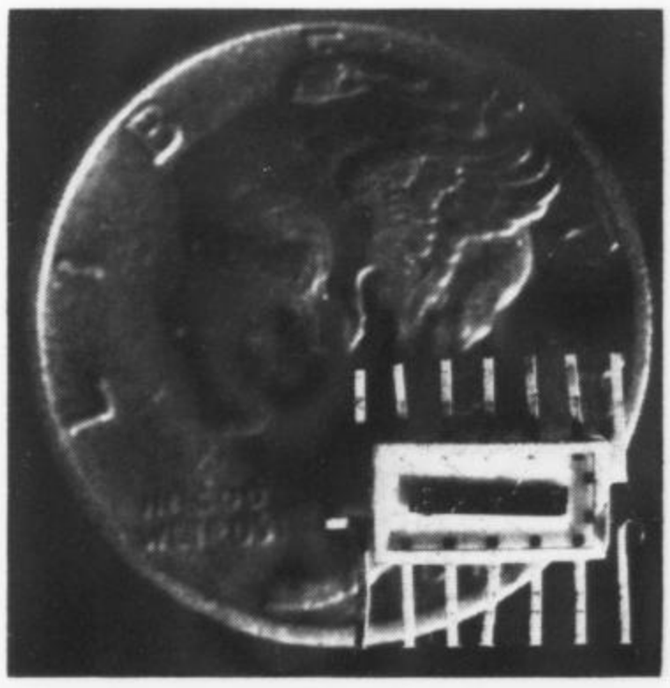
Joining Refractory Materials

A technique has been developed by Martin Co. for joining thin refractory metal sheet without incurring the brittleness caused by recrystallization from the heat of existing welding methods. Development under way for more than a year has resulted in successfully joining commercially available tungsten sheet. In the process, filler refractory material is deposited in the joint by the combined nucleation and reduction of refractory-bearing halogen gases. Heat is applied to the base sheet to be joined, and the temperature of the entire operation kept below 1500 F, well below the recrystallization temperature of the materials. The microphoto above shows a specimen of thin tungsten sheet joined by the thermochemical technique. The fine grain texture and lack of recrystallization at the juncture is evident. The new technique, the company expects, will lead to an increased use of refractory materials for structural elements of manned space vehicles, leading edges, nuclear-rocket fuel elements, and radiation shielding. Orlando Div., Martin Co., Orlando, Fla. (97)



Sun Seeker

About 3 oz in weight, 2 in. in diam, and 2 in. high, this sun seeker views a solid hemisphere of sky for such purposes as spacecraft-attitude and telemetering control. The seeker produces two DC outputs proportional to the vehicle's angular deviation from the sun. The definition is linear within a 20-deg cone of the seeker's boresight, while for larger angles the output increases as an approximate cosine function up to ±90 deg. Four photovoltaic cells mounted behind a square aperture plate sense the central, 20-deg solid cone. Eight peripheral cells mounted at right angles to the quad cell structure sense the solid hemisphere beyond the 20-deg cone. Diametrically opposed cells of the two banks are interconnected to feed into two output channels. The cell structures are hermetically sealed by a glass dome. As the Sun Seeker rotates beyond the central 20-deg cone, the response of the quad cells diminishes and that of the peripheral cells increases, providing a smooth transition in output signals. Bendix Eclipse-Pioneer, Teterboro, N.J. (98)



Microelectronic Differential Amplifier

Development of a molecular differential amplifier which eliminates transformers and capacitors has been announced by Autonetics. One quarter inch at the widest, this "general-purpose microelectronic differential amplifier" is now being made by Texas Instruments. The new circuit is expected to fill a link in the electronics industry's transistor-to-microelectronic revolution, since it is believed to be the first amplifier of this sort to be developed. The amplification circuit, which measures 1/8 in. wide, 1/4 in. long, and 35/1000 in. thick, performs the services of five transistors, five resistors and two diodes. It has a wide range of possible applications, according to Autonetics, being able to meet practically all small signal audio-frequency and DC amplifier requirements. Designed to be used in conjunction with other miniaturized circuits, the amplifier can serve in a broad range of control systems, including autonavigators, flight controls, and computer input and output circuits. Autonetics, A Division of North American Aviation Inc., Downey, Calif. (99)

Direction Finder. Portable DF-O-Matic Navigator is completely automatic homing receiver scanning at 180 times/min and is adaptable for space navigation. **Allen-Bradford, Inc.,** Chicago, Ill. (100)

New Solid Lubricant. Whytekote 505, white, nonstaining, maintains its lubricating properties to 2200 F; is effective from −40 to 290 F and and nontoxic. **Alpha-Molykote Corp.,** Stamford, Conn. (101)

Sterilizing Apparatus. Consists of two-part exposure chamber, $20^1/_2$ by 28 by $20^1/_2$ in. with 7-cu ft volume, into which ethylene oxide dichlorodifuoromethane mixture is introduced for testing or sterilization of spacecraft components or subassemblies. **American Sterilizer Co.,** Erie, Pa. (102)

Asbestos Gasket Material. Useful in many heavy duty applications, Accopac AN-892 conforms to minor irregularities in flange surfaces and seals tightly. **Armstrong Cork Co.,** Lancaster, Pa. (103)

Vibrator. This vibration testing system, 5000-lb-force machine, can reach 125-g level with components and systems up to 5 lb, and 100 g with heavier objects; frequencies range from 5 to 5000 cps. **Associated Testing Laboratories, Inc.,** Wayne, N.J. (104)

Photomultiplier. Miniature power supply, Model ARI 120, weighs 3 oz; develops between 900 and 1000 v; gives voltages to 10 dynodes. **Astronetic Research, Inc.,** Nashua, N.H. (105)

Five-Gallon Verticle Mixer. Model 1200 is suitable for mixing high viscosity fluids and castable polymers. Can mix as small as 1-gal batches. **Atlantic Research Corp.,** Alexandria, Va. (106)

Acoustic sensor. A transducer for point measurement of acoustic and ultrasonic energy, its sensitivity is −124 db, ref 1 v/microbar, capacitance, 240 picofards. **Atlantic esearch Corp.,** Alexandria, Va. (107)

Solid State Decommutator. Designed for Saturn program, this unit uses 10 master channels and 28 subchannels and affords a 280-bit system for data, and frame and subframe synchronization. **Avco Corp., Electronics & Ordnance Div.,** Cincinnati, Ohio. (108)

"Three Second Sun." The Kopito Instant Furnace produces temp approaching those of sun's surface within 3 sec. Plugs into standard electrical outlet. Available in both 100-v, 30-amp and 220-v, 15-amp models. **Baird-Atomic, Inc.,** Cambridge, Mass. (109)

Strain Gage Welder. Lightweight, portable, stored-energy unit can be attached to weldable strain gages, thermocouples, fine wire leads, or foils. **Baldwin-Lima-Hamilton Corp.,** Philadelphia, Pa. (110)

Pressure Cells. Data Bulletin 4382 describes their aplication for precise measurement of gas or liquid pressure over broad range. **Baldwin-Lima-Hamilton Corp.,** Philadelphia, Pa. (111)

Flashing Navigation Light System. Provides 1000 hr of operation; flashes from 60 to 120 times/min; has failsafe circuit. **Barber-Coleman Aircraft and Missile Products Div.,** Rockford, Ill. (112)

Counter and Precision Timer. In-line electroluminescent (EL) display of Model 8370 permits readings from wide angles. Is designed to make frequency measurements to 11,500,000 cps. Can count events separated by less than 0.1 microsec. **Beckman Instruments, Inc.,** Richmond, Calif. (113)

Go-No-Go Fuel Cleanliness Gage. New Model 5 in three sizes from 50/100 gpm and Model 1 with five sizes, 5/25 gpm supplement existing Model 20 in six sizes, 100/600 gpm. **Bendix Filter Div.,** Madison Heights, Mich. (114)

Tordoial Coil Winding Machine. The T-100C manufactures, on production basis, torids from $^1/_{32}$ in. ID to 5 in. OD, with wire in sizes from 50 to 16 AWG. **Boesch Mfg. Div., Waltham Precision Instrument Co.,** Danbury, Conn. (115)

Printed Circuit Connectors. Becon Connectors can be used without soldering or drilling holes in the boards. Available in 90 deg single and double 10 and 180 deg single 10. **Brown Engineering Co.,** Huntsville, Ala. (116)

Components Oven. Internal capacity of 7 cu in.; stability of $^1/_4$ deg C through temperature range; primarily for military applications. **Bulova Watch Co. Electronics Div.,** Woodside, N.Y. (117)

Alloy Tubing. Gold, silver, and copper plating applied to Invar alloy tubing gives properties needed for maximum frequency stability in microwave cavities. **Carpenter Steel Co. Alloy Tube Div.,** Union, N.J.

Amplifier-Meter System. Consists of three channel meter assembly equipped for direct connection to a three channel amplifier. Draws approx. 1.2 amps at 115 v, 60 cps. **Columbia Research Laboratories,** Woodlyn, Pa. (119)

Electromechanical Transducers. Linear Variable Differential Transformers (LVDT) have sensitivity of a millivolt /0.001 in./ volt. Temp range is −55 F to 1000 F. **Columbia Research Laboratories,** Woodlyn, Pa. (120)

Miniaturized Commutator. Designed for high-speed switching, Model 5015 has a maximum starting torque of 0.015 oz-in. and operates to 3000 rpm with temp range from −55 to +150 C. **Computer Instruments Corp.,** Hempstead, N.Y. (121)

Carbon-Film Transducers. Used in control, indicating, and measurement circuits, these have life of up to 500,000 full scale cycles. **Computer Instruments Corp.,** Hempstead, N.Y. (122)

Ductile Titanium Powder. With this powder, finished products one-half weight of steel and able to withstand 5000 F with accompanying heat shock resistance are being turned out. **Consolidated Astronautics,** Long Island City, N.Y. (123)

Cryostat Systems. Operate in cryogenic temp as low as 1.2 K and through temp ranges of cryogenic liquids (LH_e, LH_2, LN_2, LO_2). **Cryometric Co.,** La Jolla, Calif. (124)

Horizontal Steel Extrusion Press. "Rita" hot extrudes plain carbon steel, alloy steel, stainless steel, and a series of exotic metals. Operates at 4000, 8000, or 12,,000 tons with maximum of 4500 psi on each of three cylinders. **Curtiss-Wright Corp. Metals Processing Div.,** Buffalo, N.Y. (125)

Die Materials. A new process of producing tools and dies used within forging and extrusion operations provides a product not prone to crack in predetermined directions. **Curtiss-Wright Corp. Metals Processing Div.,** Buffalo, N.Y. (126)

Miniature Pressure Switch. Model 8A is adjustable over range of 3.0 to 150 psia and has envelope size $^{11}/_{16}$-in. diam by $1^3/_4$ in. long. **Custom Component Switches, Inc.,** Burbank, Calif. (127)

Pressure Transducers. Model PB 403 bonded strain gage combines nonlinearity and hysteresis of less than ±0.5% of full scale and ranges from 25 through 1000 psid. Withstands pressure overloads of 500%. **Data Sensors, Inc.,** Gardena, Calif. (128)

Fluid-Like Silicone Rubbers. A 12-page brochure, "How to Process and Use Silastic RTV," is available. **Dow Corning Corp.,** Midland, Mich. (129)

Time Interval Counter. Solid-state Model 108 provides time resolution of 10 nanoseconds up to 10 sec using Nixie in-line display. Operates on input level of 1 v. **Eldorado Electronics,** Berkeley, Calif. (130)

Datacom System. Input, output, and display device for alpha-numeric data. Can be used with either communications systems or data processing systems. Features input keyboard and cathode-ray display tube to provide message composition, editing, and display. **Electrada Corp. Electronics Div.,** Culver City. Calif. (131)

High-Speed Framing Camera. The KFC-600 can take six frames at 100,000,000 frames/sec and with exposure times as brief as 5 nanoseconds. **Electro-Optical Instruments, Inc.,** Pasadena, Calif. (132)

Video Quick-Look Ground Station. A 15-page brochure details the PCM/Video Quick-Look Ground Station, Model PCG6. **EPSCO, Inc.,** Cambridge, Mass. (133)

High-Temperature Alloy. Fansteel 42 has tensile properties exceeding 50,000 psi; comes in sheet form. **Fansteel Metallurgical Corp.,** N. Chicago, Ill. (i34)

70MM Space Cameras. Designed for operation at extreme altitudes, lightweight Models 206A and 206B takes 125 ft of film and $2^1/_4$- by $2^1/_4$-in. pictures at 40 frames/sec. **Flight Research, Inc.,** Richmond, Va. (135)

Cold Cathode Ionization Gage. Televac Model 7A permits vacuum measurements in either single, dual, or three range scales from 10^{-2} to 10^{-7} mm Hg. **The Fredericks Co.,** Bethayres, Pa. (136)

Windvane. "Overshoot" of Microvane is less than 30%; threshold sensitivity, 0.5 mph; and life expectancy of 30 million revolutions. **Gelman Instrument Co.,** Chelsea, Mich. (137)

Cathode Ray Tube. New 5 in., single-gun ETC Ruggedized M1055PL can withstand shock of thrust into outer space. **General Atronics Corp.,** Philadelphia, Pa. (138)

Pressure Transducer. Measures rapidly changing pressures over 260 microsec period without interference. **General Dynamics Corp., General Atomics Div.,** San Diego, Calif. (139)

Subminiature Microphone Preamplifier. Has bandwidth of 12 cps to 120 kc with capacitance microphone of 20 UUFD (mirco micro farad). Volume less than 0.25 cu in.; wt, 15 grams. **General Dynamics/Pomona,** Pomona, Calif. (140)

New Triode. One-in. long, $^3/_4$-in. in diam, Type 7768 tube has withstood 3000 g for 3-5 millisec and has transconductance of 500,000 micromhos with 24 milliamp plate current. **General Electric Receiving Tube Dept.,** Owensboro, Ky. (141)

Lens End Incandescent Lamps. For use in data processing devices, the #253 and 253X lamps give minimum of 750 ft-c of light over $^1/_{16}$ in. circle, $^3/_8$ of an inch from lamp. Has burning life over 10,000 hr. **General Electric Miniature Lamp Dept.,** Cleveland, Ohio. (142)

Tiltable Test Turntables. For testing single-axis gyros, units include tumble, servo, multimode, and sidereal rate test tables. Have table load capacity of 100 lb, tilting range, 90 or 180 deg. **General Precision Kearfott Div.,** Little Falls, N.J. (143)

Celestial/Terrain Viewing System. Simulates earth's terrain as it would appear on spacecraft's TV during takeoff and re-entry. **General Precision Kearfott Div.,** Little Falls, N.J. (144)

Motor Test Equipment. Motor test consoles test 400 cycle servo motors, motor portions of motor generators, and geared motors ranging from size 5 through 18. **General Precision Kearfott Div.,** Little Falls, N.J. (145)

Ultra-High Vacuum Test System. Type 1452 provides pressure of 1×10^{-8} Torr or lower for running long-term tests on electronic or mechanical components and subassemblies. **General Vacuum Corp.,** Medford, Mass. (146)

Altitude Control Transducer. Used for aircraft and drone altitude control, unit features ±3000 ft control range and sensitivity of 1 mv/ft, ±0.05 mv in temp ranges −54 to +100 C. **Giannini Controls Corp.,** Duarte, Calif. (147)

New Plastic Material. Called ethylene-1-olefin, it can be made either softer or stiffer than polyethylene and shares the physical characteristics of the latter. **B. F. Goodrich,** Akron, Ohio. (148)

Cryogenic Temperature Probe. Measures temp from 1 to 50 K, exhibits reproducibility of 0.017 K during 100 hr continuous cycling from room temp to liquid helium. **Gulton Industries,** Metuchen, N.J. (149)

Direct Current Motors. Using wafer-thin disk rotor, Model 91000 uses printed circuitry and has rated output of $^1/_{1000}$ hp at 1.2 v and 1.6 amps. **Bill Haydon,** Waterbury, Conn. (150)

"Ball Tracker." Air Forces uses it for tracking aircraft or missile target, Army for mobile air defense systems, and Navy for shipboard tactical data systems. Has no gears, handles, or hand wheels. Basically is single input with divided output. **Hughes Aircraft Co.,** Culver City, Calif. (151)

Traveling-Wave Tubes. Made lightweight for space use, they are metal-ceramic, periodic permanent magnet focused, and feature $7^3/_4 \times 1^3/_8$ in. OD package complete with heat sink. **Hughes Aircraft Microwave Tube Div.,** Los Angeles, Calif. (152)

Asymptotic Calorimeter Set. Consists of 5 heating rate sensors of various ranges with rapid response time in milliseconds. **Hy-Cal Engineering,** Sante Fe Springs, Calif. (153)

Analog Computer. Performs Fourier analysis in 3 min, giving DC offset and magnitude of 1st, 2nd, 3rd, and 4th harmonics of any waveform. Desktop operation or portable. **Imm Industries,** N. Hollywood, Calif. (154)

♦♦

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ARS Members Comment on Merger

THE American Rocket Society is considering whether to merge with the Institute of Aerospace Sciences to form a consolidated society to be known as the American Institute of Aeronautics and Astronautics. (See the editorial on page 10 of this issue.) Negotiations between representatives of the two societies are still continuing and probably will not be concluded before September.

In the meantime, the results of the negotiations to date have been distributed to the members of both societies in the form of a preliminary "Principles of Consolidation." It is now time for open discussion by the ARS membership of the Principles document and of the merger question itself. This is the first issue of *Astronautics* to carry letters from the membership, and this will continue in future issues.

We are interested especially in letters from past and present Technical Committee officers and Section officers, and from others who have been active in the affairs of the Society; but careful consideration will be given to *all* letters from *all* members. Such letters can serve to develop a sounder basis for membership opinion before voting takes place.

As this issue went to press, 1901 members had returned their straw vote on the Principles of Consolidation. Of these, 1825 approved, 56 were opposed, and 20 took no position. Many members offered comments on the Principles either by letter or directly on their postcard ballot. Here are excerpts from these letters and comments.

LETTERS

Received Before "Principles" Statement

"As you know, I am a member of both the societies and the more I consider the matter the more convinced I am that some plan should be worked out for combining the two societies into one society.

I find as a member of the Propulsion Panel of the IAS that it is very difficult to obtain papers that are not prepared by members who have already presented them before the ARS or vice versa. I am sure the same situation arises in other areas of guided missile technology and in astronautics."

M. J. ZUCROW

"First, as a relatively 'old' member of ARS (and, I might add, an even 'older' member of IAS), I would be extremely disappointed to see the ARS, or the subsequent merged organization, cease its efforts at public information and active participation in national affairs. It is my belief that this has always been the ARS's Number 2 task, and, with the ever-increasing importance of the space program, it becomes even more significant both to the society and to the nation. Perhaps our methods of achieving these ends could be modernized or streamlined; however, they should certainly not be reduced in scope or eliminated.

"The second consideration is that of technical responsibility. I believe it almost mandatory to maintain our method of technical committee cognizance over technical meetings, article reviews, and general technical policy. A change to sectional administration of these functions would, in my opinion, be a serious mistake."

JERRY GREY

"I am among the group who feels that this consolidation of the two groups is worthy of study and exploration, but I do not feel that it is so valuable that we should overlook certain fundamental points of difference between the two societies. These points concern the utility and value of the society to the technical membership. These points are items that we in the Rocket Society have and there are points that we in the Institute of Aeronautical Sciences do not have:

1. A sensitivity to the desires and needs of the individual members on the part of the paid professional staff.
2. The alignment and the sensitivity of the society to matters affecting the individual members, particularly in the area of education.
3. A public awareness of the society, particularly with respect to professionalism.
4. The policies and orientation of the society with respect to professional activities in the various technical disciplines.

"I believe that if the combined society were to adopt the Rocket Society policies on the above items that the national welfare, the aerospace profession, and the individual members would all gain."

VINCENT S. HANEMAN, JR.

"As an ARS member since 1955 and a subscriber to the IAS publication 'Aerospace Engineering' I am keenly interested in the present ARS/IAS merger talks. I am generally in favor of merging the societies, and wish to bring to the attention of the 'constitutional convention' some of my thoughts on how the new society should conduct its affairs. I have itemized these below:

1. *Merger with other Societies:* The AAS and other smaller groups should be invited to consider joining the new society. As a name I prefer a short phrase, such as 'American Aerospace Society,' which would encompass both engineers and scientists, rather than a name which would include the world 'Engineer.'
2. *Professional Aspects:* Being strongly in favor of professionalism in technical work, I would urge the new society to join in all efforts toward that goal, such as participating in ECPD and other groups.
3. *Membership Policy:* Three 'voting' grades should suffice (e.g., member, senior member, fellow). The membership dues should include all publications, as has been ARS practice. No journals should involve extra charges.
4. *Selection of Papers for Presentation and Publication:* It is desirable to have the same group decide whether a paper accepted for presentation should also be accepted for publication, rather than split these functions. This would reduce printing costs of final publication. The cognizant technical division or committee should perform the paper review. The whole business of paper solicitation and review should be put on a steady state rather than transient basis, to ensure better quality and continuity. It is better to have fewer papers of known quality than to rely on last minute promised papers which no one has yet seen in full form.
5. *Publication Policy:* The annual output should be so adjusted, that no publication is delayed more than a year as a rule. This should mean more literature than the ARS or IAS now carries alone, even allowing for duplication.
6. *Discussions and Communications:* These should be invited and published, together with authors' replies. This is done in ASME and SAE transactions, and other US and European technical society publications. Although this practice delays publication (see 5 above), it is invaluable in bringing the reader a balanced picture of the state of the art in a certain area. It should also cut down the volume of comments and short notes."

WALTER UNTERBERG

"I had hoped that the ARS would handle this matter differently from the "steamroller" tactics used by the IRE. My sentiments in that instance were expressed in the 'Indian River Engineer,' a publication of the Canaveral Section of the IRE, a copy of which is enclosed.

"It is incomprehensible to me that a professional engineering organization would attempt to push a vote without an opportunity for the members at large to consider the facts and discuss the pros

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and cons. Steamroller tactics give an unfair advantage to the organized group pushing the merger."

H. A. POEHLER

"I hope that if such a merger occurs we will not lose the fresh invigorating approach to Rocketry and the Space Age taken by ARS and the Astronautics Magazine. I agree with you that the objectives of both societies are becoming more similar as the years pass.

"Many years ago (1948–1952) I tried, without appreciable success to encourage many of my IAS friends and associates in the airframe business to join the ARS and divert at least some of their attention to Rocketry and Space, but they chose to wait until we had a satellite in orbit before they were willing to believe that the Space Age would ever arrive. The older IAS members have long prided themselves on having open minds and being advanced in their thinking. They have made remarkable strides in flight within the atmosphere; but have not, until recently, been willing to accept the concept that outer space travel or exploration would ever become a reality. It is unfortunate that new ideas that are revolutionary are historically hard to sell.

"If a merger is accomplished successfully, please do your best to see that ARS will not have its young aggressive freedom of thought and action restrained by the older (in terms of membership growth), more conservative and mature IAS.

"I have been a member of both societies for many years. I believe I am fair in my appraisal. I have found ARS more stimulating and beneficial to me and my associates. I believe ARS will benefit through a merger as IAS is a very sound and most capable society having the highest of technological and professional standards. I will cast my vote in favor of merging, particularly if the Committee can select and retain the better values of each organization. As an active member of both societies if I can be of assistance in any way please feel free to ask for my help."

J. A. BROADSTON

"I hope both organizations will be willing to yield more than 50% of the way wherever compromises may be necessary. It is my fond wish that similar mergers may be effected to consolidate some of my other technical society memberships (which number seven more), and a successful outcome of the present venture just might be catalyst for other areas."

GILBERT S. BAHN

"Certain advantages would follow from a merger under one or two plans. For example, the IRE has a large number of sub-societies known as professional groups. This brings together specialists in each field. In the Physical Society there are some divisions but principally the division is by area of programs together with the publishing of a series of distinctly different journals.

"As a Physicist specializing in electronics and a member of both the Rocket Society and the IAS I can offer only the remark that the Rocket Society seems to me to be more interested in furthering the interests of the members than the IAS. Thus, I would hope that the momentum of the Rocket Society would be retained in any merger."

SEVILLE CHAPMAN

"Presently the ARS Journal is included in the membership dues while this is *not* the case in the IAS. I hope that upon consolidation, the current practice of including the Journal with the dues will be continued. If it is not, I will certainly vote against merger and drop my membership in IAS which I have been currently considering.

"I would now like to propose that one of the following actions be taken:

1. Combine ARS and IAS Journals into one publication and include with membership dues.
2. Publish two or more Journals for the combined Society and let each member choose one which will be included in his membership dues, paying extra if two or more Journals are desired.

"I, of course, prefer 1 above but if 2 is selected, the following general publication divisions are suggested:

1. Flight Physics
2. Missiles and Space Craft
3. Aircraft"

K. R. VINCENT

"I hope you will be able to come out with some sort of an estimate of the probable dues for the combined society prior to the final vote.

'The combined dues should, I hope, be less than the sum of the two separate dues, but not too much more than either of the separate dues alone. This seems reasonable on the basis of fewer total meetings in the combined Society. I think many members, like myself, belonging to only one of the Societies, have felt that they should really join the other one also, but have not done so because of the cost or trouble, etc. Maybe you can effect cost savings on the excellent Journals of both Societies by putting them under one cover, but not by cutting the editorial quality or quantity."

WILLIAM H. SMYERS JR.

"It is true that the ARS overlaps some of the areas covered by the IAS. This, however, is a fault of the ARS. There are those of us who joined the ARS because it was a *rocket* society. I have been very disappointed that the Journal so often included papers in the aeronautical fields. Particular emphasis was placed on this fault during the period our Journal was entitled 'Jet Propulsion.' That title clearly indicated that there was a group who were a little embarrassed by association with rockets. Before my time (I joined as a student in 1951) there must have been a similar feeling against the word 'Interplanetary.' I think it was a mistake to go so deeply into the aeronautics field. A merger with the IAS is simply a further manifestation of that mistake.

"I, for one, will probably vote against merger. At any rate, I hope that the organization will reorient itself to catch up with the technical progress, rather than follow it as at present."

CHARLES T. PALUDAN

"As the past chairman of AIA's Guided Missile Council, which recently studied and made recommendations to AIA Board of Govenors regarding the overlapping activities of Professional Societies, and in reply to your message of January 15, 1962, I urge you to exert all possible effort to bring about a consolidation of the IAS and the ARS.

"I believe the interests and objectives of these two societies have a great deal in common, and that a consolidation would both maximize the technical benefits to members and hence to the Country and minimize the risk of confusion, cost and waste of professional time occasioned by duplications of meetings on identical or closely related subjects."

D. M. HELLER

"We, the undersigned, as members of both the American Rocket Society and the Institute of the Aerospace Sciences wish to express our wholehearted support for a merger of these two societies.

"In our opinion, some of the more obvious and important advantages in such a merger are as follows:

1. Certain specialist conferences, if not too restricted in scope, could become annual events and, at the same time, retain the high calibre exemplified by the recent International Hypersonics Conference at M. I. T. A single large annual meeting should be sufficient.
2. Both a combined journal and a combined engineering monthly could have papers of a much higher quality. Further, the possibility exists of extending the 'specialists' concept to these publications, e. g., transactions of the ASME). The latter approach would afford the space for publishing conference transactions; an alternative which spreads the information more rapidly and is less expensive to the member.
3. Combination of such features as the I. A. S. 'Aerospace Technology as seen by the Panels,' 'Recent Soviet Advances' and 'International Aerospace Abstracts' with the A. R. S. 'State of the Art' and 'Russian Supplement' would keep the member better informed.
4. A substantial reduction in total membership dues paid would be realized by those scientists and engineers who are members of both societies.
5. Last, but not least, is the resulting increase in strength of the student regional branches of the merged society.

"In conclusion, we feel that the answer to the last two questions posed by you in your "message" is a very definite *YES*!"

JEFFREY A. MOORE
ADRIAN PALLONE
GEORGE WALDMAN
ALBERT D. WOOD
MARTIN ZLOTNICK

"We wish to state our opinions since we feel rather strongly on this matter.

We feel:

(1) There could be no improvement in the aims of a joint society. Only a restatement of the present ones.

(2) An integrated society must, by virtue of its size, have more general aims and with such would not serve the specialized interests of its members to as great a degree. Consequently, much interest in joining and/or participating in the activities of the society would diminish.

(3) We agree that merger would eliminate some duplication, but we feel that the accompanying loss of competition between the societies would be detrimental to a greater degree. Clearly the national welfare would not be as well served as we feel it now is.

(4) Finally a joint society of such grossness would lose some of its professional atmosphere."

GERALD E. TAYLOR
MARVIN HECHT

"In numbers there is strength and effectiveness, hence an enhanced ability to

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serve membership and our national interests. For a 'young' society, ARS has done remarkably well in its growth, organizational policy, and technical excellence. I strongly favor merger, providing present ARS standards are not diluted nor diverted."

JAMES G. CARROLL

"Since the merger of IAS and ARS was proposed a considerable amount of material has been written on the subject. However, it has been noted with dismay that the material emanating from both IAS and ARS national officers has been strongly in favor of the proposed merger. One would almost suspect that both sets of officers are under pressure from government and industry sources to accomplish the merger in the shortest possible time. It appears that the steam roller has begun to move! Strong expression of adverse feeling by the membership is now the only way of stemming the tide.

"The ARS members should consider carefully the basic differences in policy between IAS and ARS. While these differences vary from 180° out-of-phase to almost in-phase, depending on the subject, it is apparent that the IAS is ultra conservative and the ARS is progressive and dynamic. If you believe in, and support, the ARS policy of public and political communication, as opposed to the IAS head-in-the-sand attitude, then you should strongly question the advisability of the merger.

"Vast differences are also apparent in the administration of the two societies. The ARS officers and staff are responsive to the sections and the membership. The technical committees have complete control of meetings. On the other hand, it seems that the IAS is governed by an impenetrable dynasty of conservatives who allow a paid staff (double the size of the ARS staff) to control the society, even to the planning of technical meetings.

"It is expected that a merger plan will be presented to the IAS and ARS members by May or June of this year. No ARS member can escape the responsibility if the merger is accomplished and the resulting society turns out to be a big dull IRAS (Institute of Repressed Aerospace Scientists). Advantage or disadvantage—it remains to be seen! However, let us be alert lest we be led down the primrose path to an old man's club plush with wall-to-wall conservatism."

HUGH GARDENIER

"I am a member of both organizations. Their respective policies, activities, and spirits of cooperation with similar or parallel groups have been a source of satisfaction to me. The increasing similarity of interests of IAS and ARS as evidenced by tendencies toward joint endeavor on local and national scales seem to give support to feasibility of merger."

HARRY S. BLACKSTON JR.

"Just a short note of strong endorsement of the proposed merger of the ARS and IAS. I happen to belong to both societies. However, my view is also shared by all the people at Yale who are in either one only.

"Our main interest from the university viewpoint would lie in a reduction of technical meetings of overlapping content and in a speed-up of publication of the more technical material."

PETER P. WEGENER

"Some personal thoughts on such a merger, however, lead me to the following comments which I am sure you and others involved will undoubtedly consider as the negotiations proceed.

A combined society, it seems to me, should be a new society divested of all associations in terms of loyalties and traditions from the society being merged. This, of course, takes a little time, but I would feel that a new society embracing all aspects of flight should be something new and its members should be members of this new society, not previous members of the ARS or previous members of the IAS.

To be truly effective the merger must make itself felt through all aspects of the societies such that committees and subcommittees will be eliminated where duplication exists, and not retained, again, because of prior society associations. Technical people being what they are, I am sure would accept this approach probably a good deal easier than many others.

I can also visualize an entirely new name, preferably one that again does not hark back to either merging group. There will, of course, be the problems of administration and the natural tendency, I suppose, for some members of one or the other society to hope that the new head of this new society comes from their group. I think, however, if the new society does present a completely new image that this, too, will be overcome."

GEORGE J. BROWN

"I simply wish to record personal enthusiasm for the prospect of fewer national organizations in our field. Such a merger as you outlined it would, in my opinion, be highly beneficial. I hope it happens. Many of my associates are of the same frame of mind."

MILTON B. TRAGESER

"Your statement to ARS Members concerning the possibility of a merger between the IAS and the ARS was most welcome. I strongly support any effort that may result in such a merger. It is my personal opinion that such a merger would result in a strong society that could better serve the needs of the aerospace technical community."

HAROLD B. FINGER

"In particular, I believe an integration of the societies would be of benefit to many local sections. Let us consider the Orlando area, where I can speak with some knowledge, having been a charter officer of both sections and a past president of the Orlando Section of the ARS and a past chairman of the Central Florida Section of the IAS.

"We have found that local section activities conflict, and that attendance at meetings suffers. Many people limit their professional society meetings to a certain level and simply will not attend meetings for both the IAS and ARS in a single month. The attendance problems caused by geographic location could also be mitigated by a merger. When the Central Florida Section of the IAS holds a meeting at the Cape, only a carload or so will drive over from Orlando, and vice versa. Very few ARS members will expend the effort to come over from St. Petersburg to a meeting of the Orlando Section of the ARS in Orlando. If the societies were integrated, there are sufficient members to form a separate section in the Cape area and one in the Orlando area, and perhaps even one in the Tampa-St. Petersburg area. Members would be better concentrated geographically, and participation in section affairs should increase accordingly.

"I am not so naive as to believe that upon a merger I will continue to receive all of the benefits and publications of both societies, but only pay a single membership fee. However, I do feel that integrated services could be supplied at a rate less than the sum of the present *two* fees."

DONALD K. ROBERTSON

"This seems both reasonable and timely, and should lead to improved contribution and services to all members of the present organizations.

"In order that you may better place this response in the distribution of responses—

"I was and am somewhat opposed to the consolidation of the IRE-AIEE, since they did not appear to have as significant an overlap of members, nor in the case of the IRE was it clear how such amalgamation would benefit its members."

GIB WOLFE

"It was very interesting to read your letter of January 15 to American Rocket Society members concerning the possibilities of consolidating or integrating our organization and the IAS. The subject is one of significance not only to our various professions but also to the nation's state of preparedness and well-being.

"I want to express my interest in assisting you and the committe in any way I can."

CHARLES F. HARTEL

"I am 100% for it. The technical fields of interest of the two societies have much in common and will have even more in common as time progresses.

"Both societies are having financial problems and have raised the membership fees. We members also have financial problems and I would rather solve these by paying an adequate fee to one society, rather than have to choose between one or the other.

"May I suggest that you give some thought to the manner in which the Institute of Radio Engineers has organized subgroups that hold specialist meetings in their own areas of technology, such as the Professional Group on Military Electronics, etc. This seems to be a fine way to have an over-all, large professional society and also serve the specialized interests of the many separate areas of interest.

"It seems to me there are some inherent obstacles to mergers of this type. Speaking frankly, I think one of the most serious comes from the permanent staffs because their positions may suffer. Another obstacle is from the small minority of 'old-timers' who helped found a particular society and may feel that another society is a bunch of upstarts and not good enough for them—or some such natural and human attitude. I am inclined to think that not too much attention should be given to either of these points of view. The main consideration can be the improved service that the merger can provide to the majority of its members. Professional societies should be organized facing towards the future, rather than looking into the past."

DELBERT W. JONES

"I feel very strongly that the time has come when it is absolutely essential that the number of professional societies be

reduced. It seems to me that at the very least, we should be able to get down to one in the professional area covered by the 'aerospace sciences.' I think it is most important in that area because we begin with the difficult fact that this is almost the only area known to me where a professional society covers a field that is in fact highly diversified with respect to the application of technical and scientific disciplines. The traditional societies, and even the newer ones like the Institute of Radio Engineers, had at least a basic orientation to a recognized area of engineering. Here in the Rocket Society and the Institute of Aerospace Sciences (and I believe there is another that I cannot recall at the moment), we do not have that cohesive element. Instead, we are dealing with a field of products, the development and production of which cover the total gamut of scientific and engineering knowledge.

"Almost everyone who belongs to the ARS or IAS is also involved with one or more of the professional engineering or scientific societies devoted to his specialty. That much duplication is perhaps tolerable, but more should be avoided.

"I am therefore wholly in favor of any action that will bring together under a single professional banner all of those who have a fundamental interest in space and astronautics."

J. B. Medaris

"For many months we the 'rank and file' of the American Rocket Society have been presented various pieces of literature advocating ARS/IAS consolidation. In this literature as well as your editorial, I am presented quote, 'Members of both societies can expect to be asked to vote on a definitive proposal this summer.' Now the concept of 'voting' is a democratic heritage which I respect and cherish very highly, but in exercising this privilege I feel that I should know both sides of the issue on which I am proposing to vote. In the plan of consolidation of IAS and ARS, you as National President have had at your disposal the manpower and machinery of the national organization to promote the consolidation effort. You are going to present to me a proposal on which I am to vote 'yes' or 'no' and yet up to the time of voting, I have only been presented the reasons why I should vote 'Yes.' Now doesn't this seem to be a little one-sided?"

L. H. Horn

"I believe that there is a general realization on the part of both ARS and IAS local membership that though the societies differ substantially in their origin, their evolution into the same type of astronautics society is almost complete. As president of the local ARS section last year, I polled the ARS membership with respect to the feelings of members about joint IAS/ARS section meetings. At the same time the chairmen of the local IAS section conducted a similar poll. In both organizations the sentiment was about 90% in favor of joint meetings. I suspect that not significantly less than this percentage will be in favor of a merger.

"We have sampled the opinions of members of the Rocky Mountain Section of the ARS regarding aspects of the proposed merger of the ARS and IAS. I am enclosing a copy of the letter which accompanied the questionnaire together with the results. You will note that the local section appears to be overwhelmingly in favor of the merger.

1. What dues would you be willing to pay to a merged society in order to continue receiving present services?
   - 28.8% (19) Less than $20
   - 62.1% (41) $20
   - 9.1% (6) More than $20
2. How do you feel that national officers and directors should be selected?
   - 65.1% (43) Direct ballot with more candidates nominated than offices.
   - 21.2% (14) Balloting at annual meeting.
   - 13.7% (9) Appointment by the current administration.
3. What publications do you feel should be furnished as a part of dues?
   - 21.2% (14) Monthly journal
   - 22.7% (15) Monthly engineering magazine
   - 56.1% (37) Both
4. Would you be in favor of holding major public education programs at appropriate intervals such as that held in connection with the Space Flight Report to the Nation (Oct. 1961 Annual Meeting Theme in New York)?
   - 81.8% (54) Yes
   - 16.7% (11) No (One 'no opinion')
5. Assuming that the proposed conditions of merger were favorable to you as indicated above, would you approve the merger?
   - 95.5% (63) Yes
   - 4.5% (3) No"

Denis J. Zigrang

"In the professional societies, as in our own industrial societies, the intent and spirit behind competing groups is invaluable. The possible apathy and feeling of 'where else can a potential member go?' that may develop among less dedicated leaders, to me more than outweighs the possible advantages that may be derived from the proposed merger between the IAS and the ARS. I hope this is among the considerations you are making when considering the long term effects of such a merger."

Russell E. Loftman

"Mirabile dictu! . . . Perhaps ARS and IAS will get together—I sure hope so!

"Whoever thought up this super-member grade in ARS must have been contemplating such a move. To be cast in the mold of free men would seem to be distinction enough in these turbulent days."

E. A. Quarterman

"I feel that the merger of the American Rocket Society and the Institute of Aerospace Sciences would enhance the profession, as one society could serve better than two of such similar nature. It seems to me that general duplication of society missions serves no useful purpose and, indeed, tends to dissipate the efforts of the officers and members. Rather than using the name of either of the existing societies, I suggest that the new organization be entitled 'Institute of Space and Aeronautical Sciences' (ISAS)."

Howard A. Wilcox

"Presently, both organizations have their own publications, and as an advertiser we contract for space in their respective books. Obviously there is a duplication or overlapping of readers, and knowing today of the great number of magazines that go across the desk of the executive, designer, engineer, etc. many books are not read, or possibly are only scanned.

"As only one of many angles that must be considered in uniting the two organizations, it would seem that the consolidation of their books would enhance readership and make their respective publication of the organization far more valuable both from the standpoint of the member as well as the advertiser.

"My reaction to the proposed idea of consolidation is most favorable."

P. R. Johnson

"Having been in an informal luncheon group at a recent ARS meeting in which both ARS and IAS members talked of possible merger, I am impressed that such a merger is generally desirable. Speaking as one of the less active members, I await with much interest your coming words of progress in working out the necessary details."

Joseph A. Bergantz

"I would like to cast a most emphatic vote in favor of the merger of IAS and ARS. The reasons for consolidating the various 'space' societies far outweigh any objections that I can think of.

"An important consideration for your committee would be the degree of duplicate memberships already existing. I am a member of both organizations and believe this to be quite common. Could you obtain an accurate estimate of the number who are members of both societies?

"Obviously there may be short-sighted objections from the paid staffs of the merging societies. However, the combined group should provide plenty of jobs for really competent individuals."

R. A. Carpenter

"One could surmise from the series of official reports on the proposed ARS–IAS consolidation that the leaders of the two organizations are commendably concerned not only about the wisdom of the move but also about the attitudes of the grass-roots membership. The purpose of this note is to assure you that from the vantage point of a member concerned with technical (rather than managerial) activities in a large aerospace organization I see around me only approval of the aims outlined for the Consolidation Committee. They seem to go to the heart of the problem.

"A large number of us decide which meetings we should attend or contribute to on the basis of the program and not on the basis of membership. In other words, it is the contents and quality of professional papers which matter to us. In recent years, the boom in meetings resulted (for various understandable reasons), in a perceptible dilution of quality of papers presented before both societies. The consolidation would undoubtedly counteract this trend; it offers an opportunity for more effective reviewing control and especially for more consistently successful sessions of the 'specialists.'

"There are, of course, many other important facets of the problem, but the intent of the note is to single out the main issue which prompts many of us to support the striving towards consolidation, and convey to you this general support."

Mark V. Morkovin

"The recent questionnaire regarding

Before "Principles" Statement

IAS merger was responded to with evident interest (by ARS members in the Greater Philadelphia Section). There were 281 returns (over 40% of inquiries).

1. What annual dues would you be willing to pay to a merged Society, in order to continue receiving present services?

		Votes
Present or	$ 0–$14	10
	$15–$20	188 (67%)
	$21–$30	48 (15%)
	$31–$50	12
	Other	23

2. How should National Officers and Directors be selected?

	Votes
Direct Ballot with one candidate nominated for each office	36 (13%)
Direct Ballot with more candidates nominated than offices	206 (73%)
Proxy with no name candidates	7
Appointment by the current administration	29
Other	3

3. What publications do you feel should be furnished as a part of dues?

	Votes
Monthly Journal	56 (20%)
Monthly Engineering Magazine	50 (18%)
Both	163 (58%)
Other response	12

4. Would you be in favor of holding major public education programs at appropriate intervals, such as those held in connection with Space Flight Report to the Nation?

	Votes
Yes	239 (85%)
No	40 (14%)
Other response	2

5. Assuming that the proposed conditions of merger were favorable to you as indicated above, would you approve the merger?

	Votes
Yes	267 (95%)
No	10 (4%)
Other response	4

Results compiled by—"

NEIL E. MUNCH

"We are members of ARS. We are not members of IAS. We can, nevertheless, appreciate the advantages of a united technical organization to represent all segments of engineering and manufacturing.

"The writer directs three sales divisions for Raybestos-Manhattan. I already have twelve weeks scheduled in 1962 for attendance at industry conventions and will no doubt have to add a couple more before the year is over.

"This represents a larger share of a business year than is warranted by the good to be accomplished. We are heartily in favor of any consolidation which will enable management personnel to make more effective use of their time."

J. A. BETTES JR.

"I am one of the 16% who already form a unified membership. I have been very disturbed to see how the competition between the two societies has caused an unwarranted increase in meetings and papers with consequent deterioration in quality. In the past, the emphasis of the two organizations has been different but recently they have come together as the result of the change in technology and it is only conceivable that they would be even closer in the future."

ABNER KAPLAN

"I am a member of both organizations and am *completely in agreement* with the merger, which should go through at the earliest possible date."

ROBERT J. EDEN

"The steps being taken toward consolidation with IAS certainly do meet my approval. The combined organization would eliminate wasteful duplication and should be capable of doing a much better job for the profession.

"For a number of years I have been receiving the IAS publications through our corporate membership and recently became a member of ARS. As your January 26 letter points out, there is considerable duplication."

W. R. KRUESI

"I have long felt that the coverage of the aerospace field by so many technical organizations has exceeded reasonable bounds for reasons that have been obvious to everyone. Although I am a member of both the organizations under discussion and do pay the various fees required, my main interest is to see the aerospace field have one voice. In short, this is visualized as one organization that, in addition to being divided by geographically located chapters, might also be divided in the other direction by specialties. This would immediately eliminate major meetings in specific fields that are sponsored by various organizations. In addtion, the combined organization could make for stronger local chapters or enable a wider geographical spread of chapters since small groups of IAS and ARS members could now be combined to form a respectable sized chapter without traveling large distances which may have been necessary before.

"I would also like to suggest the possibility of interesting those members of the ASME, SAE, and other recognized engineering organizations who have aerospace interests to join in the new IAS-ARS organization. With the approval of the other engineering organizations, it may be possible for those members who wish to switch to do so without paying a new initiation fee. I realize that this particular suggestion must be pursued delicately, but it would serve to bring another group of individuals with aerospace interests into one mother organization and would further strengthen the aims of the new IAS-ARS organization."

S. FERDMAN

"The American Rocket Society has unquestionably, both directly and indirectly, performed a most important service in the development of our aerospace science technology. I believe, however, that we have now reached a point where continued growth and improvement in the service for our profession can best be accomplished by a combination with another similar organization such as the Institute of Aerospace Sciences. As a member of both the American Rocket Society and the Institute of Aerospace Sciences, I am decidedly in favor of your merger plans."

J. E. ARNOLD

"As Vice President of the local section (Detroit) of ARS, and as an executive of a company vitally concerned in the areospace industry, I want to put myself firmly on record as being very much in favor of this merger."

B. W. BADENOCH

"I would like you to know that I am very much in favor of an ARS and IAS merger. My approval stems not only from the reasons which have been given in the publicity released to date, but is also based on the favorable effect which I feel such a merger would have on aeronautical education in the United States.

"As you well know, there is considerable confusion in academic circles about what properly constitutes an education in aeronautical engineering. This confusion is abetted by the fact that the educators have no single society to look to for advice, counsel, and collaboration. I therefore feel that a merged ARS, IAS society could have a profound effect on the training of engineers for the future."

HAROLD DEGROFF

"This seems to be an excellent idea from the standpoint of minimizing the number of meetings as well as improving the technical level of the meetings.

"Since I am a member of both societies, as well as being a member of both Panels on Hypersonics, the need of a merged society to serve the interests of individual members, universities, government agencies, and companies is evident to me. Good luck on the success of the proposed merger."

HENRY T. NAGAMATSU

"As a member of both the IAS and the ARS I should like to endorse heartily your effort to consolidate the two organizations. Most of the members with whom I have talked concur in this program of consolidation even though we recognize that it involves the usual difficulties when any two companies engage in a merger."

WILLIAM BOLLAY

"In reference to the proposed ARS-IAS merger, may I say (as a member of both societies and a committeeman, ARS) that I heartily favor the consolidation. In my opinion, just the reduction in number of meetings and journals more than compensates for the admittedly difficult adjustments that must be made."

BRUCE W. PINC

"In general, we feel that the merger will be an excellent step in regard to national meetings and national activities. With two large, powerful, overlapping societies like the ARS and IAS, competition and duplication of effort, both in preparing meetings and in attending them, are inevitable. This is not to say that reduction in the number of technical societies is always desirable per se. I personally believe that small limited-interest organizations should spring up whenever the need arises and should be nurtured up to the point at which they begin to encroach on existing domans, at which time the conflict should be resolved."

A. P. PENNOCK

"I am writing to express my enthusiastic approval of the possible consolidation of the IAS and the ARS. May I also

add that all of my colleagues with whom I have talked support the proposal. We hope also that such a merger would result in an improvement in the technical and professional level of the meetings and publications of both societies."

JAMES E. BROADWELL

"First of all, I am a member of both organizations, and believe that they have been of beneficial service to the aeropsace industry in the past years. However, it has been increasingly obvious that there has been a developing redundancy between the activities of the two groups.

"From the standpoint of our business, we believe that a consolidation would be extremely desirable and are wholeheartedly in support of this plan. We feel that it will improve the dissemination of worthwhile technical information on a non-repetitive basis; that it will allow us to devote the time to prepare occasional well-qualified technical papers to be presented to a consolidated appropriate audience; that it will minimize the requirement to participate in desired seminars and trade exhibits.

"Locally, the chapters of the ARS and IAS have already adopted plans to hold meetings primarily on a joint basis. Further, I am sure that the local directors unanimously recommend consolidation. Best wishes for your success in working to this end."

RICHARD H. OLSON

"In addition to the advantages which you mentioned in your recent letter, the consolidation will greatly strengthen the local chapters, providing a basis for more effective and noncompetitive meetings."

G. R. SHIELDS

"Why not select a name a little more neutral as to the sciences and professions involved? A name such as 'The American Institute of Aero and Space Sciences,' or even more encompassing, 'The American Institute of Aero-Space Sciences and Technology' would in my estimation be more satisfactory. Such names would still have the connotation of favoring aeronautics and astronautics."

PER A. LARSSEN

Received After "Principles" Statement

GENERAL COMMENTS

"I believe the knowledge and purposes of both ARS and IAS have progressed to the state that much more can come from their combined efforts and talent towards accelerating our nation's need in a field now becoming an actuality."

EDWARD W. JOHNSON

"Congratulations for a fine presentation. AIAA Consolidation will cover a vast technical area and trust ARS past performance will not lose its identity. There is a close association between the two organizations. Nationally, we need a strong society to represent our talent and industry in a continually expanding science."

HENRY F. WINTERLING

"I do not see why ARS must merge into the IAS. If this consolidation is a true merger, then one organization does not merge into another one."

LOREN E. BOLLINGER

"After so much sincere effort has been spent on the proposed A.R.S.–I.A.S. merger, it is very difficult to take an adamant stand against the consolidation; however, the stakes are high and it must be done. Although it may be considered heresy, I believe the merger would be catastrophic for the Societies, members, and the technical interests of the nation. The only possible result of a consolidated organization would be a society so large in size and scope that its very nature would require a conservative approach in a field that thrives on progressive thinking. It would be and must be big business and in any large business the engineers and scientists would be subservient to business administrators, as they should be; however, in a technical society, the technical man must reign supreme. That the merged society would follow the pattern discussed is evident in the complex administrative organization given in Chart 2 (organization composition) of the Principles of Consolidation. Particularly, the proposed Board of Directors deserves attention. Why distinguish between technical directors and other types?

"The basic argument for the merger centers about one theme. The two Societies perform in numerous areas redundant functions in terms of meetings, publications, service, etc., at great cost to the corporations and the nation. This financial argument is a very poor one. The cost to the nation is trivial compared to the over-all space and defense budget. If one good idea is stifled, the cost would be much greater. Similarly, the argument about too many meetings is a poor one. Why don't the engineers practice a little self-restraint in the meetings they attend and the papers they submit. The companies complain about attendance at meetings, yet they encourage their staff to present and publish papers—publish anything. Merging of the Societies will not stop the overlap of meetings in the aerospace fields.

"The A.C.S. and A.I.Ch.E. still will have meetings on chemical propellants and propulsion, the Combustion Institute on combustion, the A.S.M.E. on propulsion, power, fluid flow and heat transfer, the S.A.E. on propulsion, the Amer. Phys. Soc. on space physics, electrical propulsion phenomena and MHD, the American Nuclear Society on nuclear propulsion, etc. We don't need fewer meetings, we need better meetings and the competitive spirit of the two Societies is beginning to give us just that. Stronger control by technical people, courage to reject poor papers, to criticize poor presentation, and to stimulate open technical discussion, more specialist conferences, etc., will create better meetings, not merger of the Societies.

"Government and business are obligated to support many technical societies for the same reasons that they are obligated to support many universities. For the sake of the future we must realize that these are the wrong areas for cost reduction. Certainly, all of us can think of much better ways to save the government and corporations money."

IRVIN GLASSMAN

"I strongly endorse the consolidation as explained. I also strongly recommend merger with other societies, such as AAS, but only after the present proposal is either carried or rejected by the membership."

KENNETH H. KUHN

"I am opposed to the consolidation as a whole. These comments should be anonymous, and the final vote on the consolidation should be by closed ballot."

NO SIGNATURE

"The principles of consolidation are clear, equitable, and deserving of the wholehearted support of every member of both organizations. Congratulations!"

ROBERT H. GOSLOW

"I also endorse the merger as a member of IAS."

KURT MOSES

"I believe the interests served by each organization are disparate enough that each could well stick to its familiar province. In particular, I have some hope of seeing fluid mechanics regaining its respectability under IAS, while the chief prospects for stock ingredients to ARS outpourings will be some development of ion engines or Van Allen radiation belt suppressors useful on Pluto."

RAYMOND H. CRAMER

"The ARS is a stronger body than the IAS in modern technology. LET US MERGE AS EQUALS. The present proposals make IAS the top body. We are just supplicants!"

LIONEL A. DICKINSON

"I am against the loss of definitive identity—both of group and purpose—which will occur to the ARS under these conditions."

B. BRENTNALL

"Why can't the AIAA be instituted initially instead of having the ARS merge first with the IAS?"

MAX HALEBSKY

"This consolidation is needed as that of the IRE/AIEE. Why not bring in the AAS too?"

ROBERT H. LIGHT

"Being a member of both organizations, I look forward to consolidation."

CHARLES S. CASCIONE

"Ambitious plan, but excellent."

CHARLES J. O'BRIEN

"The plans for consolidation are very well organized."

RENE E. DREW

"Let's be on with it!"

WILLIAM F. BARRETT

"Don't merge!"

THEO. G. STASTNY

"I strongly believe this will be to the best interest of both organizations."

DAN G. KIMBELL

"I am convinced that everybody will benefit from this consolidation."

WILLY LEY

After "Principles" Statement

"I strongly endorse consolidation of the two societies."

IRVING FORSTEN

COMMENTS ON PUBLICATIONS

"I would like to see members receive both Journals 'A' and 'B,' or a combined 'A' and 'B' journal, free of charge. If this is not possible, the charge to the member for the second journal should be nominal. For the greater part of the membership, the journals sent to them are their most tangible relationship with their society. The proposed 'either A or B' plan would have a decisive effect, contrary to the intent of consolidation."

BERNARD A. TEITELBAUM

"Journals 'A' and 'B' should be included as part of membership, even to the detriment of other services. These publications are the real meat of any technical society and should be served whole."

DONALD L. WITT

"Five journals is a lot of work for a new starting society—even consolidating two. How about starting with two journals of excellent quality—then slowly add the others. We need good journals."

P. H. CARDWELL

"I would prefer that both Journal 'A' and 'B' be made available—perhaps at an additional charge, to those who wanted the second."

J. BERK

"I sincerely hope that the 'Letters' Journal 'D' will be available without charge to members. This would be a most important issue—responsible for keeping the membership currently informed of the preliminary research findings of others—a most important service."

JOHN D. LAIRD

"Sorry to see the non-engineering journal split into two sections issued separately. The split cuts right across my fields of interest."

CHARLES E. HOFFHAUS

"Include the proposed quarterly magazine as one of the optional choices with Journals 'A' and 'B.'"

EDWARD M. RISLEY

"The two (2) Journals A and B include most all disciplines except *Human Factors*. Last account noted approximately 1000+ members in ARS showing interest in this area and they should have a forum for information exchange."

STANLEY C. WHITE, L/COL.

"It is desirable, if possible, to combine Journals A and B. Combined or otherwise, these journals should be extra-cost to members. This could permit either a reduction in dues or increase in income. I feel that too many publications are planned."

JOHN R. BIRCHFIELD JR.

"No mention of bioastronautics, Man/Machine relationships—role of man in aerospace systems, etc., as worthy subject of papers. This is usually the biologist's only hope of effective contact with engineers."

BRUCE W. PINC

"To reduce cost of mailing and publishing, combine Journals 'A,' 'B,' and 'C' for the first two years, edited and published monthly."

MICHAEL G. BECCIO

"My main benefit from being a member of ARS is the two publications; therefore any change in the quality of editorial policy would make the AIAA of lesser value to me."

TOM R. STRAYHORN

"I would like very much to continue to receive a journal such as ASTRONAUTICS or at least a news and general information bulletin."

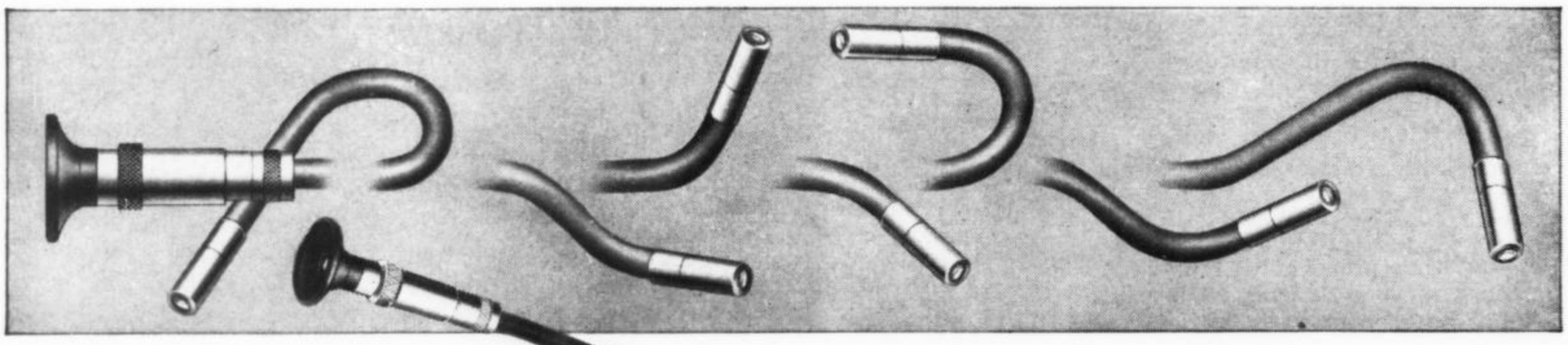
EDWARD LANTZ

"The Journals A, B, and C mention many topics, but none lists anything remotely near the Life Sciences area. Granted, we have our own journals, but so do the other specialties. If we are to be involved, and be part of the cross-fertilization bit, there may be a better forum for us too. (I am sure this is an oversight—but reassure us.)"

PAUL WEBB, M.D.

"The second journal ('A' or 'B') should be made available to each member for a nominal charge."

IRA M. GRINBERG



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" Would prefer that:
(a) Journals A and B be combined and available to members, or
(b) One free and the other at nominal charge—max. $5.00/yr., or
(c) A rearrangement of subject headings such that Space Physics, Meteorology, Control and Guidance, Instrumentation and Communication, and Aero and Gas Dynamics be included in one Journal."

HUGH J. MCLAUGHLIN

"The venture into numerous journals, especially item 5 of Section II, has me concerned, especially during early stages."

K. MABUCHI

"I would think that most members would be more interested in receiving Journals A *and* B, and having Journals C and/or D available by subscription."

R. G. RAGSDALE

"One publication per month for each member is enough, I think. Choice of specialty is good, and quarterly summary fine."

E. M. COAN

"Publishing four separate Journals will be a financial drain on the new organization. I suggest that general publication, similar to the present ASTRONAUTICS be distributed to the general membership. Special technical interests could be served by professional group publications per IRE."

S. D. DOUGHTY

"Journal 'D' should be available to each member free of charge."

ALFRED EGGEN

"I believe you propose too many publications. . . . ."

PAUL R. JOHNSON

"The publications are the principal benefit I get from membership. I like the idea of journals A, B, C, D, and especially, the new quarterly journal. The Russian Supplement is also of interest. If money were not a problm, I would prefer that journals A and B not have any advertising, like the IAS Journal and publications of the American Institute of Physics."

HOWARD C. RODEAN

"Prefer one magazine with all material in it rather than separate A, B, C, etc., magazines."

ALLEN W. NILES

"Journal 'D' should have high priority. Quarterly journal should have low priority on financial support."

MELVIN L. ROBERTS

"Consolidation of Journals A and B might have the desirable effect of broadening the material available to readers."

RICHARD L. DAVIS

"I prefer that all journals published by AIAA be available to each member free of charge."

JOSEF BOEHM

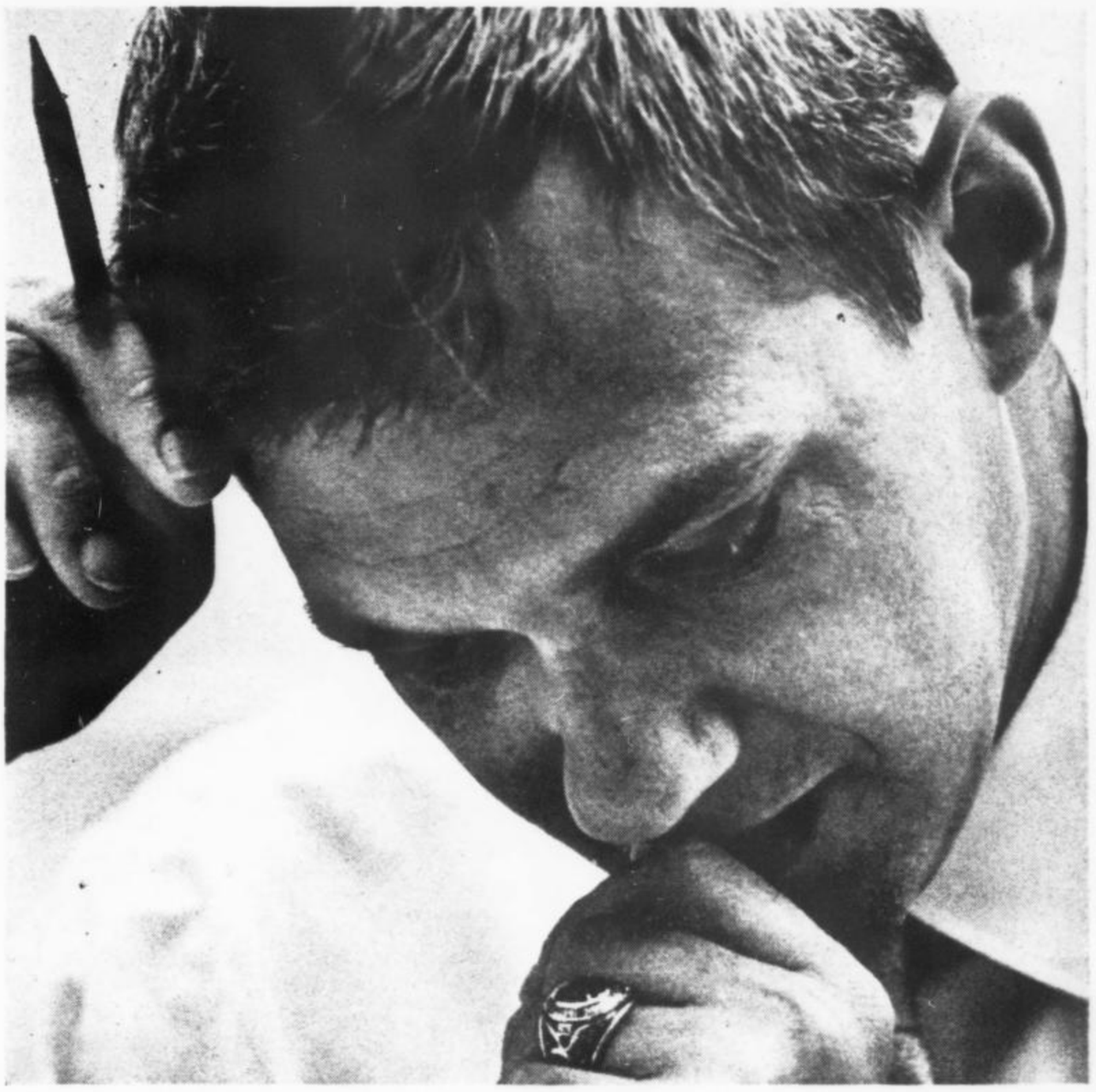
"What happens to ASTRONAUTICS? Will it become Journal C?"

CHARLES MCCRACKEN

"Journals A, B, D, and Quarterly sound like they will waste as much money and time as the ARS Journal does now. Put them all on a subscription basis and stop trying to stuff them down the Membership's throat."

J. A. JANOUSEK

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Engineers to work in data reduction.
Scientists who know structures research and dynamics.
Scientists who have done supersonic aerodynamic research.
Scientists experienced in working with information and sensing systems, platforms, infrared, sensors, flight controls, airborne computing and data handling systems.
Engineers familiar with programming, operations, and instrumentation for ballistic missile flight test.
Reliability Engineers to assess the reliability and to optimize the configurations and mission profiles of space systems.
Chemical Engineers to work on the development and applications of structural adhesives for aerospace vehicles.
Metallurgical Engineers for research and development on materials and joining.

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"Combine Journals *A and B*, use advertising if necessary. If not combined, what will be the cost per year of the journal not taken free with membership? Make quarterly journal a monthly one, available on newstands."

LEO J. MANDA

"Doesn't seem to be any specific mention of papers pertaining to complete systems-maybe implicit in the description of Journal 'C?' "

MAJ. JAMES K. HOEY, U.S.A.

"Publication of technical papers in two separate journals A and B is a good idea."

ROBERT E. DANNENBERG

"Favor single journal. Interested in more details of financial plan and in keeping dues down, if possible."

RICHARD MADEY

COMMENTS ON NAME

"The society should be primarily devoted to astronautics; Aeronautics should be represented by a separate society or as a subgroup in the American Institute of Astronautics."

MAX HALEBSKY

"AIAA is satisfactory, but would have preferred a shorter title such as 'American Aerospace Institute.' "

S. D. DOUGHTY

"Proposed name is utterly undistinquished. Can't you come up with something having a little more force to it?"

DR. JEAN I. F. KING

"I would like to see a more simplified title for the organization."

R. A. GAISER

"Care must be taken that ARS point of view not be swallowed up. Proposed new name is a bit turgid."

JEROME EISENBACH

"I suggest only that in view of its historical significance that some *formal* means be developed to continue the name 'American Rocket Society,' in existence somewhere within AIAA's structure."

EDWARD W. S. HULL

"I am *not impressed* with the new name . . ."

LT. COL. HARVEY J. SORRENSON

"Would like a shorter name . . ."

LEONARD A. GUARALDI

"Proposed name (AIAA) sounds unwieldy. How about American Aerospace Institute of American Aerospace Society?"

THOMAS J. KELLY

"I prefer American Society for Astronautics as a title. Institute implies a working technical staff and is misleading as such."

STEPHEN J. FRAENKEL

"The name should remain American Rocket Society."

B. C. DANNER

"I feel that the proposed new society name is much too long to be remembered effectively by the general public. The terms 'Aeronautics' and 'Astronautics' may be amply conveyed by the term 'Aerospace.' Therefore, I propose that the new society be known as the American Aerospace Society."

JAMES H. WALLACE

"I do not care for the proposed name. I believe the word 'rocket' should be part of the organization's title."

D. C. JONES

"I prefer title to be shortened to: 'American Institute of Flight' (AIF) or 'Aerospace Society of America' (ASA)."

CHARLES W. BENFIELD

"The proposed name is long and unwieldy."

RONALD G. ADOLPH

"I do not approve of the merger. The name of the American Rocket Society has become fairly well known. The new organization will be new. It will not have the identity of either outfit."

DONALD CARL

"I am opposed to changing the name. Keep American Rocket Society!"

HOWARD G. HEMBREE

"I do not like the proposed name—(1) too long and complicated (2) loses Rocket Society identity."

G. RICHARD LOTT

"Too bad you couldn't get agreement on a briefer title such as American Aerospace Institute, but that's a minor matter now."

D. V. WADSWORTH

"But it looks like you could have done better on the name. Too big!!"

PAUL BLUNT

"I feel that the acronym AIAA is unfortunately similar to the AIA (Aerospace Industries Association) and will inevitably result in much confusion."

DOUGLAS M. HELLER

COMMENTS ON FINANCES

"How will the difference in financial resources between ARS and IAS be resolved during consolidation?"

STANLEY I. LIEBERMAN

"Impression is given that way out of the 'red' is to consolidate. If we can't stand on our own feet, raise the dues to $50 across the board."

D. W. GAILEY

"Very well thought out or excellent job! Onc touchy point, however, is the equitable adjustment of the two societies assets. This issue is obviously glossed over in Section III, Paragraph 3."

ARTHUR E. BRYSON JR.

"Suggest strongly increased effort to recruit organizations as Corporate Members, with incentives such as Library Loans."

JOHN M. STEPHENSON

"What rights accrue to IAS by p. 9 paragraph 5?"

DR. WILLIAM E. FELLING

"Have you given consideration to the fact that the income of the AIAA will be considerably less than the sum of the incomes of ARS and IAS because of membership overlap?"

WILLIAM L. BADE

COMMENTS ON ORGANIZATION

"Seems to be 'over-organized.' "

MARVIN WECHSLER

"Too much obvious 'overhead.' The total 'staff" of the combined societies

should not be any larger than the present IAS staff."

I. L. HELMS

"Services to members—this section is a "mish mash" particularly paragraphs 2, 3, and 4. More care should be given to the tangible products of the organization—its publications and the documentation of the art, science, engineering should be resolved into logical sectors of interest and responsibilities."

ALEXANDER LEVIN

"Have not made up my mind as there is little proof shown of the promised results. Now-a-days things get bigger like the government, but not necessarily better. Personally I'd like to see it kept at a high quality level and less scrambling for prestige and position."

PAUL CARPENTER

"I am in favor of three regional affairs vice presidents."

RICHARD L. DAVIS

"There should be two names per position for each officer nomination—more democratic."

MAX HALEBSKY

"Combined activities of AIAA would seem to warrant three vice presidents for regional affairs."

HAZEN O. SUTTKUS

"How will secretariat be established from existing staffs of ARS and IAS?"

WILLIAM E. FELLING

"Enlarge National Nominating Committee."

D. J. SALLEY

"Treasurer should serve two years. It takes one year to learn the job. Elect regional directors so that both directors from each region do not change at the same time. Provide more continuity on regional problems."

JOSEPH H. BACH

"There should be two candidates for veep and treasurer at least."

WILLIAM D. STUART

"Vice President for regional affairs—I favor IAS view of three vice presidents, one from East, Central and West Regions."

MYRON MADURAS

"Three regional vice presidents are favored. The responsibility of the vice president for technical activities should be more clearly defined, i.e., executive management of technical committees and specialty groups at the national level. Technical specialty groups recommended to be organized under the administration of the technical committees."

DONALD J. HEALY

"I strongly urge that multiple choice voting for directors be established as permanent feature (except perhaps for first year of operation)."

MITCHEL H. BERTRAM

"Recommend following ARS point of view on vice president for regional affairs."

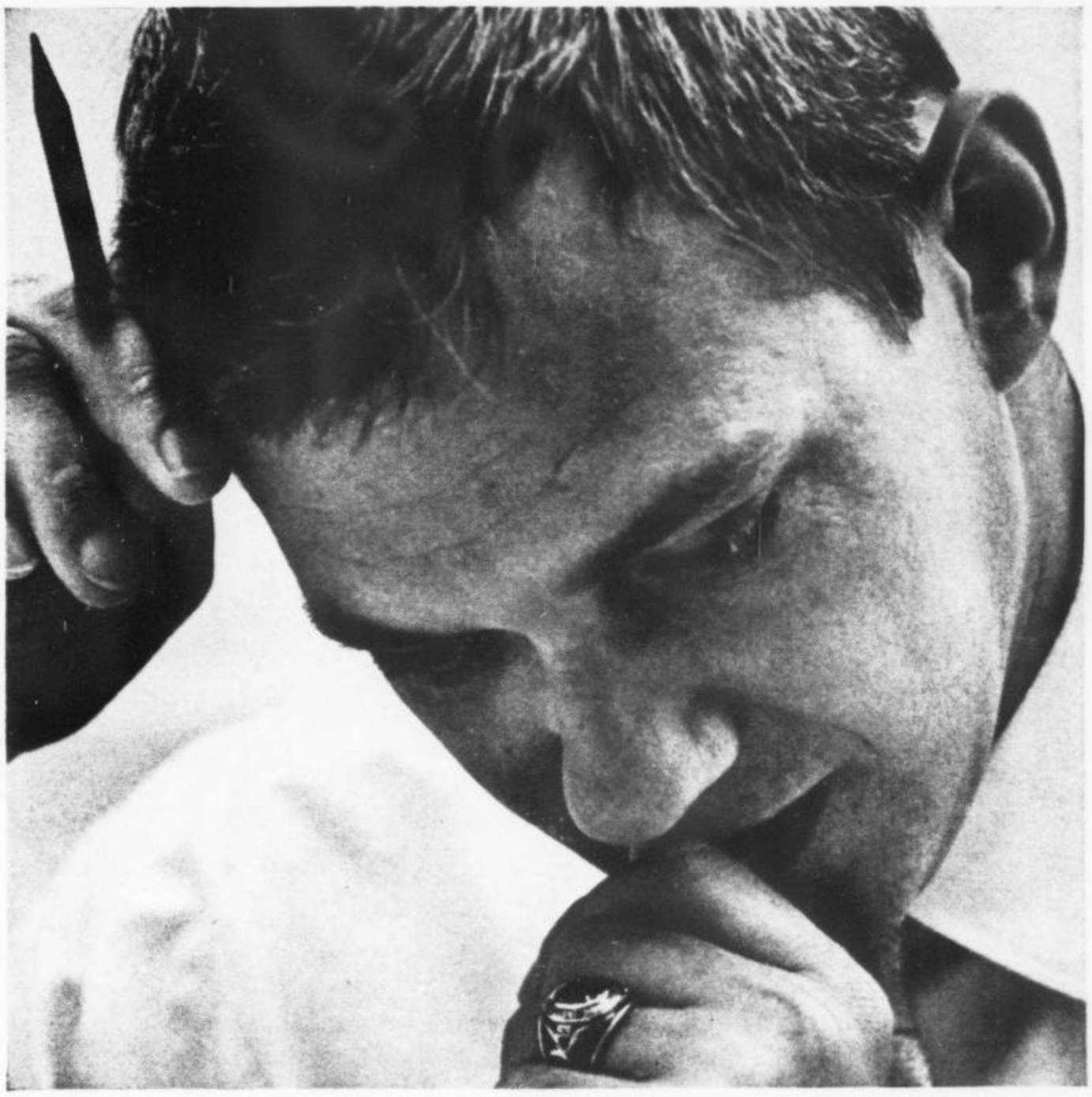
EDMUND PUJDOWSKI, JR.

"I feel that three regional vice presidents are needed for effective control, coordination, etc."

HAROLD E. MATSON

"I strongly prefer two names per posi-

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Structural engineers, to do stress analysis and optimize the design of advanced space structures.

A plasma physicist, to join our growing program in the measurement of plasma properties, spectroscopy, diagnostics, accelerators, and power conversion devices.

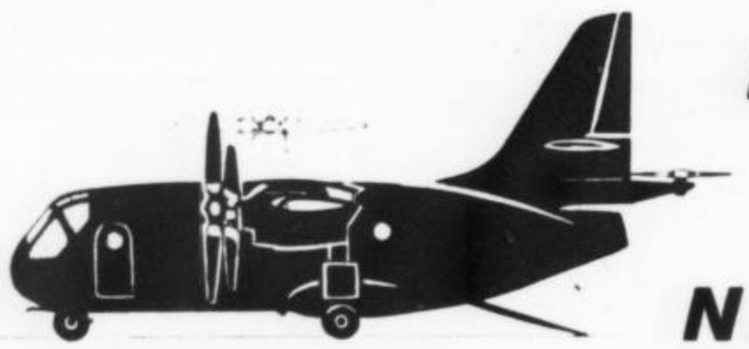
A mathematician-physicist, to concentrate on systems analysis and operations research applied to military and non-military space systems.

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tion. I want a choice! Check with American Chemical Society."

SIDNEY HEILVEIL

"Although the issue was not discussed in the "Principles," I favor three Regional vice presidents to stimulate interest in local meetings more fully."

R. C. HAEFELI

COMMENTS ON MEETINGS

"Why have the national meetings—Winter-east Summer-west? A logical choice would seem to be to reverse the two locations."

R. L. RYAN

"Would you consider reversing the location of general meetings—winter meeting in west and summer meeting in the east. Might involve better weather conditions due to possibility of winter storms in east."

FRED T. SARGINSON

"I would suggest a general meeting should be held in the western part of the country during the winter months, and the reverse in the summer."

JUDSON R. GRIFFIN

"Give highest possible priority to raising the standards of our technical meetings!"

LT. COL. G. D. COLCHAGOFF

COMMENTS ON SECTIONS

"Central Texas ARS Chapter (Waco-McGregor) not shown on map. Does this mean it will be eliminated from the new organization?"

W. M. BURKES

"What arrangements for financing local sections are envisioned?"

BENJAMIN W. BOVA

"I suggest more thought be given the handling of large sections formed by the merger, such as L. A. and Boston. I suggest that maybe the sub-sections be made up along divisions such as between Journals A and B."

R. EARL GOOD

COMMENTS ON HEADQUARTERS

"Nothing has been said about where National Headquarters are to be located. I have always felt that because of its importance in real decision-making matters in the areas of aeronautics and space, the headquarters should be in Washington, D. C. The tremendous opportunity being offered to the new AIAA by the Zeckendorf group, in connection with the new Communications-Space Center, should be thoroughly explored and, at the very least, put to the membership for a vote along with the other proposals."

GLEN P. WILSON

"In view of the geographical distribution of members, why not consider a new central location of headquarters, say Dallas?"

R. H. HELMHOLZ

COMMENTS ON MEMBERSHIP AND DUES

"Strongly recommend: no grades of membership."

JOHN D. NICOLAIDES

"The number of types of members has reached the ridiculous stage. Just count

the number of types. Why not one type just 'member' (perhaps adding one corporate or benefactor type). The classification as proposed has in other organizations resulted in top people being listed in the bottom classification just because they haven't campaigned to be promoted and nobodies at certain institutions being listed as big shots. If you *must* have all the grades then let's have a special group to review all classifications yearly and make recommendations."

ROBERT M. BESANCON

"Simplify the membership structure; specifically combine senior, member, and associate into one grade, to wit, member."

D. J. SALLEY

"I am opposed to the merger, but since it appears to be coming in spite of me, I must admit that these 'principles' are adequate. I do not like the $10 entrance fee."

GERALD E. TAYLOR

"I think that the $10 entrance fee is a poor idea, as it will tend to discourage growth of the AIAA."

WILLIAM L. BADE

"I strongly believe that there should be one membership grade rather than the distinctive list shown."

HARRY DORNBRAND

"Can see no real reason for advancing dues of fellow members above regular ones. Appears that those who might be expected to contribute most are also expected to pay the most!"

M/GEN. J. B. MEDARIS

"Recommend drop title 'senior member' and use 'associate fellow' as in IAS at present."

CAPT. R. J. SCHNEIDER

"I believe that the many grades of membership are unnecessary and inappropriate in a democratic organization. It appears to be a continuation of the feudal system for the benefit of the status seekers of the profession."

MILTON BEHEM

"Nine grades of membership are too many. This unnecessarily complicates bookkeeping requirements, adding costs. I suggest that 4 or 5 would be more than adequate."

O. T. CARVER

"Too many classes—lump all honorary into 1, also lump fellows and senior members. Two recommendations should be all that are necessary—many people can't get 4 without considerable trouble because of location."

EDWIN J. CALLAN

"Agree with proposed annual dues but *disagree* with entrance fee, particularly for member grade, and associate members grade."

M. L. LEHMAN

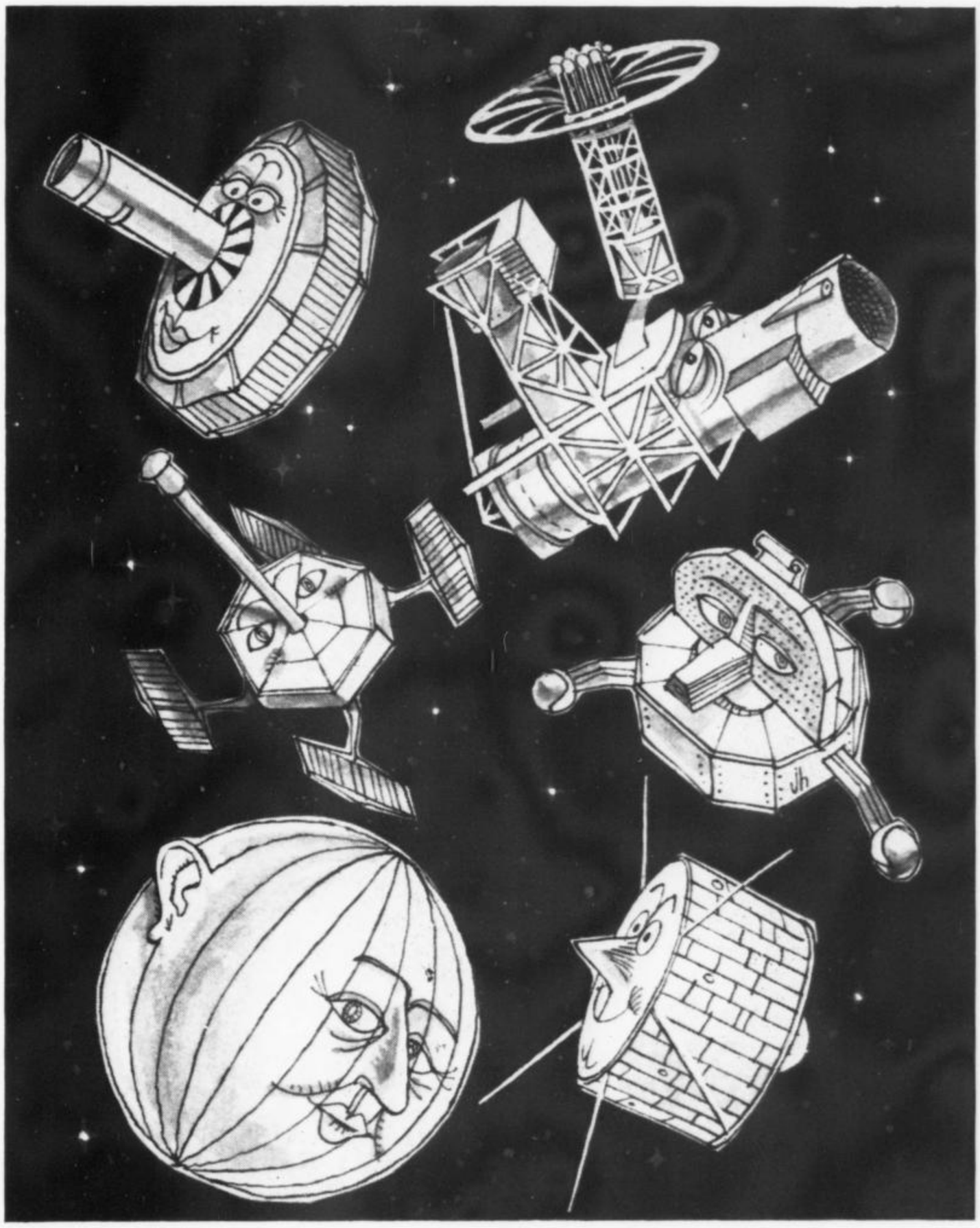
"I do not endorse consolidation or change in dues."

PAUL E. FRANKLIN

"There are too many different grades of membership in particular the upper echelon, i.e., honorary fellow, honorary member, etc., are redundant and unnecessary. Our organization is a technical one, not a fraternal one."

GEORGE EMANUEL

♦♦

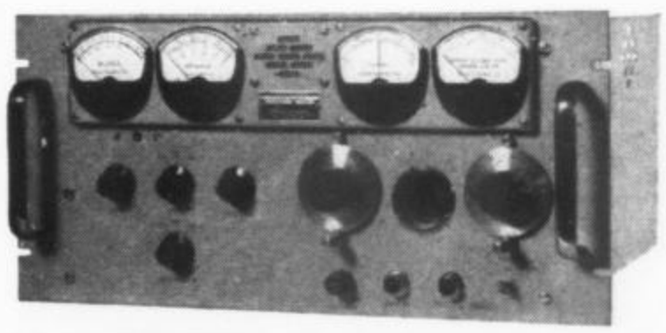


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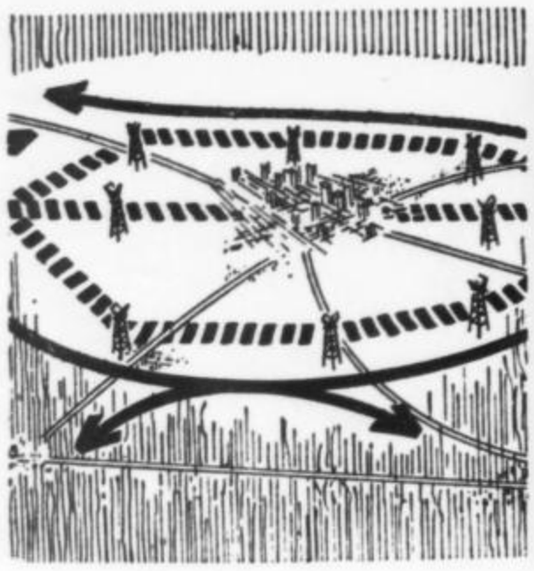
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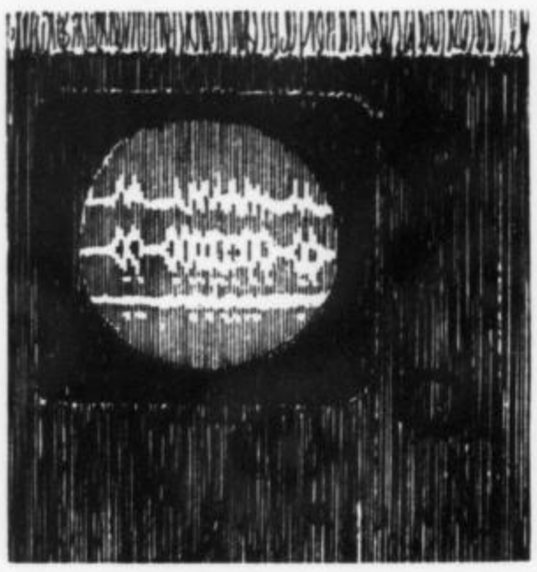
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6. Video Output	adjustable
7. Video Frequency Response	400 cps to 15 kc
8. Sensitivity	0.3 v peak to peak per kc of deviation, minimum



Bypass routes



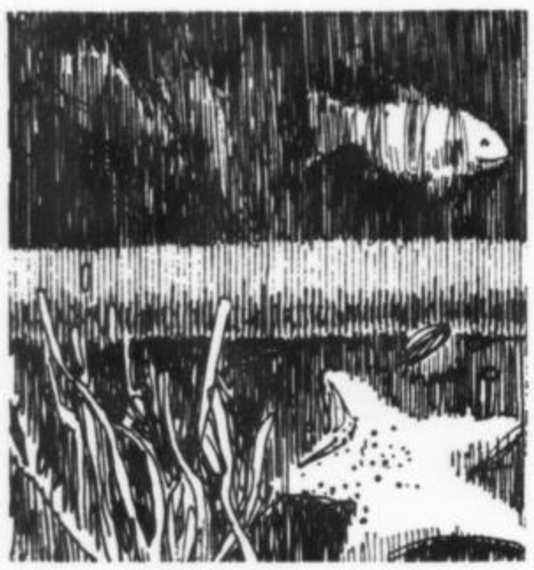
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Communications satellites



Microwave transmission



Submarine cable



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Astro notes

MAN IN SPACE

• A six-orbit attempt appears likely for the next Mercury flight in late summer. Recovery would take place in the Pacific, northeast of Midway Island, where the tracks of orbits 4, 5, and 6 intersect in the form of a triangle. The astronaut would be out of touch with the regular Mercury tracking net for much of the latter part of his flight, but a station would probably be established in the Philippines to control retrofire. No modifications would be necessary in the basic Mercury spacecraft to carry out the extended mission, but stricter control of fuel supply and conservation of battery power would be necessary. The latter would be accomplished by limiting the astronaut's communications to the ground.

• One advantage of a Pacific recovery will be extra daylight time for the mission. Even if the astronaut were launched from Cape Canaveral as late as noon, he could carry out his entire 9-hr orbital mission and be in the water by 4:00 P.M. sun time in the vicinity of Midway. Only a few additional ships would be required for a Pacific recovery because of the concentration of the potential recovery zones near Midway; but a considerably greater contingency operation must be carried out with aircraft, because of the larger area of the earth's surface to be traversed by the astronaut.

• Prolonged manned satellite operations in high inclination orbits may never prove feasible, according to a discovery by Herman Yagoda of the Air Force Cambridge Research Laboratory. Analysis of six photographic emulsion blocks carried aloft by Discoverer XVIII in December 1960 disclosed that the inner Van Allen radiation belt dips as low as 180 mi. The production of star tracks and "enders" (energetic particles which came to rest inside the block) increased exponentially with altitude from 180 up to 340 mi., indicating that the lower fringes of the Van Allen belt were being sampled. If this is the case, manned space operations will probably be restricted to lower latitudes, because it is not feasible to shield against the energetic protons of the inner belt with present payload limitations.

• The space flights of Soviet cosmonauts Yuri Gagarin and Gherman Titov both occurred at "safe" times from the standpoint of the solar-flare hazard, according to Maj. Gen. Daniel E. Hooks, commander of Aerospace Research for the AF. He surmises that the Russians have established a solar-flare monitoring program similar to that now used in connection with U.S. orbital flights. The USAF Sacramento Peak Observatory is presently providing such services, and it will be necessary to refine the predictions to an ever more discriminating appraisal of flare indicators to keep pace with the increasing duration of manned flights, Hooks said.

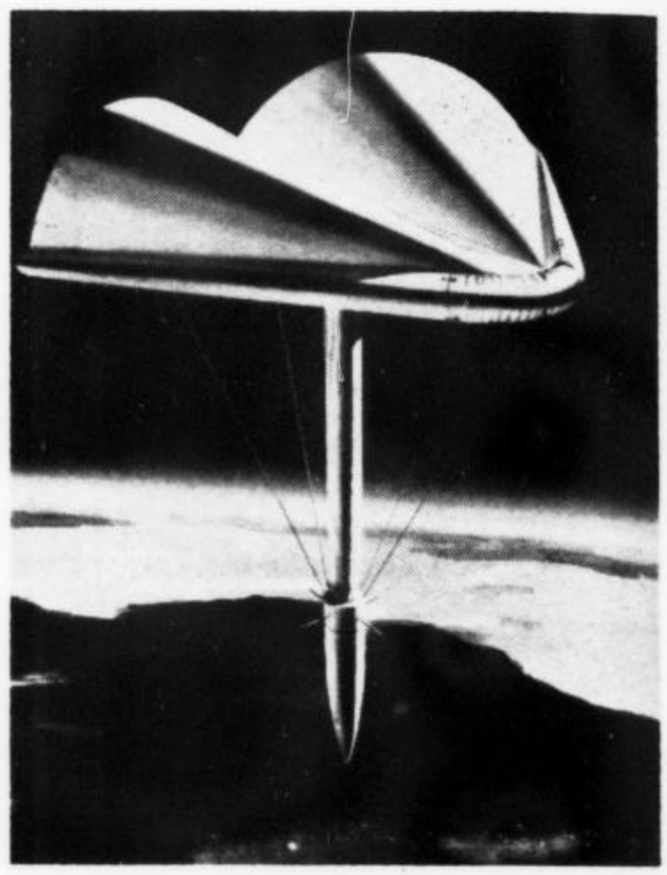
• Contemplating the day when it will be engaged in extensive space rendezvous operations, the AF is inviting research on the effects of extreme luminance and harsh contrasts on human vision in the space environment. A principal objective of the work will be development of protective devices for the eyes capable of softening the glare from high-contrast targets.

SPACE TECHNOLOGY

• The Air Force is pushing the art of electromagnetic countermeasures (ECM) and counter-countermeasures into the area of ICBM re-entry. It has requested proposals for study and development of ECM antennas capable of operating at re-entry speeds of 10,000 mph (Mach 15) and temperatures to 3000 F. Another recent request calls for proposals to minimize the deleterious effects of atmospheric re-entry plasma on electronic jamming techniques. Still another request calls for proposals on means to suppress the electromagnetic echo from the plasma created by re-entry vehicles.

• NASA was scheduled to select a contractor in June to design, develop, and test a 156-in.-diam filament-wound fiberglass motor case for a solid-propellant rocket. Reinforced fiberglass cases are said to cost half as much as steel cases and to possess a 30% weight advantage. If this could be achieved in very large sizes, it could result in a significant enhancement in the efficiency of a solid-propellant Nova.

• AF is conducting three separate balloon-astronomy projects aimed at gathering detailed information on the moon and the planet Venus this year. Project Star Gazer will be a manned system to obtain data this fall on atmospheric turbulence and infrared absorption up to 86,000 ft. Capt. Joseph Kittinger Jr. will pilot the balloon, and William C. White of the Naval Ordnance Test Station will be the balloon astronomer. The other two balloon projects, Sky Top and Balast, will be unmanned. Sky Top is intended to gather extremely accurate infrared temperature measurements of the moon, Mars, and Venus, while Balast will carry passive star trackers and other intruments to analyze the atmosphere of Venus. The the unmanned balloons are scheduled for a summer launching.



Artist's sketch of inflatable micrometeoroid paraglider (IMP) to be developed by Space-General.

• Under a $300,000 contract from NASA-Langley, Space-General Corp. will develop an inflatable paraglider to aid in measuring micrometeoroid flux in the lower regions of space up to about 700,000 ft. At first, two flight models and a prototype for ground testing will be built. The paraglider will also test re-entry flight.

NUCLEAR TESTS

• The initial U.S. attempt to obtain important new weapons-effects data at high altitude went awry when a Thor rocket launched from Johnstown Island suffered a tracking malfunction and had to be destroyed shortly after take-off. It was to have detonated a hydrogen device at 30-mi. altitude about midnight local time. The hydrogen warhead, like the rocket, was blown apart by chemical explosives, and the pieces fell in more than 1 mi. of water off the island. The setback will delay

by at least 2 wk completion of the U.S. Pacific tests, because this is the minimum time required to refurbish the temporary Thor pad after each launching.

• The high-altitude test series continued to come under fire from several quarters. The Soviet Union said the tests would upset radio communications and the weather and endanger the lives of astronauts, and it warned that it would take measures "to insure its security" in the event the U.S. goes through with the blasts. It charged that the shots are part of a program to develop weapons to paralyze radar and communications and indicate that the U.S. wants to take the initiative in a nuclear war. The tests were also criticized by U.N. Secretary General U Thant, who said they evidenced a "very dangerous psychosis" on the part of the U.S.

• For its part, the U.S. issued a statement generally minimizing the effects of the tests. Only the very highest shot (at an estimated altitude of 500 mi.) is expected to disturb the inner Van Allen belt. It is expected to create a " bubble" several hundred kilometers in diameter in the earth's magnetic field, with the result that trapped particles traveling along the affected field lines may be dumped into the atmosphere. The field lines are expected to be restored in 30 to 40 min. and the inner belt within a few days to weeks.

• The Pacific shots are also expected to create shells of energetic electrons similar to those formed in the Argus experiments, and they are also expected to produce radio disturbances similar to those which occured during the Teak and Orange shots in 1958. Those shots caused blackouts of several hours duration in high-frequency traffic. Special controls on U.S. commercial air traffic have been instituted by the Federal Aviation Agency in the Pacific area for the duration of the high-altitude shots.

VEHICLES

• Rocketdyne achieved a full-duration static test of its 1.5-million-lb F-1 lox-kerosene engine. The powerplant actually fired for 151.8 sec at a thrust level higher than its nominal rating. Previous long firings had lasted 90 and 96 sec. The F-1 is the mainstay of the U.S. Advanced Saturn vehicle, which will incorporate five F-1s in the first stage. Rocketdyne is scheduled to deliver its first F-1 to NASA next year.

• North American's Space and Information Systems Div. will build the



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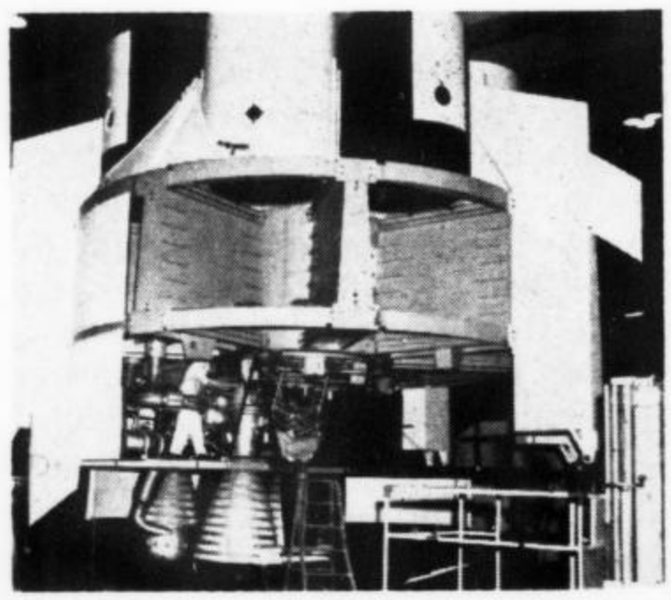
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S-II stage of the Advanced Saturn at Seal Beach, Calif., NASA announced. It said construction will begin this summer on a $7-million assembly and test facility on a 35-acre site made available by the Naval Ammunition and Net Depot at Seal Beach. Comprising five buildings and a hydrostatic test tower, the facility will be completed about 18 months after start of construction. The S-II, second stage of the C-5 Advanced Saturn, will be powered by five Rocketdyne lox-liquid hydrogen J-2 engines aggregating 1-million-lb thrust.

• With the fifth flight vehicle, the Saturn C-1 will include tail fins to give the greater stability and control needed for Apollo launches. Other changes include extension of the booster tankage by 6 ft, increasing propellant capacity by about 100,000 lb, and addition of solid-propellant retrorockets at the top of the main booster to make a clean and safe separation of the first and second stages.

• Technical difficulties in mastering liquid-hydrogen technology, inadequate funds at the outset, and poor liasion between Marshall Space Flight Center and the AF were cited by Wernher von Braun as the chief reasons for the troublesome delays in the Centaur program. Now 16 months behind schedule, the program suffered another setback on its initial test flight in May when a thermal-insulation panel tore loose from the Centaur stage ending the flight after 40 sec. NASA's Homer E. Newell told a House Science and Astronautics subcommittee that the program has been streamlined in recent months, with Huntsville replacing the AF as the manager of the project.

• Some idea of NASA's growing appetite for liquid hydrogen can be formed from its latest contract—a $75-million procurement of the fuel from Linde Div. of Union Carbide Corp., calling for delivery of a maximum of 275-million lb over a 7-yr period. The cryogenic fuel will be delivered to



NASA-Marshall mockup of finned Saturn (SA-5) provides guide for transition to hardware.

Aerojet-General in Sacramento, to meet the requirements of M-1 engine development for Nova.

NOVA PROGRESS

• Selection of study contractors for Nova should be in the offing, what with the initial proposal work done and NASA moving to firm plans for both solid and liquid versions of the giant booster. Rocketdyne's progress on the F-1 engine and Aerojet's on the 1.2-million-lb-thrust M-1 lox-liquid hydrogen engine should put the early emphasis on the liquid system. Rocketdyne, by the way, has tested four F-1 engine systems with thrust levels between 0.9- and 1.5-million lb, building up a total of 997 sec of running time through first quarter 1962.

• According to Otto Lange of NASA-Marshall, preliminary definition of the Nova configuration began during the second quarter of this year. Subject to change, says Lange, the general configuration of Nova would be a three-stage liquid-propellant vehicle about 300 ft high (minus the spacecraft) and 50 ft in diam. The first stage would employ a cluster of eight F-1 engines, and the second stage two to four M-1's. A modified Saturn S-IVB stage might be used for the third.

RIFT AND ROVER

• NASA selected Lockheed Missiles and Space Co. for negotiation of a $180-million contract to develop and test the Reactor-in-Flight Test (RIFT) vehicle. Lockheed nosed out Martin Marietta Co. and GD/Astronautics. Initial flight test of the 35-ft-diam RIFT as a dummy third stage on a C-5 Advanced Saturn is expected in 1966. It will be followed by three ballistic tests of live RIFT vehicles over a 500 to 2000 mi. range from Cape Canaveral.

• The Rover nuclear-reactor test program has encountered delays in test-stand preparation for the initial static firing of a Kiwi-B reactor with cryogenic hydrogen as the coolant. Harold Finger, director of the joint NASA-AEC Nuclear Propulsion Office, had predicted Kiwi-B tests at the rate of one every other month, but more than six months have elapsed since the last Kiwi-B test at Jackass Flats, Nev. The delay means it may not be possible to specify a Rover reactor design by the end of 1962, as Finger had hoped.

• Nuclear power in small packages came in for discussion by J. G. Morse of Martin-Baltimore at a BIS meeting

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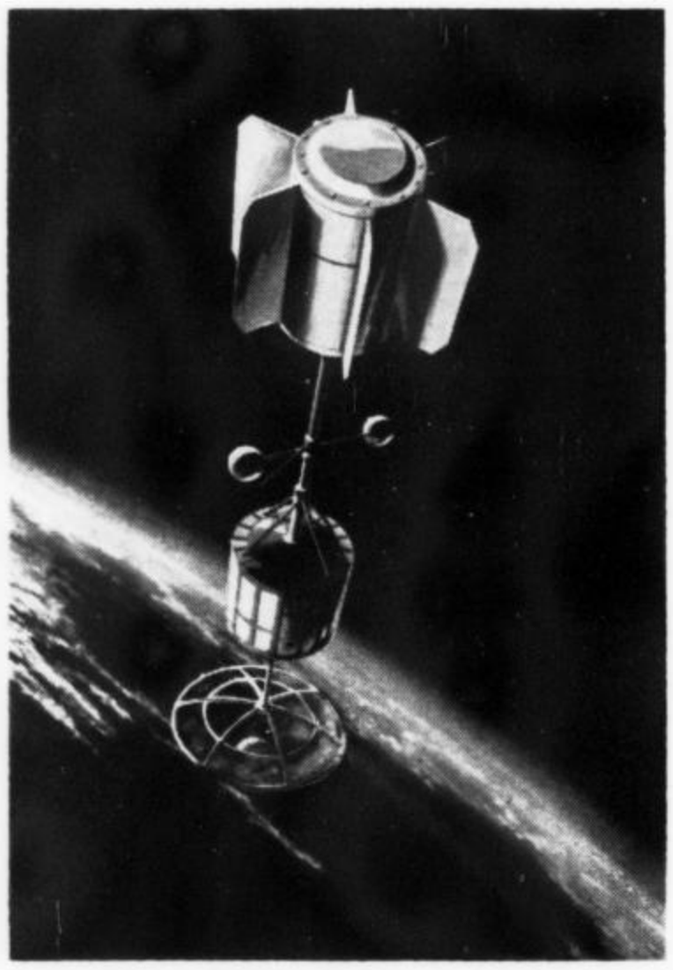
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in London in June. Dr. Morse thinks the next step with isotope-powered generators could be a communications satellite. He gave a figure of 65 lb for a 60-w generator using plutonium-238, and cited between 50 and 350 w as possibly adequate for radio and TV relay satellites (see June *Astronautics*, page 86).

SATELLITES

• After a long delay, NASA resumed publication of its Satellite Situation Report, but entries concerning secret AF activity are more cryptic than ever. It appears the airmen attempted nine satellite launchings during the two-month period up to early June. They involved five Discoverer-type systems using the Thor-Agena B, one Midas and one Samos, using the Atlas-Agena B, and two Blue Scout attempts. Both Blue Scouts failed, but the other seven systems attained orbit, and the evidence indicates that capsules were recovered from three of them after orbital periods of up to three days.

• The Samos system launched April 26 demonstrated successful recovery of the E-6 data capsule under development by General Electric. The operation was conducted in the Pacific, although later operational models will return Samos reconnaissance data to a north-south range between Wendover, Nev., and Edwards AFB, Calif. The new Samos data capsule remained in space three days before recovery. The successful test flight gives an additional boost to the supposition that the U.S. will rely principally upon physical recovery of reconnaissance data rather than TV relay from space. (See "Observation Satellites" by Amrom Katz, beginning in the April 1960 *Astronautics*, page 26).



J. G. Morse of Martin-Baltimore suggested isotope-powered generators would help solve communication satellite problems, perhaps in a scheme like the one sketched, which shows a 65-lb generator at the top.

• Barring a major advance in infrared sensors, the Midas early-warning satellite appears to have limited usefulness as an alarm system against ICBM attack. According to guarded reports in industry circles, Midas has found it impossible to discriminate missile exhausts from sunlight reflected from clouds during its dayside passes. This means its warning potential is limited to nightside passes and its value is accordingly diminished. The Pentagon asked only $100 million for Midas for fiscal 1963, less than half the amount voted for the present year, and it deferred indefinitely the operational date for the system.

• The Soviet Union launched the fifth in its Cosmos series of scientific satellites into the most elliptical orbit yet. According to USAF data, the Soviet satellite has an apogee of 973 mi., a perigee of 120 mi., a period of 102.5 min, and an inclination of 49 deg to the equator. One of its principal ob-

jectives is presumably the measurement of the earth's trapped radiation. As with all the Cosmos shots, the payload weights have not been disclosed.

• It has been conjectured that the Cosmos IV spacecraft launched by the Russians on April 26 and recovered three days later was actually an unmanned version of a "two-seater" Vostok ship. The idea rests more on logic than hard evidence. As for evidence, there is the fact that the recovered spacecraft was fired on the 65-deg inclination used in Soviet tests of manned and unmanned spacecraft, while all the other Cosmos vehicles employed the 49-deg inclination.

• NASA's Orbiting Solar Observatory satellite broke down after a lifetime of 77 days. Though this was less than half the hoped-for life, the remarkable 440-lb "space wheel" transmitted almost 1000 hr of information on solar activity, measuring more than 75 solar flares during its lifetime. Cause of the failure was a malfunction in the spin control system, resulting in a speedup in OSO's rotation rate to the point where its servo-control system could no longer orient the experiments and solar-cell array to the sun.

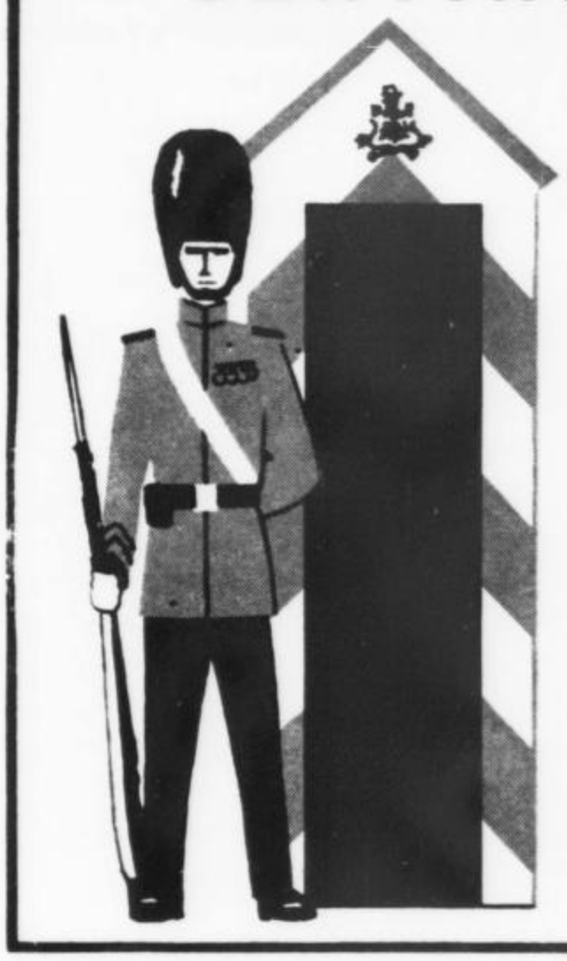
SPACE COOPERATION

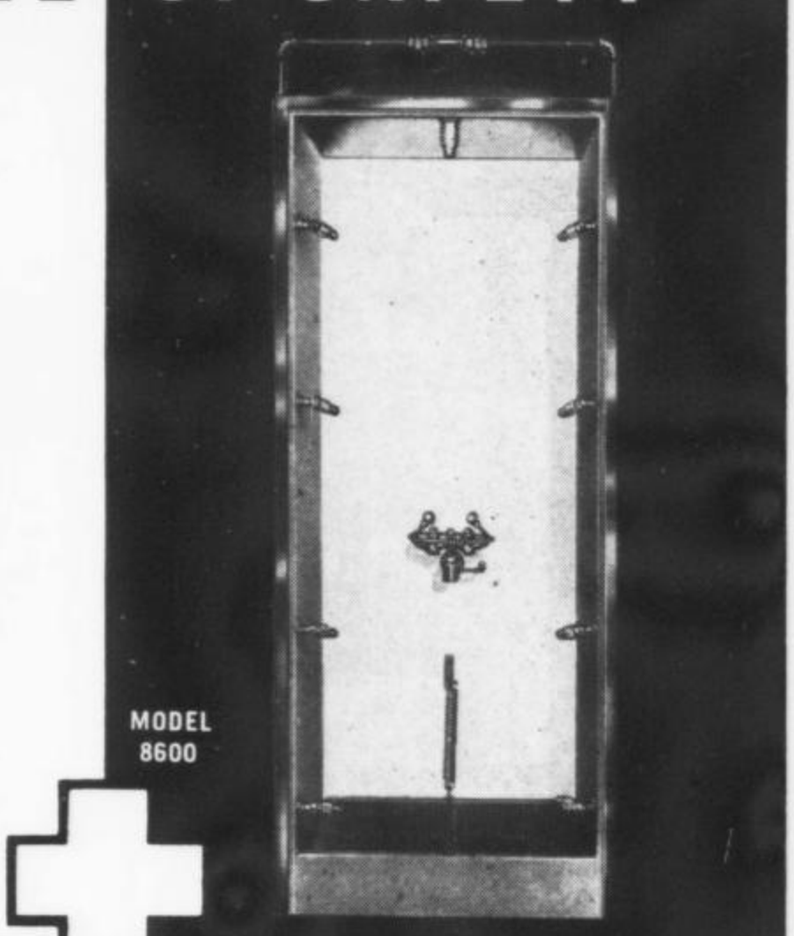
• The U.S. and Russia inched toward an agreement on exchange of information derived from sounding rockets and weather satellites in talks at Geneva between NASA Deputy Administrator Hugh Dryden and Soviet Academician Anatoli Blagonravov. Contrary to early reports, it does not appear likely that any initial East-West space agreement will involve joint launchings of space hardware.

• The European Space Research Organization (ESRO) and the European Launcher Development Organization (ELDO) are planning a combined budget of $100 million a year, according to Pierre Auger, executive secretary of committee plans for the two cooperative agencies. Prof. Auger said he hopes a convention defining ESRO will be signed shortly by Belgium, West Germany, France, Italy, the Netherlands and Britain, with ratification by the end of the year. No manned flights are contemplated by ESRO, he said, but a tentative program covering the next several years contemplates the launching of 440 sounding rockets, 22 small earth satellites, eight space probes, two stabilized astronomical satellites, and two lunar satellites.

• NASA reported the successful launching of a Nike-Cajun sounding rocket to an altitude of 80 mi. by Pakistan under the terms of a cooperative

SENTINEL OF SAFETY





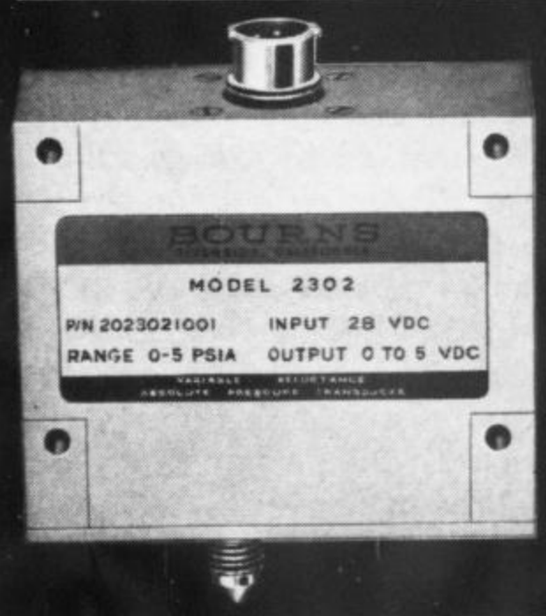
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agreement reached last fall. The rocket, named Rehbar I, carried a sodium vapor experiment and was launched near Karachi by Pakistani scientists and technicians who were initially trained at Wallops Island, Va., and NASA's Goddard Space Flight Center.

• A new Memorandum of Understanding has been reached with Sweden that provides for the launching of four Nike-Cajun rockets to make direct samplings of noctilucent clouds this summer in the auroral zone. The U.S. will supply the launcher and associated support and telemetry equipment, the rockets, and four instrument payloads, while Sweden will provide supplementary instrumentation to measure energetic particles as well as the launch pad, control center, and facilities for assembling and testing the rockets and payloads.

PROJECT MERCURY—MA-7

• The thesis of Project Mercury—that the pilot adds reliability to the machine—was put to a severe test by Scott Carpenter in his three-orbit Aurora 7 flight in May. Like John Glenn, Astronaut Carpenter was able to carry out his mission despite an equipment failure which might have crippled an automatic flight. Yet his active participation in the mission introduced new complexities, new possibilities for human error, and it was these which appear to have caused most of his difficulties.

• After the flight, Carpenter confessed to mismanagement of his fuel supply. In his eagerness to carry out his voluminous schedule of observations, the 37-yr-old astronaut put his spacecraft through such an abrupt series of attitude changes that he was down to 45% of his automatic fuel supply and 70% of manual by the middle of his mission. To assure a minimum of 35% in each tank at the time of retrofire, he had to go into a drifting mode for most of the balance of his flight. And when the time came for retrofire, he inadvertently expended both automatic and manual fuel, exhausting the latter during the maneuver.

• His major in-flight error, however, was failure to perform a thorough checkout of the capsule's attitude-reference system. Carpenter first noticed that his window view did not coincide with his instruments when he passed over the Canaries on his initial orbit, but he never got around to analyzing the problem until it was much too late. The Mercury ground control net must share responsibility for this, inasmuch as it had positive telemetry evidence of an 11-deg error in the pitch gyros from the moment the escape tower jettisoned after 2 min of powered flight.

• The undiscovered malfunction in the Automatic Stabilization and Control System came home to roost during the retrofire maneuver. Carpenter had been ordered to place his capsule in the proper retrofire attitude (zero yaw and roll and −34-deg pitch) and turn on his ASCS for primary damping of the spacecraft, leaving the manual system operable should a backup be needed. Carpenter complied, but as the time for retrofire approached, he found that his attitude-reference system was out of kilter, indicating a much steeper pitch than his window view. He thereupon switched to fly-by-wire, bypassing his autopilot with his control stick. He forgot in the press of his immediate needs to shut off his manual system.

• Because his attitude-reference system was indicating an error greater than the permissible margin for retrofire (30 deg in roll and yaw and 12 deg in pitch), Carpenter had to break into the automatic-control sequence at this point. He manually bypassed the veto imposed on retrofire by the attitude-reference system, and then fired his retrorockets manually about 3 sec late. He managed to steer accurately on the pitch and roll axes using the window as a reference, but he erred 25 deg to the right on the yaw axis. This misalignment of the thrust vector of the retros was primarily responsible for his 250-mi. overshoot in landing.

• Following retrofire, Carpenter was left with only 15% of his automatic fuel (ground telemetry reported 10%), a dangerously thin margin in the event his capsule had been tumbling at any appreciable rate. Fortunately, the rates were low and he was able to place the spacecraft in almost the precise re-entry attitude and introduce the 2-rpm roll rate with the additional expenditure of only 1% of his remaining fuel.

• As the ship plunged toward the altitude of maximum dynamic pressure, its inherent stability at supersonic speeds suppressed its oscillations. But once it traversed this region at about 120,000 ft, the oscillations began to build up again in wider and wider swings. Carpenter exhausted the rest of his fuel trying to damp the oscillations, and finally deployed his drogue chute at 27,000 ft when it appeared that he might soon tumble end over end. (The flight program called for manual drogue deployment at 21,000 ft.) He also popped his main chute manually at 9500 ft because the baro-

stat did not release it at 10,000 ft. Failure of the barostat to activate the chute is not necessarily a mechanical malfunction, however, since these devices have an altitude tolerance of 1000 ft.

• If Carpenter was not attentive to his piloting tasks, he was certainly a conscientious observer and photographer. He provided a wealth of photographic and photometric data on the earth's haze layer (believed to be related to the airglow phenomenon), on man's visual acuity in space (he reported day-glo orange as the brightest color on his balloon experiment, and said he could distinguish four separate cloud layers in the atmosphere from 100 mi. altitude), on manual attitude control by star navigation on the dark side of the earth, and on the mysterious particles first noted by John Glenn. He furnished strong evidence that the particles are bits of frost which collect on the sides of the capsule, and he was able to produce them at will by rapping on the sides of his ship.

• Carpenter's flight was more rigorous than John Glenn's, mainly because of a difficulty in controlling suit temperature, which at one point ran his body temperature up to 102 deg. The astronaut lost 7 lb during the mission, despite consumption of considerable water. Like Glenn, he encountered no problems with zero-g despite efforts to induce disorientation by head movements.

• Of particular interest was the widening which occurred between his systolic and diastolic blood-pressure readings. This tendency was noticed on Glenn's flight, but it was much more marked with Carpenter, who recorded 210/60 at one point. The implications of this are not yet known; and until the matter is more thoroughly scrutinized, it would appear unlikelv that Astronaut Donald K. Slayton will be picked for an orbital mission. Slayton was originally tapped for the MA-7 flight, but a slight heart defect caused his replacement by Carpenter.

ADVENT REVISED

• DOD wiped out the Army's Advent communication satellite program and sought proposals this month for two new relay-satellite systems more closely matched with existing booster capability. One of the systems would be a station-keeping satellite weighing about 500 lb for operations in a 24-hr equatorial orbit. The other would be a nonstabilized 100-lb satellite, similar to NASA's Relay, which could operate in polar orbits at 5000- to 7000-mi. altitude.

• An operational system based on a scaled-down Advent would require at least three, and perhaps as many as 10, spacecraft in equatorial orbit. A random satellite system would require 40 to 50 relay packages in continuous operation, and this means a multiple-launch capability would have to be developed if the system were put into operation. The Atlas-Agena B would be the workhorse booster for either system, rather than the Atlas-Centaur planned for the original Advent, which weighed 1250 lb.

• The delay in the Centaur program was a big factor in cancellation of Advent; but mismanagement of the project by the Army, and specifically by the Advent Management Agency at Fort Monmouth, was probably the key reason for ending the project. Also a factor was the cost over-runs encountered by General Electric, which was developing the Advent spacecraft in Philadelphia. Instead of ordering the Army to scale down the existing Advent, DOD decided to wipe the slate clean and start all over with a new team.

• Under the new arrangement, the Army still has responsibility for ground elements of new systems. The AF will develop, produce, and launch the satellites. The Defense Communications Agency will have responsibility for integrating ground elements with the satellite portion of the system.

• The Pentagon hopes the new approach to a military communication satellite system will lead to initial flights and an interim operating capability in 1964, with full operation a year later. As a result of delays, the original Advent could not have become operational until 1966.

• A total of $172 million had been voted Advent through Fiscal Year 1962, including $74 million to GE for the spacecraft, $23 million to Bendix for the communication package, and $11 million to Philco and $12 million to Sylvania for ground equipment.

• This upheaval means the AF will now undertake two more space projects almost exactly paralleling two NASA programs—the medium-altitude, random-orbit Relay and the 500-lb synchronous-orbit Syncom, which is still in the discussion stage. In defense of the apparent duplication, DOD officials say the major burden of the development programs will be in the ground systems, and that the NASA satellites will not have specialized anti-jam and anti-spoof capabilities.

• NASA expects a maiden launch this month of Bell Telephone's Telstar satellite. ♦♦



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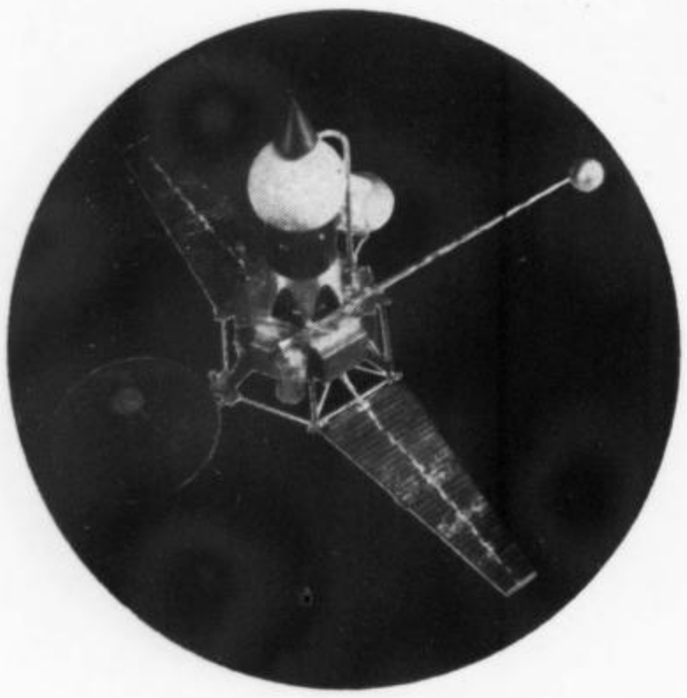
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AMERICAN ROCKET SOCIETY
500 FIFTH AVENUE
NEW YORK 36, N. Y.

MEMBERSHIP DEPT.

MEMBERSHIP

All persons professionally engaged in science or engineering relating to rocketry and astronautics are eligible for membership and will be assigned grades commensurate with educational attainment and with professional experience. Applications for admission to, or transfer from, one grade to another will be reviewed by the Membership Committee or its authorized representatives.

There are only two types of application forms for new members. They are the Student Member application and the application for professional grades. Applicants for professional grades will merely apply for membership in the Society and the grade of Associate Member or Member will be assigned by the Membership Committee at the completion of processing.

Persons holding Bachelor's degrees in science or engineering from accredited universities, colleges or technological institutes after four or more years of study, are deemed to have four years of professional experience.

Members

Shall be professional persons with at least six years experience in science or engineering in or related to rocketry and astronautics who have demonstrated competence in their fields. Applicants must be recommended by three persons, two of whom must be members of the Society.

Associate Members

Shall be persons having professional activity or interest in fields in or related to rocketry and astronautics. Applicants must be recommended by three persons, two of whom must be members of the Society, except that Student Members, upon completion of their education, are automatically eligible for Associate Member grade without additional recommendations.

Student Members

Shall be undergraduate or graduate students, under 28 years of age, who are in full time attendance at accredited universities, colleges, or technological institutes.

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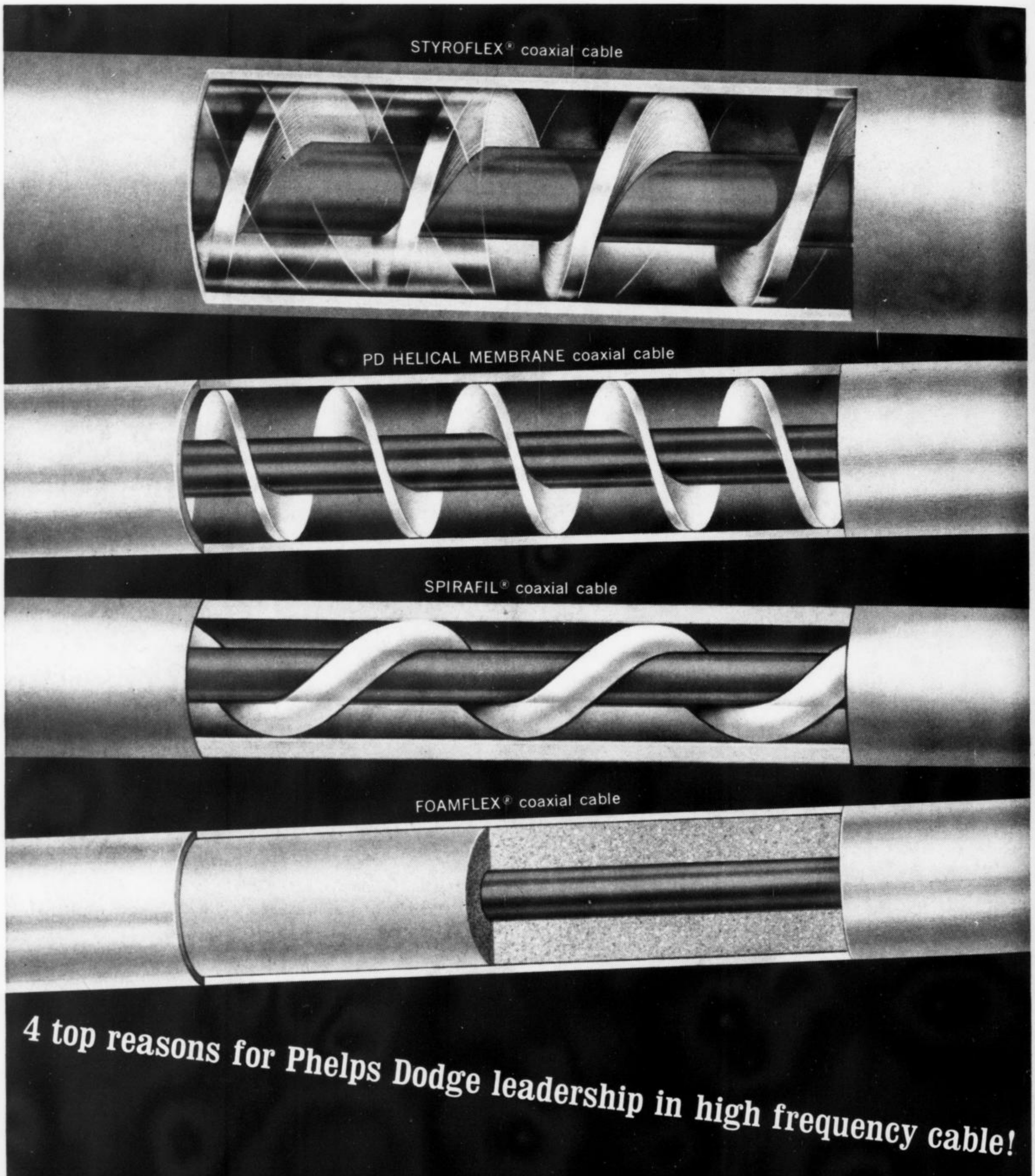
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ADVENT . . . NIMBUS . . . RANGER . . . during the months and years ahead extensive scientific data will be gathered from these and other satellite systems circling about or with the earth. Extremely complex, extremely sophisticated, these space vehicles must of necessity be put through tests simulating as closely as possible the spacial environment. Cold beyond comprehension, searing heat, ultra high vacuums — these are some of the conditions that must be simulated. CRYOVAC, the leader in the field of space-age cryogenics, has built and is building most of the cryogenic systems required to achieve these conditions. Satellites like Advent and Nimbus will be orbited only after hours and hours of grueling punishment in space simulators, the design and construction of which CryoVac played an important part ■ The experience and know-how gained in testing and building these sophisticated test facilities are at your disposal. Why not get in touch with CryoVac at your earliest convenience. ■ Inquiries from scientists and engineers regarding employment opportunities invited.

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