Space TECHNICAL INFORMATION DIGEST

SPACE SYSTEMS INFORMATION BRANCH, GEORGE C. MARSHALL SPACE FLIGHT CENTER

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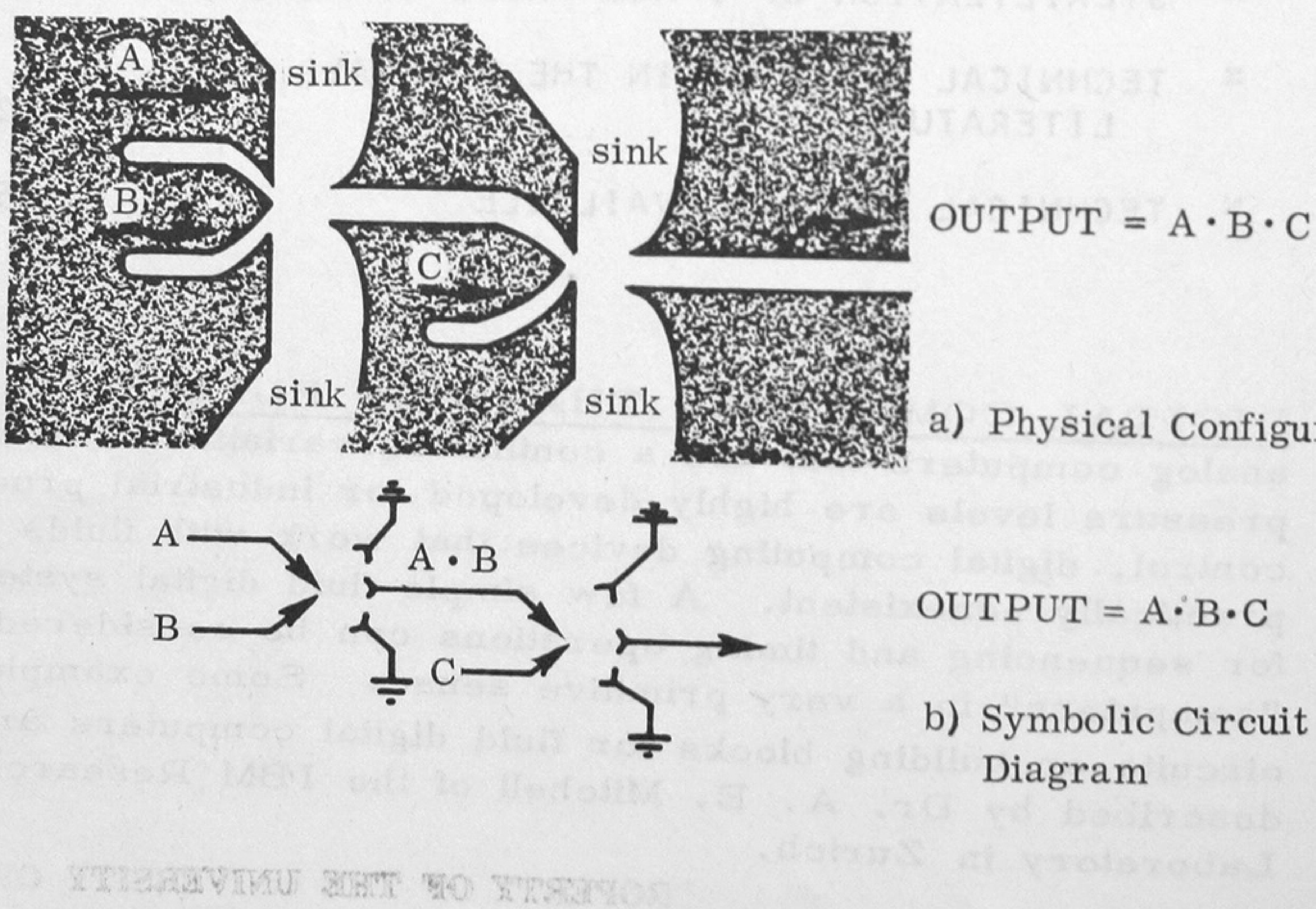
DIGITAL COMPUTERS THAT USE FLUIDS. Although analog computers that use a continuous variation of flow or pressure levels are highly developed for industrial process control, digital computing devices that work with fluids are practically nonexistent. A few simple fluid digital systems for sequencing and timing operations can be considered "computers" in a very primitive sense. Some examples of circuits or building blocks for fluid digital computers are described by Dr. A. E. Mitchell of the IBM Research Laboratory in Zurich.

One of his examples, shown in Fig. 1, is a three-input "And" gate that uses interacting jets. An output is obtained only when all three inputs are present; otherwise, the input flows into the sinks. Devices such as this have no mechanical parts and need only the interaction of fluid jets for the desired output jet. The interaction of the A and B information flows produces an output in the first channel; this output can then interact with the input flow of C to give an output in the second channel; hence an output flow occurs only when all input flows, A, B, and C, are present. Feedback paths (not shown in Fig. 1) can be designed for a memory cell; such a device can be made to act as a multivibrator by reversing the feedback connections for an oscillating output.

Another type of fluid computing device described uses the principle of "attachment" of a jet to a wall in the Coanda effect. The fluid jet flows along the solid boundary wall and is diverted from its emerging direction; the fluid is injected from the nozzle into an area between two boundary walls. Two possible output positions are available, as the jet can be deflected from one wall to the other by an "instruction" flow created by a jet much smaller than the main jet.



a) Physical Configuration

b) Symbolic Circuit Diagram

FIG. 1

Combinations of fluid flow control devices are described that can provide a variety of logic applications, including "Exclusive or" and "Equivalence" gates. Many types of these small, reliable devices can be constructed for applications in data processing systems where the speed of operations is limited by the input and output of data transfer to and from the system. Once actuated, for example by manual keying, these devices can perform digital operations within about a millisecond. (Source: New Scientist, March 7, 1963)

HIGH-VACUUM TECHNOLOGY TO SIMULATE SPACE. Of all the known hazards of deep space, perhaps the easiest to simulate is that of a hard vacuum. However, the techniques for simulating the vacuums of deep space become progressively more complex--and more expensive--as the volumes are made greater.

(NOTE: In the following discussion of vacuum simulation, the vacuum-technology term, torr, is used quite often. A torr is defined as the air pressure required to support a column of mercury 1 mm high. At the Earth's surface, this height is generally 760 mm, or 760 torr. In Giorgi units, 1 torr = 133.3 newton/m^2.)

A hard-vacuum system, 2.15 m (7 ft) long and 0.9 m (3 ft) in diameter, with a working region reported as half this size, has produced a pressure as low as 10^{-15} torr; most vacuum technologists believe 10^{-7} torr is satisfactory for large tanks. Several facilities throughout the nation, including both industrial and governmental systems, have vacuum chambers with dimensions from 1.25 m (4 ft) in diameter and 1.5 m (5 ft) long to 12 m (39 ft) spheres. Typical vacuums are in the 10^{-5} to 10^{-10} torr range.

The necessity of these vacuum-simulators is apparent to designers of hardware for space, particularly for applications of high-reliability Earth satellites and planetary probes. Questions pertaining to vacuum, or near-vacuum, effects on materials and fabrication processes during space missions are no longer academic; answers are needed now. Environmental engineers say that while true space simulation may not be achieved, whatever close approximation possible is highly desirable: By finding a possible "weak link" in a vital component, a costly space failure can be prevented.

In creating vacuums, the first step is to begin evacuation with mechanical roughing pumps. Diffusion pumps take over at about 10^{-3} torr, with jets of oil or mercury vapor used to carry along the molecules being ejected. A check valve, in the form of a cryogenic baffle system, traps and freezes out any oil vapor backing into the system.

Large chambers that require less than 10^{-6} torr utilize cryogenic pumping, an ultra-high-vacuum system that freezes out unwanted gas molecules. Molecules are condensed on a surface and cooled internally by liquid helium. Cooled baffles form radiation barriers and hence make the condensation more effective.

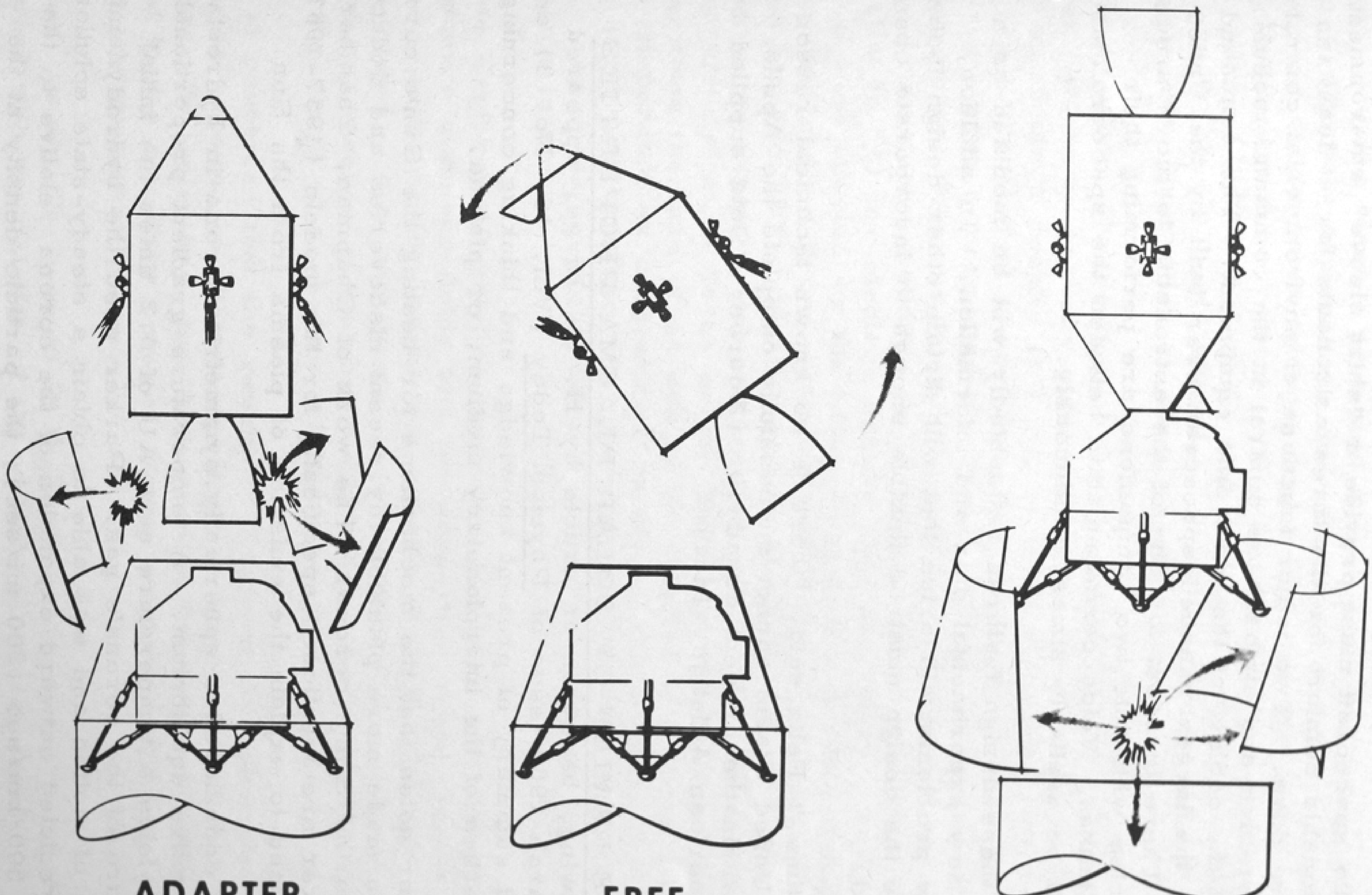
Future developments in space-simulation chambers may be exemplified by the facility at the Arnold Engineering Development Center (USAF) in Tullahoma, Tennessee. It is to be operational next August and has a chamber 13 m (42 ft) in diameter and a height of 25 m (82 ft). Testing capability will include the accommodation of large vehicles, such as the Agena B, at a pressure of 10^{-8} torr. (Source: Aerospace Management, November, 1962)

SPECIAL FEATURES OF APOLLO SPACECRAFT DESCRIBED. Special design features associated with lunar landing and Earth return were described by Charles H. Feltz in a paper presented at the American Institute of Aeronautics and Astronautics' Second Manned Space Flight Meeting, April 22-24, 1962. He presented the paper at a confidential session headed by Harrison A. Storms, President of North American Aviation's Space and Information Systems Division.

Feltz said the main factors affecting design of the conical-shaped command module (Fig. 2) were booster limitations, crew safety, and natural mission requirements. Astronaut safety through system redundancy and exhaustive testing has been emphasized throughout. As an example of a specific safety consideration, Feltz described the flight trajectory, which is designed to permit abort any time prior to lunar touchdown.

To insure stability of the command module in the event of an abort at low level, two strakes, or fins, have been added vertically to the command module. The command module can be lowered to Earth either on land or water by using three main parachutes, any two of which will permit a safe landing.

TRANSPOSITION & DOCKING



ADAPTER SEPARATION

FREE FLY-AROUND

DOCKING

FIG. 2

The Apollo spacecraft must provide a "shirt sleeve" environment with reasonable comfort for the three astronauts for at least ten consecutive days. Two major functions of environmental control are temperature and atmosphere control in the command module cabin and the cooling of the electronic equipment. The command module is the largest manned spacecraft ever built by the United States. There is room for one of the astronauts to move around and exercise while his two companions are performing their assigned tasks. Voice communication between the spacecraft and Earth will be available almost continuously.

Some of these design features undoubtedly will be modified as a result of new experimental data and information. In addition, some new problems will arise that will dictate other design features. Therefore the design must be flexible enough to incorporate changes as needed.

"At this time," Feltz said, "there is no known technical reason why the United States cannot successfully complete the Apollo mission within the present decade." (Source: Data supplied by North American Aviation, Inc.)

A BRIEF REVIEW OF SOLAR PLASMA PROPERTIES.

The following, based on an article by H. S. Birge, appeared in the March 1963 issue of Physics Today (Vol. 16, No. 3) and is a brief summary of present knowledge and thinking concerning the properties of the interplanetary medium, or plasma.

The author notes that the mechanisms for heating the Sun's corona have been made more plausible by recent discoveries and deductions relating to the Sun's corona. The work of Chapman, Chamberlain, and Parker are mentioned specifically for the models (1957-1961) that they adduced to explain the emission of plasma from the Sun.

Chapman considered a spherically symmetric corona in hydrostatic and conductive equilibrium. A temperature gradient proportional to $r^{-2/7}$ yields a temperature at 1 AU of 0.2 times the initial temperature of the corona's gas. Parker used the hydrodynamic equations of motion and was able to obtain a steady-state solution with a predicted outward expansion of the corona relative to the Earth of 500 km/sec (300 mi/sec); the particle density at the Earth was set at about 200 cm^{-3} (3333 $in.^{-3}$). This expansion, called "solar wind," prompted Chamberlain and other scientists to seek alternate explanations and solutions; Chamberlain proposed a solution of the basic hydrodynamic equations that leads to a much smaller expansion velocity. His figures for temperatures and densities (10^5°K to 10^4°K, and densities from a few hundreds per cc to 30 cm^{-3}) lends little theoretical encouragement; the evidence gained by observation is almost equally speculative.

Results from observation of the "zodiacal light," which showed this light to be partially polarized, have been interpreted in terms of an electron density at 1 AU of about 600 cm^{-3} (10,000 $in.^{-3}$). (The zodiacal light phenomenon is actually caused by the envelope of hot gases surrounding the Sun.) These measurements are complicated by many intervening effects, including dust, so that the best present estimate is an upper limit of less than 100 cm^{-3} (1700 $in.^{-3}$) for electron density near the Earth. Observations of comets affected by the solar wind give a number density of a few hundred cc if one assumes a velocity for the solar wind of 500 km/sec (300 mi/sec) to 000 km/sec (621 mi/sec). Another source of experimental evidence of solar flare characteristics is the effect of such flares on the Earth, usually delayed by about a day from the time of an optical observation of a solar disturbance. If interpreted as corpuscular radiation, the velocity of the particles is about 1000 km/sec (621 mi/sec). However, neither theories nor observations provide much real information on the actual conditions in space.

The Explorer 10 satellite, launched in 1961, was designed to measure magnetic fields and the properties of the plasma. A geomagnetic cavity, consistent with the findings of Explorer 10, is postulated: "On any basis, it is difficult to escape the conclusion that the absence of an observable plasma up to 21 R_e Earth radii is the result of a shadow effect of the Earth's field."

It is concluded that the results of Explorer 10 show just such a region because of alternate periods of "plasma" and "no plasma" during its trajectory, and further, that its trajectory "lay fortuitously just in the boundary between the geomagnetic cavity and the flow of the interplanetary plasma."

When the satellite was at 21.5 Earth radii, a signal appeared that varied with the rotation of the vehicle at energy levels of 80 ev, 250 ev, 800 ev, and 2300 ev, but never less; the average energy was about 500 ev. The corresponding bulk velocity was about 3×10^7 cm/sec (1.2×10^6 in/sec), and the number density was about 10 cm^{-3} (4 $in.^3$). (Source: Physics Today, March 1963, Vol. 16, No. 3)

IMPs DESCRIBED. Further use of atomic power in space will be explored by the Atomic Energy Commission (AEC) through two newly awarded contracts. One contract is for a nuclear generator designed for NASA's interplanetary monitoring probe (IMP) scientific satellites (Fig. 3). The other calls for development of a new atomic fuel to power communications satellites.

The AEC has selected Martin Company's Nuclear Division to design a 40-w radioisotope electrical system for IMP satellites. It is expected that an IMP with nuclear auxiliary power could be operational by 1964.

IMP is designed to gather information about radiation and magnetic fields between Earth and the Moon before NASA Apollo manned lunar flights begin later in this decade.

NASA has requested a nuclear generator because it would eliminate the problems experienced by solar cell systems when they are not oriented toward the Sun and when they are affected by the radiation environment of space.

IMP's eccentric orbit will have an apogee of 240,000 km (150,000 mi) and a perigee of only 170 km (110 mi). This orbit will take the satellite through the artificial and natural radiation belts.

Initial IMP satellites, scheduled for launch beginning in late 1963, will use solar systems for electrical power. If the design for the atomic generator is compatible with the IMP system, a number of these generators may be built.

Vital radiation data could be gathered by IMP for direct support of later Apollo manned flights; an operational IMP would be in orbit at all times during the project. Atomic generators, which are not affected by space radiation, may extend the useful lifetime of the satellite and therefore reduce the number of satellites needed.

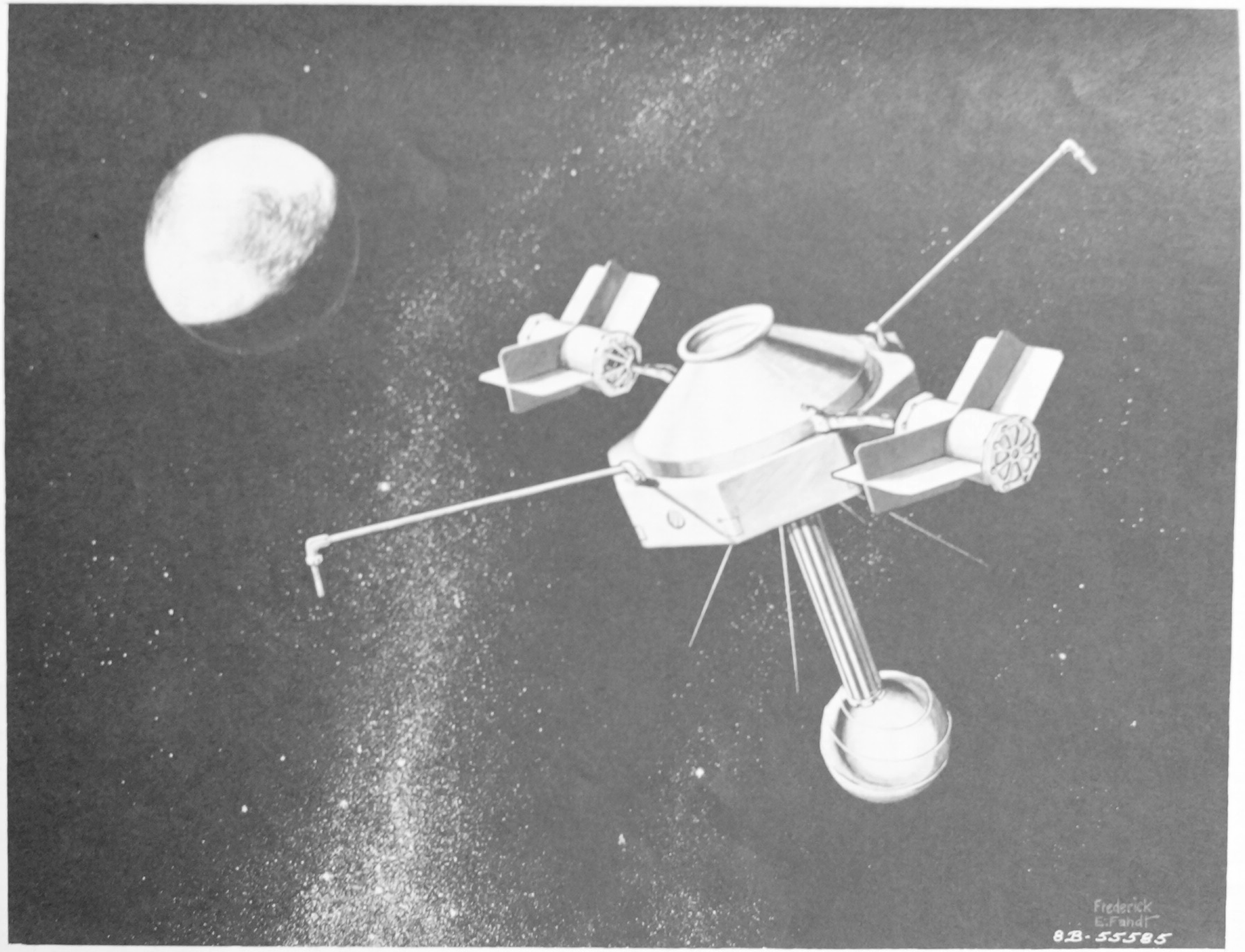


FIG. 3

This country's first nuclear-powered unit in space, a 2.7-w SNAP generator developed for the Navy's Transit 4-A navigational satellite, was launched nearly two years ago. It is still producing power for the spacecraft's instruments. SNAP-9A generators with 25-w capacities are being developed for future operational Transit satellites. The SNAP units for IMP will use plutonium-238, a nonfissionable form plutonium, as fuel. Thermocouples will convert heat from radioactive material directly into electricity.

Under a second program, Martin's Nuclear Division is to start immediate development of a strontium-90 fuel form for future space use. The program is expected to yield a form of strontium that will meet the rigid safety requirements set for nuclear space systems. This use of a waste fission product will make SNAP generators more economical and still provide the dependability inherent in radioisotope generators.

Strontium titanate, a virtually insoluable form of the radioisotope, has been used successfully in SNAP generators in land and sea applications. Radioisotope fuel may be needed for the nation's communication satellite program. Strontium-90 is abundantly available as a waste product of nuclear reactors. Cost of strontium fuel is far less than isotopes like plutonium and cirium. (Source: Data supplied by the Martin Company)

SPACE TECHNOLOGY THREATENS SPIDER LIVELIHOOD.

Pity the lowly spider. Space age precision is putting him out of business. Scientists at Chrysler Corporation's Space Division reveal that spider webs, once widely used for cross-hairs in optical instruments, are now taking a back seat to a new development: the etching of extremely fine lines directly into glass.

Space age tolerances make demands that nature cannot fulfill. For instance, the cross-hairs of the spider web (the black widow has the premium web) range in thickness between 70 μ in. and 100 in.; etched hairlines are between 100 in. and 120 in. in diameter.

Of the 46 optical sighting instruments that will be used in aligning the Saturn booster, only two have spider web cross-hairs. All others have recently been replaced with the etched lines.

Many alignments are now accomplished by shining a light through the cross-lines in the optical instruments; the same lines, reflected from a mirror, are lined up with each other to form a perfect alignment. This is similar to superimposing images in a range-finder, only in this case it is superimposing the etched lines in the glass. Spider webs are almost impossible to reflect through a mirror because of their microscopic construction. The etched lines, however, are sharp and clear. There are over 50 optical sightings for the Saturn booster alignment and more than 1000 optical probes of subassemblies, jigs, and fixtures.

These tests occur many times between the time the parts of the vehicle come in one door and travel down the assembly line and depart through the other.

The mirrors that reflect the optical sighting lines, whether they be spider webs or etched, are optically flat. They range in size from 2.54 cm (1 in.) to 7.6 cm (3 in.) in diameter.

Etched glass cross-lines will be used in the following instruments: 2 auto collimators; 14 precision levels, 7 alignment telescopes, and 10 universal theodolites. Spider webs are used for cross-hairs in only 2 of the 11 transit squares. All the other optical instruments will use etched glass lines.

A microptic precision clinometer employs a visual level vial for the measurement of angles and has no cross-hairs of any kind.

The art of the spider is being relegated by the space age to where it belongs--catching insects. (Source: Data supplied by Chrysler Corporation)

STERILIZATION OF SPACE PROBE COMPONENTS. In a report by Martin G. Koesterer of Wilmot Castle, several methods of sterilization of space probe components to avoid contamination of other worlds have been studied: (1) dry heat, the method most emphasized (the investigation centered on temperatures in the range from 120° to 150° C); (2) irradiation; and (3) other techniques, including the use of chemical sterilants (liquid and gaseous) and aseptic assembly.

The studies attempted to define the various biological, chemical, and physical factors that could influence the effectiveness of dry-heat as a sterilizing process. Five areas were investigated: (1) the screening, isolation, and growth of organisms resistant to dry heat; (2) the effects of time, temperature, strain of microorganism, and concentration on the effectiveness of dry heat sterilization; (3) the effect of the physical carrier (paper strip, glass tube, sand, and vermiculite) on the effectiveness of dry heat sterilization; (4) the effects of air, vacuum, inert gases, entrapment of organisms in non-aqueous liquid and on solids; and (5) methods for sterility testing of components after inoculation with spores of known resistance to dry heat and the subsequent application of adequate sterilization cycles.

The following findings were reported:

(1) Mesophilic aerobic spore-formers are, in general, more resistant to dry heat than are the anaerobic and thermophilic spore-forming bacteria.

(2) The type of carrier markedly affects the dose requirements for dry heat sterilization. Soil samples are the most resistant, with sand, vermiculite, glass, and paper following in that order.

(3) The gaseous environment also markedly influences the time required for sterilization. Samples in air are the most resistant with samples under helium and under low vacuum ($10^{-1}10^{-2}$ mm Hg) being less resistant, respectively.

(4) Entrapment of dry bacterial spores in solids definitely increases the dose of dry heat required for sterilization.

(5) There data raise a question concerning the adequacy of the proposed 24 hour dry heat cycle at a temperature of 125° C. (Source: "Sterilization of Space Probe Components", Final Report, Wilmot Castle Co.)

TECHNICAL ARTICLES IN THE JOURNAL LITERATURE.

From time to time STID will report on articles appearing in the journal literature of potential interest to our readers. Requests for copies of these articles should be directed to the Library, M-MS-IPL.

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"Engineers Repair Telstar," ISA Journal, 10, No. 2 (February 1963), 22.

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TECHNICAL REPORTS AVAILABLE. The following listed technical reports can be requested through the NASA library, M-MS-IPL, Bldg. 4481.

NOTE: Those reports with an AD number may be on file in the local DDC branch in Bldg. 4484. Readers can save time by calling 876-6088 and inquiring if such reports are available before ordering them through NASA.

1. ELEVATED TEMPERATURE CREEP PROPERTIES OF 17-7 PH AND A-286 STAINLESS STEEL, M. Knight. AD 285 471
2. STUDIES OF METAL-WATER REACTIONS AT HIGH TEMPERATURES-III-EXPERIMENTAL AND THEORETICAL, L. Baker, Jr., and L. C. Just. ANL-6548
3. NUCLEAR REACTOR CHEMISTRY, SECOND CONFERENCE, GATLINBURG, TENNESSEE, October 10-12, 1961. TID 7622
4. PROPERTIES OF GLASSES AT ELEVATED TEMPERATURES, M. J. Kerper. AD 286 893

5. THE EFFECT OF HIGH TEMPERATURES ON THE STABILITY AND IGNITION PROPERTIES OF COMMERCIAL TRIARYL PHOSPHATE FLUIDS, A. Chiantella, A. W. Affens, and J. Johnson. AD 285 684
6. A STUDY OF THE WIND PROFILE IN THE LOWEST 400 FEET OF THE ATMOSPHERE, I. Singer and C. Nagle. BNL 718 (T-254)
7. PHYSICS OF THE UPPER ATMOSPHERE, N. Fedorova. 62-11795