DECEMBER 19, 1960

missiles and rockets

THE MISSILE/SPACE WEEKLY

Tullahoma's Space Age Wind Tunnel

AN M/R EXCLUSIVE—

20-Year Guide for Missile Makers .....

1961 to be Crucial Year in Space Race ... 17

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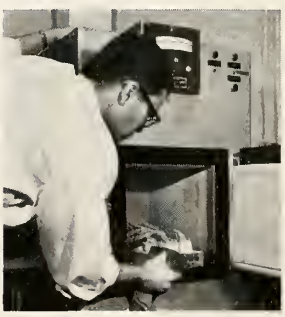

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THE MISSILE / SPACE WEEKLY

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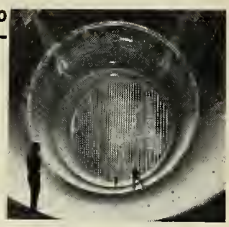

THE COVER

Interior of Air Force's Propulsion Wind Tunnel at the Arnold Center, Tullahoma, Tenn., providing first space environment testing for whole vehicles. See p. 14.

DECEMBER 19 HEADLINES

SPECIAL REPORT

SUPPORT EQUIPMENT

ELECTRONICS

ADVANCED MATERIALS†

INTERNATIONAL

NUCLEONICS

SPECIAL SECTION

DEPARTMENTS

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Season's Greetings—The Editors

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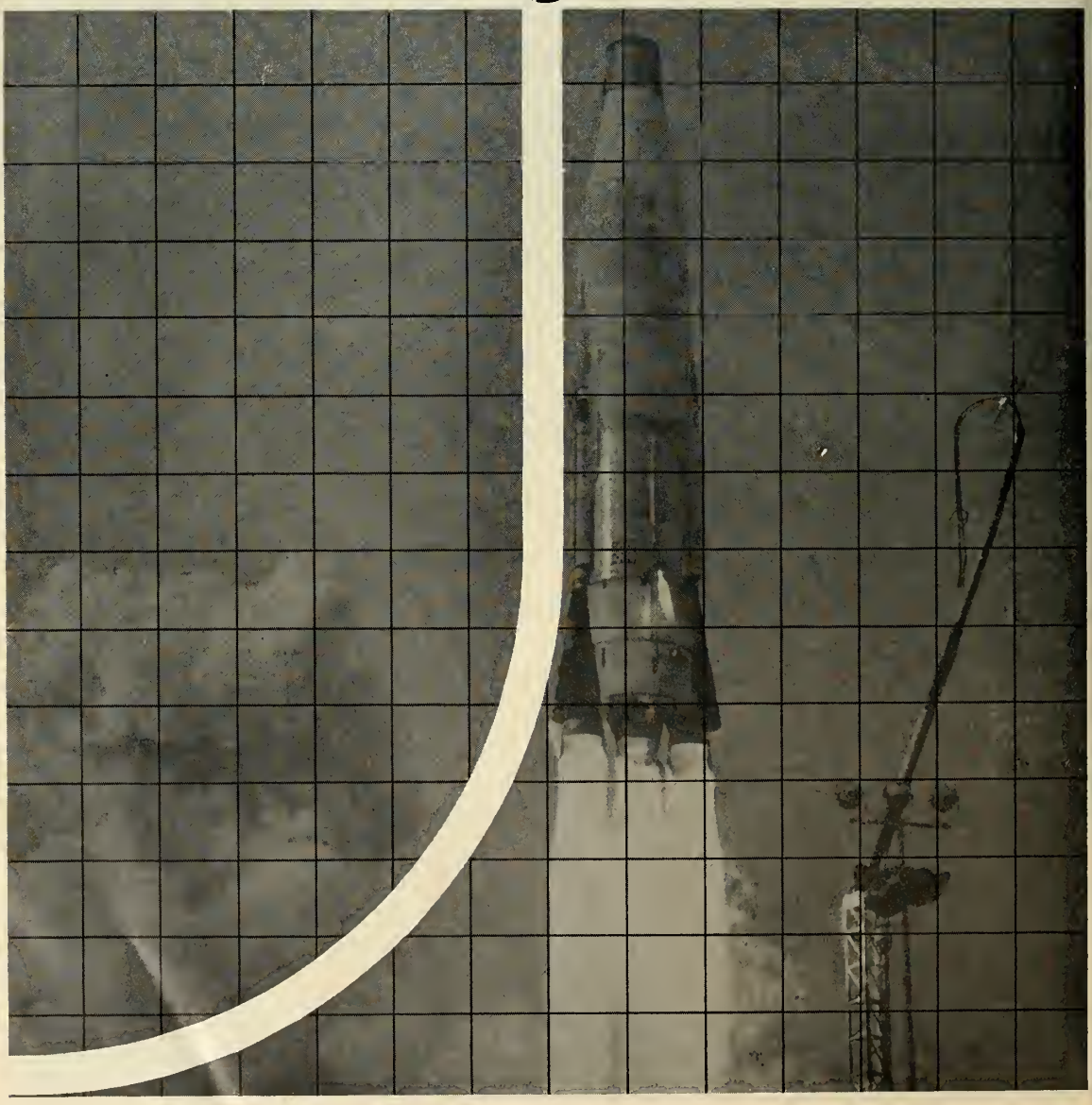

The Countdown

WASHINGTON

Polaris Subs: The Numbers Game

Latest word on the behind-the-door swapping at the Pentagon puts the number of *Polaris* submarines in the final Eisenhower budget at about five. Meantime, the Navy is understood to be preparing a proposal for the new Administration: Put about three more in the FY 1961 supplemental money bill and increase the number in the FY 1962 bill to 12.

Will Minuteman Fly for Christmas?

The first *Minuteman* launching from Cape Canaveral is still scheduled for about Christmastime. The test bird may or may not contain its inertial guidance system. However, whether or not the guidance system flies this time, reports of difficulties with it are definitely understood to be unfounded.

Congress Looks into Space

Congressional plans for a new round of hearings on the nation's space programs are still unsettled because of the changes involved in the arrival of a new Administration and Congress. However, current thinking is that the Senate will take more of a wait-and-observe approach while the House holds earlier hearings. *Mercury* slippage is expected to be a prime target.

Mobile A-ICBM Progress Report

Contractors working on feasibility studies for *FABMIDS*—The Army's proposed mobile antimissile missile—are expected to come up with their answers by about mid-1961. So far, insiders feel that it is still too early to evaluate the concept.

TAC's New Big Punch Coming Soon

The Air Force's tactical aircraft in the very near future will carry two powerful new missiles: The Hughes *GAR-11* and the Martin *GAM-83*. Both the air-to-air *GAR-11* (latest in the *Falcon* family) and the air-to-surface *GAM-83* (the Navy's *Bullpup*) are capable of packing nuclear warheads.

Sen. Symington: How Much Influence?

Among the questions about the Kennedy Administration still to be answered is how much leverage Sen. Stuart Symington will have on defense policies. Symington, who sits on the key Senate Armed Services and Space Committees, is reported to have turned down an offer to become Kennedy's Defense Secretary in order to remain in Congress.

INDUSTRY

Wanted: More Industrial Efficiency

Defense officials are saying both privately and publicly that the Missile/Space Industry must do something about rising costs. They argue the United States could price itself out of business. One recently cited example: While the cost of living in the last decade has increased about 25%, the cost of the *Sergeant* is 400% higher than the *Corporal* which it is replacing.

Recession and Defense Spending

Capital money men feel that any mild business slump in 1961 can only have a buoying effect on defense buying. The Kennedy Administration is already committed to sizeable increases in the defense budget. Any slackening in business conditions is expected by some to result in still further boosts.

Sales and Future Sales

Sperry is understood to have sold the *Sergeant* surface-to-surface tactical missile to the Royal Netherlands Army . . . the Air Force buy for mobile train-based *Minuteman* may hit more than 300 to 400 birds . . . the first big purchases of tactical missiles by Latin America are expected to come in 1961.

Soviet Translating Business Slows to Crawl

The Commerce Department reports that the post-*Sputnik* boom of industry interest in translations of Soviet technical papers and journals is all but dead. Some of the department's Soviet translating services have been dropped and others curtailed.

Air Force-Industry Plan Spaceports

Contractors involved in developing manned spacecraft are to be asked by the Air Force what recovery systems will be needed to convert airfields to spaceports during the next decade. The Air Force study—called Project *Meteor*—will seek to establish as early as possible the standardization of spaceport electronic facilities.

INTERNATIONAL

Red China Seeks To Join IRBM Club

The pinpointing by mountain climbers of a suspected Red Chinese missile test base in Tibet underlines a principal worry of military strategists—the eventual emergence of Red China as a major missile power. The Communist bosses of China are believed to be striving for a buildup of nuclear-tipped IRBM's with which they could hold all of Asia at gunpoint. The question is: When? Some military men speculate 1966 or 1967.

Low-Cost Space for Scandinavians

Norway, Denmark and Sweden are planning a three-year space research program to be conducted by scientists from all three countries. They are expected to use relatively inexpensive rockets launched from portable platforms—possibly balloons. Each country will launch about 75 research rockets primarily to determine electron densities in the ionosphere around the aurora borealis.

Clydeside Remains Unshaken by Red Threats

The stout Scots of Holy Loch for the most part are ignoring repeated Soviet threats that the planned establishment of an advanced floating *Polaris* base in the Clyde Estuary places the area in the bullseye of a Red ICBM. The majority of Holy Loch residents are reported to be fully aware that they already are a prime target. Moreover, the jingle in the Yankees' pockets does warm many a Scot soul.

Building Begins on African Space Tracker

Cement is being poured for the planned 85-foot radio telescope near Krugersdorp in South Africa. Erection of the 100-foot-high antenna is scheduled to begin next month. The big telescope will be used to track American and other space launchings. It will be operated by South African Council for Scientific and Industrial Research. Construction cost: Under $6 million.

The Missile/Space Week

The Missile Gap Yawns Wider

A British report reminded the Free World this last week of the coming East-West Missile Gap.

The Institute for Strategic Studies says the U.S.S.R. is believed to have 35 ICBM's already on launchers and to be capable of having some 200 by next winter. Moreover, the report said Russia is understood to have six nuclear-powered submarines under construction.

Other reliable sources said all of the nuclear subs in Russian shipyards are believed to be capable of carrying short-range missiles—as are an estimated several dozen Soviet diesel-powered submarines.

The United States at present has approximately a dozen *Atlas* ICBM's operational and 16 *Polaris* missiles aboard the nuclear-powered submarine George Washington. Possibly 60 more American ICBM's will become operational by next winter along with three or four more *Polaris* subs.

McNamara: Harvard to Detroit to the "E" Ring

The majority opinion on the nomination of Ford President Robert McNamara as Defense Secretary is that a driving new force will be taking over the Pentagon's front office in January.

The 44-year-old executive—known in Detroit as one of Ford's "whiz kids"—brings to the Defense Department what is described as incisive administrative ability, acute business sense and a brilliant academic record.

But, most of all, observers noted that McNamara brings a Harvard-trained intellect that takes an imaginative, unfettered approach to the most complex problems.

Dyna-Soar Team Adds Minneapolis-Honeywell

The first R&D program aimed at turning out an inertial guidance system for the nation's first piloted spacecraft—the Air Force's *Dyna-Soar*—got underway this week.

The Air Force tapped Minneapolis-Honeywell to do the job as associate prime contractor. A dozen firms took part in the competition.

The contract covers the first phase of the R&D program. No dollar figures were announced.

M-H said it would center its work on the program at its Aeronautical Division Facility in St. Petersburg, Fla.

New Gains for Pershing, Polaris—and the Cape

Both the Martin *Pershing* and Lockheed *Polaris* programs bolted forward this last week.

The 34-ft solid-propelled *Pershing* roared down the Atlantic Missile Range carrying an inertial guidance system as a passenger for the first time. A fully-guided shot is expected to follow in a matter of weeks.

Meantime, the nuclear-powered submarine Robert E. Lee prepared to begin a series of *Polaris* launchings while submerged off the Florida coast.

But the biggest news at Canaveral involved the Cape itself. The Pentagon released $62 million for a range modernization and expansion program. Much of the money will be used to convert two 11,000-ton ships into seaborne missile tracking stations.

Missile Mystery behind Iron Curtain

The question was asked last week in Washington, in London, in Rome:

Is there any truth in the Italian news agency report that a new type of Soviet rocket exploded on Oct. 21, killing about 100 people including three top Soviet missile bosses?

The news agency—Continentale—said the new missile was exploded while being tested in preparation for a "spectacular launching" in November on the anniversary of the Bolshevik Revolution.

Among those reported killed in the blast were Soviet Rocket Marshal M. I. Nedelin, Gen. N. O. Pavlovsky and Prof. D. V. Efremov. Russia had announced their deaths separately.

(See Soviet Affairs column, M/R, Nov. 21, p. 36.)

He took the luck out of heads or tails

This AMF engineer had a delicate problem: to accomplish the separation of the expended stages of a multi-stage rocket. If separation occurs too soon, thrust in the nearly burned out stage may exceed the aerodynamic drag, the tail overtakes the head, and...boom. A million dollar collision and no insurance.

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20-Year Production Guide Due

- *Manufacturing methods for future outlined*
- *Report to aid industry in long-range planning*
- *29 major vehicle classes systematically studied*
- *No attention given to the 'normal' developments*

by John F. Judge

THE MISSILE/SPACE INDUSTRY will soon be handed an Air Force-sponsored master space guide to expected needs in materials and manufacturing techniques over the next 20 years.

The highly classified guide covering the space production needs of all three military services and NASA has just been completed by a panel of the National Academy of Science's Materials Advisory Board.

It is expected to be circulated on a tightly regulated need-to-know basis. Details of its distribution have yet to be worked out.

The project was initiated by the Manufacturing Methods Division of the Air Force's Air Materiel Command in order to assist in development of manufacturing capability to support long-range advanced weapon system programs. The Department of Defense cooperated with the panel.

The scope of the study includes all aerospace vehicles or weapons systems, except the warheads per se, technically feasible and required in the designated time period.

The three major objectives of the study were:

1. To establish and analyze future mission and system requirements with respect to design criteria, application and environment.

2. Determining and outlining the major areas of materials development and needs based on the above analysis and requirements.

3. Projecting a broad outline covering the major areas requiring manufacturing process development related to the applications and materials requirements identified above.

The study was undertaken by the Aircraft and Astronautics Application Panel in May, 1959, under the chairman, Dr. Elliot L. Katz of Ford Aeronutronic. Warren J. Eding, Staff Aeronautical Engineer, represented the Materials Advisory Board on the Panel.

• **Integrated approach**—The Panel tackled the problem through four subgroups—Communication and Guidance; Propulsion and Auxiliary Power; Structures and Airframes; and Pneumatics, Hydraulics and Launch Complex.

Each subgroup had its own military liaison member and all used the same general methods. The three main objectives were designated Phase I, II and III respectively and each subgroup adhered to this format through their 16 months of operation.

Approximately 10,000 man hours were spent by panel members on preparation of reports in subgroup and panel meetings. The total man-hour figure involving the time spent in collecting and analyzing data could easily increase this conservative figure by a factor of 10. The panel produced a systems analysis of 29 vehicles classes.

• **In the beginning**—Eding says it soon became evident that the outlining of major areas in requiring manufacturing process development made it necessary to progress consecutively from design and applications requirements, through resulting material requirements to the final manufacturing development requirements.

Thus the panel was staffed with personnel from several distinct disciplines and with definite background experience. Technical areas represented included preliminary design, materials evaluation. basic research, fabricating techniques. manufacturing methods development and the military.

Men were selected from 21 different companies active in missiles, aircraft, propulsion, communication, navigation and space systems. Each of these in turn called on persons and sections within his own company for specialized and detailed information.

The common reference point for each of the subgroups is a master vehicle chart which divides the vehicle classes into three major flight regimes—atmospheric, space and combinations. The vehicles listed are a category or type rather than a specific model.

The identification of vehicle categories was dependent upon technical feasibility and prime interest, so that a broad basis of materials and manufacturing requirements could be determined. It was not intended to merely list specifically those vehicles which the Defense Department would build in the designated time period.

Inputs from ARDC, BMD, WADD,

NASA, Army R&D, and BuWEAPS long range planning groups and the preliminary design sections of the represented companies were used to establish the master list. Vehicles thought to be within the state of the art were excluded.

Along with the vehicle classes, a series of parameters such as velocity, mission, life, manned or unmanned etc. were included. These were identified in order to basically describe the vehicle requirements to the design engineer.

Phase I also called for an analysis with respect to induced and imposed environments. Once the problem areas were identified with respect to design and environmental requirements, the next step was to review and evaluate each one in detail. This involved stating the nature of the problem, identifying its components and placing numerical values and ranges on these components. Now the subgroups were ready for Phase II.

• **Building blocks**—The data established in Phase I served as the primary basis for the determination of materials requirements. A "long form" was developed for systematic statement of materials requirements relating to the major components and environments of each vehicle class. Conclusions were extracted from these "long forms" and, since the panel assumed that these results were to be primarily directed to materials experts, arranged accordingly.

For the completion of Phase III, the manufacturing development requirements were ascertained for each specific component of each vehicle, utilizing all of the data from each of the preceding phases.

• **A typical experience**—The operation of Propulsion and Auxiliary Power Subgroup might serve as a brief example of the method employed.

Basing their analysis on the master chart which established the vehicle types in their flight regimes, this group identified a total of nine primary propulsion systems and seven auxiliary power systems. The environmental problem chart prepared from this data permitted the subgroup to specifically define each problem, its parameters of importance and common requirements.

A materials description form was prepared for each of the application problem areas. Then Phase II in propulsion was completed with the identification of materials requirements in 11 basic materials descriptions. The final phase entailed an analysis of all of the accumulated data and the identifying of manufacturing requirements in nine established categories.

These categories aided in the formulation of manufacturing conclusions. The list covered such concepts as materials forming processes, joining and mechanical fastening, material treatment, electrical and electronic component fabricating techniques and others of a similar nature.

Solid Propulsion Subgroup —A Typical Problem Chart

		Thermal	Chemical	Radiation	Loading	Duration	Atmosphere
Atmosphere	Subsonic						
	Supersonic						
	Hypersonic						
	Booster	●	S	P	O	S	P	O
Space	Orbital						
	Interplanetary		S	P	P	S	P	O
	Space Platform						
Combinations	Boost Glide	●	S	P	O	S	P	O
	Orbital & Return		S	P	O	S	P	O
	Interplanetary & Return		S	P	O	S	P	O

O No Problem P Problems S Serious Problems
● Application

• **Cannibalizing**—The flexibility of the panel as it progressed can best be illustrated by the fate of one subgroup —Hydraulics, Pneumatics and Launch Complex. This subgroup defined the systems within the launch complex and vehicle support systems which were required for the vehicle types under consideration. While the major problems were identified as they emerged, the subgroup found it impossible to assign quantitative environmental parameters.

Since this data was not definable enough to ultimately call out required materials characteristics, the subgroup foundered. The principal reason was that the environmental parameters are so closely related to detailed vehicle design configurations that it was not feasible to predict worthwhile requirements without these design descriptions.

The subgroup was disbanded and absorbed by the other subgroups as was their first and second phase reports. Thus an apparent loss was turned into a net gain because each of the other subgroups used the personnel and reports where applicable.

The Communications and Guidance Subgroup identified their materials and process requirements in categories of electronics. magnetics, mechanical requirements, radomes and antennae. Eding states that this section of the report " . . . adds a refreshing and most important contribution to the analysis of materials requirements by pointing out the non-structural application requirements."

• **Normal progress excluded**—The report does not offer solutions to the major manufacturing problems—it only identifies them. In addition, the panel members restricted their efforts to those requirements which they felt would need an additional effort and emphasis beyond the state of the art. Hence the report does not outline all materials research and development or manufacturing development needs.

In Eding's words—"It is not intended to be a detailed road map which will substitute for thinking. It is a strong skeleton built from a great deal of effort and depth of experience . . ." but the flesh will be added by the user.

The report will be released to those who establish proper clearance and need-to-know through the Air Force, ASTIA and other agencies authorized to handle these documents. ⌗

Turn to page 32 for a complete list of the membership of the Panel.

Test Tunnel Readied

Mach 5 Flight in Near-Vacuum

THE NEW SUPERSONIC Propulsion Wind Tunnel at the Air Force's Arnold Engineering Center, Tullahoma, Tenn., will soon be able to test rocket engines at speeds up to Mach 5 and at simulated altitudes up to about 200,000 ft. The supersonic nozzle (above) has flexible steel sidewalls to regulate the velocity of the airflow. The supersonic circuit (right) is 27 feet wide. The test section is 16 x 16 x 40 ft. The great scavenging scoop (below) removes exhaust gases from the airstream during a test. The tunnel is expected to save millions of dollars by performing preflight testing which was previously impossible. ⁂

NASA Lacks Funds Now For Next Lunar Orbit Shot

Planning calls for putting Ranger III into lunar trajectory in 1962

REGARDLESS OF the success or failure of last week's scheduled *Atlas-Able* moon shot, there will be no followup for more than a year. There is no money.

On Wednesday morning, the *Atlas-Able* came within seven minutes of launch at Cape Canaveral, but was postponed when a difficulty developed in the autopilot. This was corrected immediately, but then a special technician was flown in from Convair-San Diego to do a small welding job. At M/R's press time, the launching was still pending.

Under current funding and development plans of the National Aeronautics and Space Administration, the next attempt at a lunar trajectory will be made by the third *Ranger,* early in 1961.

Flight tests of the *Ranger* spacecraft, boosted by *Atlas-Agena B* vehicles, are scheduled to begin in the third quarter of 1961. However, the first two *Rangers* will be deep space probes. *Ranger III* will be the first to carry the lunar rough landing capsule and a retrorocket to slow its descent.

Edgar M. Cortright, head of NASA's lunar and planetary programs, said *Ranger I* will be launched into a highly elliptical earth orbit with apogee of more than 100,000 miles. The distance is not known more exactly because there is still some uncertainty about the exact *Agena B* performance, he explained.

The trajectory for *Ranger II,* whose launch date target is in the fourth quarter of 1961, has not yet been established. Cortright said there is a possibility it will go near the moon but no attempt will be made at a lunar orbit, such as in the *Atlas-Able* program.

• **Progress cited**—Cortright declared in an interview that he is satisfied with the NASA lunar program because of its steady progression from the *Atlas-Able* shots to the five *Rangers* and then to the *Centaur*-launched *Surveyor* soft-landing spacecraft, beginning in 1963.

There is no consideration of adding to the lunar orbit program in progress, he said, adding that he is satisfied with the internal balance of apportionment of resources among the various NASA programs.

In response to a question whether it is possible to add an *Atlas-Able* to the program, if the administration should direct it, Cortright said yes—at a cost of about $10 million per launch.

Cortright did comment that, if such a shot were ordered, an *Able* need not be used as the second stage. He noted that *Delta* stages are now being delivered for NASA vehicles. Although he did not say so, one can assume that the *Delta*'s guidance would be of great value in achieving the accuracy needed for a moon shot.

• **Guidance untested**—The *Atlas-Able* mission has been to place a 388 lb. paddlewheeled sphere into a 5000-mile lunar orbit. Objectives are to make a more thorough investigation of the space environment near the moon and to develop a technology for controlling and maneuvering a spacecraft at the lunar distance of a quarter million miles.

However, in the first three attempts, one *Atlas* exploded on the pad in a preflight test and two launch vehicles failed during powered flight. The terminal guidance technique, using a hydrazine engine commanded from the earth, had never been tested in flight.

The first two *Rangers* will carry a series of seven experiments to investigate electromagnetic and particle radiation and measure micrometeorites, similar to experiments aboard the *Atlas-Ables.*

However, the later *Rangers* will have television cameras and gamma ray spectrometers for the flight phase and a single-axis seismometer protected by crushable material for the rough-landing package. Many materials, from honeycomb to balso wood, are being considered for the spacecraft protection.

The seismometer will be locked during flight. A fluid lock will open either on impact or on a time basis. The seismometer will be capable of detecting moonquakes and the impact of meteorites.

• The five *Ranger* flights are to take place in a period of about a year beginning in the third quarter of 1961. Meanwhile, NASA is preparing to select a contractor to develop the *Surveyor,* which will make a true soft landing on the moon.

Four contractors—Space Technology Laboratories, McDonnell Aircraft, North American's Missile Division and Hughes Aircraft—completed five-month competitive studies last week. Cortright said he expects to choose a prime contractor from among them early in 1961. Flight tests of *Surveyor,* boosted by a *Centaur* vehicle, are to begin in 1963.

Discoverer XVIII

AF Studies Specimens For Shielding Date

THE AIR FORCE is analyzing biological specimens recovered from *Discoverer XVIII* with hope that they will bear out the favorable shielding data indicated in *Discoverer XVII.*

The latest *Discoverer* capsule carrying human bone marrow, eyelid tissue, gamma globulin and cancer cells was recovered Dec. 10, after 48 orbits in three days. Jubilant Ballistic Missile Division officials termed the shot "most successful" in the *Discoverer* series because of the precision of the recovery operation.

The extended trip was made possible by the use of an improved *Thor-Agena B* which had 15,000 lbs. more thrust than *Thors* used in other shots. The booster was streamlined by eliminating the unnecessary guidance compartment.

The *Agena B* carried for the first time an inertial reference package developed by Minneapolis-Honeywell's Aeronautical Division. The one-foot-diameter package contained three gyroscopes which sensed satellite deviation and signalled the control system. It prevented tumbling and maintained planned satellite orientation to earth.

Reentry was triggered by ground command overriding a preset timer in the vehicle.

Results of the previous shot, *Discoverer* XVII launched Nov. 12, have indicated that biological specimens including man may be able to withstand heavy solar flares with a minimum of shielding.

Some seven hours before launch a massive solar flare began which continued for the first 13 hours of the satellite's orbit. Dr. George W. Crawford, nuclear physicist at the School of Aviation Medicine disclosed that the specimens received up to 30-35 RAD during the 50 hours they were in space.

He reported that radiation dosimeters indicated that the specimens had not received a lethal dose. Previous estimates of the radiation level of such flares put the dose at intensities as to kill living specimens unless they were protected by heavy shielding.

The experiment also indicated that aluminum might be a more effective shielding material than lead. Dr. Crawford reported that some specimens were encased in different types of metals to test their shielding properties. Some were shielded only by the thin aluminum covering of the specimen capsule and the recovery vehicle. These specimens apparently fared better than those protected by lead shielding. ⌘

Tory II-A tests near . . .

Will Pluto Provide Power for SLAM?

by Frank G. McGuire

JACKASS FLATS, NEV.—Tests of the Tory II-A reactor for the Pluto nuclear ramjet program slated for next month may prove the feasibility of the concept as a powerplant—possibly for the Air Force supersonic low altitude missile—*SLAM*.

Coincident with the announcement of the beginning of tests, the Atomic Energy Commission and the Air Force released major design and operating details of the prototype reactor test unit here.

Brig. Gen. Irving Branch, charged with development of the reactors for the program, said the Tory II-A has "strained the state-of-the-art in reactor technology." He said design of the fuel elements posed some difficulties during hardware design, but he expects future problems to mainly involve testing methods. Testing is now limited to a maximum of 90 seconds by available air supply in the tank farm adjacent to the test bunker.

"How do you adequately test something like this . . . designed for operation at Mach 3 for several days?" Branch asked. "Our present test procedure requires the air to be heated to over 1000°F before introduction into the reactor. At the rate of 720 lbs. of air per second at 360 psia, it's going to be tough."

The Air Force has set no target date for a flying nuclear ramjet; under the current pace, one could materialize about 1965. How close this would be to the proposed *SLAM* configuration, no one has said.

Branch strongly emphasized that there is no established military requirement for the Pluto program.

Nevertheless, Pluto seems to be the most likely, and perhaps the only, program capable of turning out a powerplant for the *SLAM*, and it will very likely be a descendant of Tory II-A which eventually powers the supersonic low altitude missile.

When a military requirement is established, funding for the program will probably be increased, but the present rate of funding is expected to continue for the next several years. Funds for the next fiscal year will reportedly run around $25 to $30 million, with AF providing about 25% of the total. To date, funding has amounted to $63,400,000 since 1956, not all at the same annual rate. Of this, AF has put up $17.4 million, and AEC the remainder.

The Air Force said there is close coordination between the Pluto program and the aircraft nuclear propulsion (ANP) program developing a nuclear turbojet. Following the Tory II-A program will be the Tory C series of reactors, closer to flight-type hardware and having a control system which will approximate that to be found in airborne vehicles.

(Except for identifying Coors Porcelain Co. as fabricator of the fuel elements, AEC/USAF have revealed little about the Tory C series. The air supply at the test site will be modified to allow for longer test times.)

Lawrence Radiation Laboratory of the University of California at Livermore, Calif., is under contract to AEC to determine the feasibility of the nuclear ramjet, and is responsible for the overall Pluto program. It fills the same role as Los Alamos Scientific Laboratory does on the *Rover* nuclear rocket program, although there is no similarity in the reactors used.

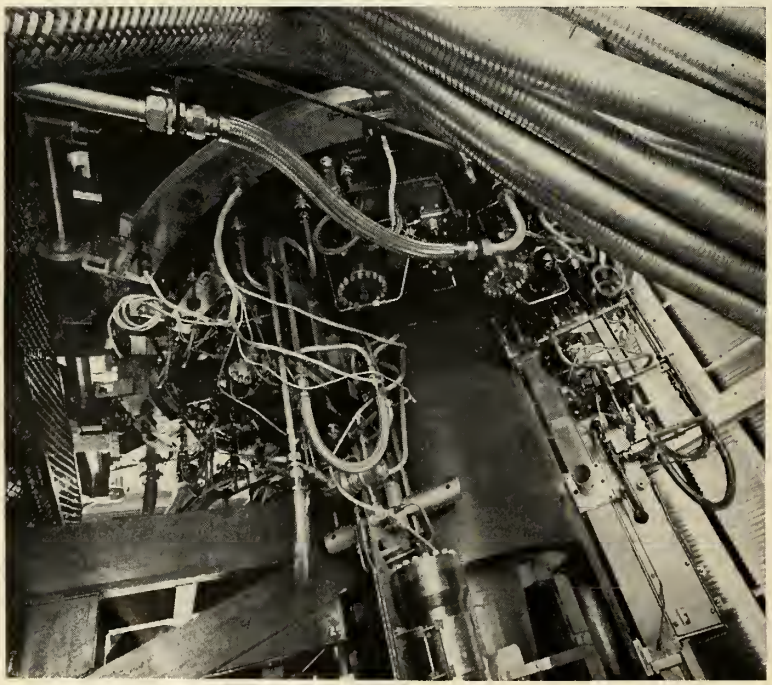
• **Tory II-A design**—Two reactors presently make up the Tory II-A "family"—Tory II-A-1 and Tory II-A-2. The former is the result of early R&D work at LRL, and it is this reactor which will be tested next month. AEC has one reactor core and two test units for this model. The core can be used in either. Fuel elements were produced by General Electric's Aircraft Nuclear Propulsion Department.

Tory II-A-2 is a backup system and is similar except for fuel element design. The fuel elements are being fabricated by Atomics International Division of North American Aviation.

Tory II-A-1 is a direct-cycle, air-cooled reactor fueled with highly enriched uranium homogeneously mixed with beryllium oxide. Total design power of the core is 150 thermal megawatts.

Prime objective of the initial tests is to determine reactor operation under supersonic aerodynamic conditions, with anticipated high shock, force and g loadings. Objectives for the overall program also include the study of struc-

(Continued on Page 35)



VIEW OF TORY II-A reactor in test facility shows control vanes. Allowing neutrons to escape through the vanes reduces the power level as desired.

1961

Key Phase In Race For Space Lead

Soviets and U.S. to try manned shots; Titan due to become operational; new Administration will hike funding; prospects for propulsion, materials, electronics, GSE

by Jay Holmes

1961 WILL BE THE YEAR of the Astronaut.

The race for space will enter a major new phase with attempted manned launchings by both Russia and the U.S.

So far as is known, Russia's manned space exploration efforts will be a continuation of her experiments with the 10,000-lb. *Sputnik* space ship. Every indication is that, when the spacecraft passes developmental tests, it will be used to carry one or two men on an orbital mission.

America's program revolves around Project *Mercury*, a one-ton capsule designed to carry one man in orbit with an *Atlas* booster. But prior to the *Atlas* orbital flights will be a series of 200-mile ballistic training flights of the capsule with use of a Redstone booster.

• **Chance to beat Russia**—Manned *Redstone* flights probably will begin in March or April. Since *Sputnik VI* burned up on an attempted re-entry with its dogs and other living passengers Dec. 2, it seems safe to assume that the next *Sputnik* will not carry a man. And, since the Soviet *Sputnik* space ship tests have been at three-month intervals, it also seems safe to guess that Russia will not achieve manned orbital flight before April or May at the earliest.

Thus there seems a chance that one of America's astronauts may make the short hop before Russia puts a man or men in orbit—thus gaining at least a technical first by lifting him to an altitude of 125 miles, above everyone's definition of the threshold of space.

But the first manned U.S. orbital shots cannot take place until late in the year, and indeed may well slip into 1962. Thus it still seems almost certain that Russia will win the race for manned orbital flight.

In unmanned space exploration, 1961 will see the first flight tests of the *Ranger*, a spacecraft designed for rough lunar landings of a moonquake seismometer. Two deep space probes with the *Ranger*—launched by an *Atlas-Agena B*—are programed for 1962 in preparation for lunar landings in 1962.

Altogether, NASA will fire about a dozen satellites and five to eight deep space probes during the year, in addition to test and training shots in the *Mercury* program.

• **Adding ICBM's**—On the military side, *Titan* can be expected to join *Atlas* as an operational U.S. ICBM, and the first major increments will take place in America's ICBM forces—now consisting of a scant dozen *Atlases* at Vandenberg and Warren Air Force bases.

The Air Force will try for its first successful *Samos* reconnaissance satellite and *Midas* early-warning satellite launchings.

In civilian applications, NASA can be expected to launch its first active communications satellite—a prototype of the eventual commercial satellite. The Federal Communications Commission will authorize one or more private companies to use portions of the radio spectrum on a temporary basis for similar experiments—although the industry launchings probably will not take place before 1962.

In the space sciences, major efforts will be made with satellites, deep space probes and sounding rockets to map the danger zones of the Van Allen belts and to assess the danger to manned flight from solar flares.

Industry will encounter tighter competition as airframe companies, facing continued downtrend in aircraft, expand their capabilities in the missile/space field.

On the international scene, a third country will enter the satellite field with a U.S. launching of a *Scout* satellite with British instrumentation aboard.

• **Boosting propulsion**—America expects to make major strides in the race to develop bigger propulsion systems during 1961. The year will see the first flight of the *Saturn* booster, with dummy upper stages. A radical change in upper stage propulsion will be tested with the first flight of the *Centaur*, a liquid hydrogen-burning upper stage atop an *Atlas*. The *Centaur* flight will be America's first attempt to put a satellite into a 24-hour orbit.

The *Agena B* restartable upper stage, first tested in late 1960, will be used on missions with both *Thor* and *Atlas* boosters. The all-solid *Scout* satellite launcher will complete flight tests.

In materials, 1961 will be a year of production, particularly of missiles. If the degree of effort involved is any criterion, such pressing problems as those associated with reinforced plastic cases will be solved.

In electronics, probably the year's major effort will be aimed at component reliability, as systems become bigger and more complex.

GSE facilities due to go into operation in 1961 include the *Saturn* and *Centaur* complexes at Cape Canaveral, the *Scout-Little Joe* blockhouse at Wallops Island, a new test cell for the *Rover* nuclear rocket at Mercury, Nev., and several new installations for the Pacific Missile Range.

• **Where money may grow**—With a new administration taking office Jan. 20, moves will be made to increase the current rate of missile/space activity. The final Eisenhower budget is expected to include $41 billion for defense and a little over $1 billion for the National Aeronautics and Space Administration. The big question is how much the new Kennedy Administration will modify it with a supplemental budget or suggested amendments in testimony before the congressional committees.

The most likely final figure for defense is in the neighborhood of $43 to $44 billion. A big space item increased may be *Dyna-Soar*, if the new administration supports its Air Force proponents. The Army will continue its drive for production of *Nike-Zeus*, while the Navy presses hard for seaborne launch facilities.

In the civilian space program, the biggest single program increase may

(Continued on page 34)

For more than a quarter century, Hallicrafters has worked in close partnership with our armed forces on fast solutions to critical military electronics problems. Out of this priceless experience are emerging startling new ideas and hard-hitting, fast-moving techniques to keep our country one jump ahead in electronic warfare . . .

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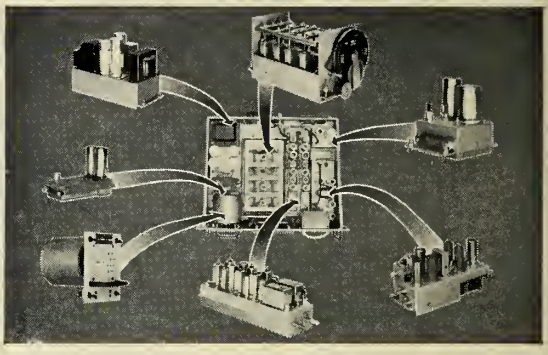
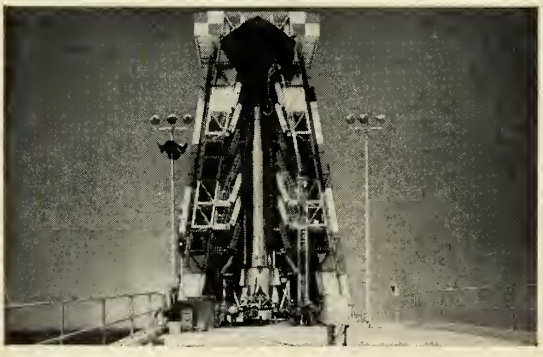
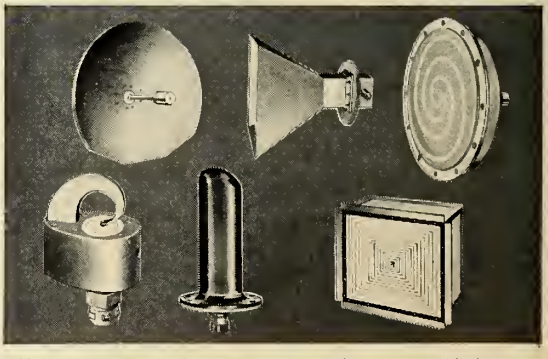
New levels of speed and efficiency are being reached in equipment modernization, retrofit and technical support programs with Hallicrafters' radical new "Blue Streak" project. Specially-trained Maintenance and Technical Support Teams, close-knit and flexible, can be tactically deployed to accomplish maintenance, installation and testing of electronics weapons systems anywhere in the world.



Hallicrafters communications leadership is exemplified by new high frequency Single Sideband receiver, (model no. SX-116). 100% modular design permits simple modification for compatability with existing and future communications systems. Stability, with proper available plug-ins, is better than one part in 10,000,000 per month. Hallicrafters also offers an existing capability in receiving and transmitting techniques up to frequencies of 50,000 megacycles.



Hallicrafters participation in the Atlas missile project helped to develop capability for many areas of the complex missile field, including code translator data systems; ground support equipment; ECM testing and antenna systems. Current explorations involve latest Infra Red techniques.



Airborne antennas and micro-wave components with power capability in excess of 1,000 watts, can be made available to solve tomorrow's very high power handling requirements. Testing of microwave components is possible with special high power generators, designed and built by Hallicrafters.

Looking for a challenging new opportunity? We are interested in qualified engineers at all levels. For full details in confidence, contact William F. Frankart, Director of Engineering.

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Military Electronics Division,
Chicago 24, Illinois

Technical Countdown

ELECTRONICS

Piano Tuned Radar for Boston

A low-cost radar antenna will be constructed for the Air Force by North American Aviation's Columbus Division at Tyngsboro, Mass. Tension rods will connect the five concentric rings forming the reflector's backup structure. Proper tension on the rods will be measured sonically.

Navy Gets 3D Radar

Hughes Aircraft's Frescan, a single-antenna radar system capable of pinpointing simultaneously a target's range, bearing and altitude are standard equipment on *Talos, Terrier* and *Tartar* armed ships. Range and height information is obtained by electronic scanning in a vertical plane in milliseconds while rapid rotation of the antenna supplies target bearing.

Missile Reliability Formula Standardized

Vitro Laboratories is establishing a yardstick for predicting how often a missile system will fail to perform acceptably under specified conditions from launch to target and detonation of the warhead. The study is being supported by a Navy BuWEAPS contract.

Satellite Warranty Proposed

Reliability requirements of communications satellites demand establishment of a new parameter, says NASA's Leonard Jaffe. Mean time to failure must be replaced by the concept of guaranteed lifetime.

Short Circuitless Relay Developed

Mathematicians at Moscow State University have reportedly completely synthesized a contact relay circuit which is not disrupted by any short circuit. It's claimed that the circuit uses no duplication of components to achieve the immunity.

PROPULSION

MGD Thrust Measured Directly

Continuous thrust levels on the order of two pounds have been measured directly by Northrop engineers on their magnetogasdynamics engine. The engine uses a three degrees-of-freedom thrust balance and strain gages in the measurement, which is believed to be the first of its kind.

Solids Ignited Hypergolically

United Technology Corp. reports successful tests of hypergolic ignition of solid-propellant motors—by spraying with a small quantity of chlorine trifluoride. Tests succeeded with both PBAA and polyurethane motors, UTC says.

Reverse-Flow Nozzle Display Reversed

Rocketdyne's plans to show its reverse-flow nozzle at the ARS convention were okayed by the Air Force—but classified secret by the Department of Defense.

MATERIALS

Largest Columbium Ingot Forged

Wyman-Gordan pressed out a closed-die forging from a 1300-lb. ingot of electron beam-melted columbium producing the world's largest forged piece of the refractory metal.

Ideal Fuel Cell Fuel Lacking

Hydrogen appears to be the best available fuel for fuel cells but it and other known fuels fall short of the ideal. Union Carbide scientists expect new developments in cryogenics to offset the high cost of using hydrogen.

X-15 Nose Blunted

Northrop Corp's new "hot nose" will be flight-tested on the *X-15* in the near future. The rounded profile is expected to aid the rocket ship's pilot in determining the attitude angles that minimize frictional heat during the critical exit and entry phases of hypersonic flight in the upper atmosphere.

Russian Pressure Soars

Pressures of five million atmospheres have been reported by Soviet scientists, who say they achieved the level for a fraction of a second through use of an explosion principle. The Russian researchers also are constructing a device for producing hydrostatic pressures of one million atmospheres at the USSR Academy of Sciences.

New Space Chamber at G.E.

General Electric's 50-ft. vacuum chamber is now under construction. Designed for testing satellite payloads, the chamber will pump down to 10^{-6} to 10^{-7} mm Hg and will have a simulated sun, radiating all of the solar spectrum during quiet periods.

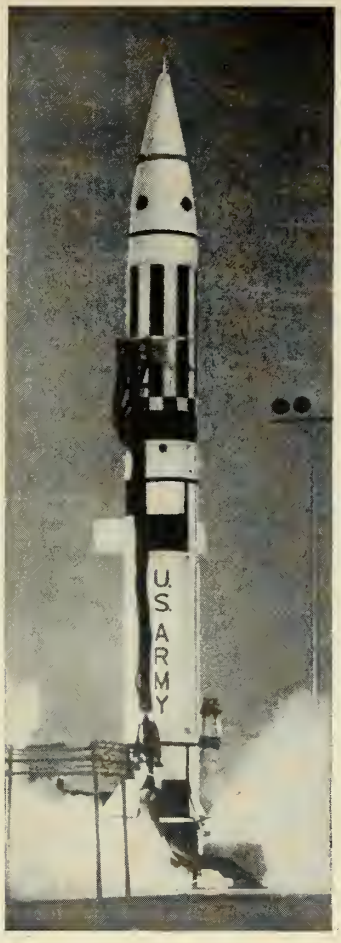
SUPPORT EQUIPMENT

PMR's All-Weather Facility Operational

Two systems, Cubic Corp's COTAR and Gilfillan radar, are in operation at Point Arguello, providing launch ability under extreme overcast conditions. Previously, seasonal fog had sometimes prevented optical tracking instruments from "seeing" the vehicle at launch to insure safety to persons and property in the immediate post-launch phases. End results of the systems are the same—although COTAR is passive while the Gilfillan radar "skin tracks" the vehicles.

Russians Control Plant Growth

Electronic control of the growth of "Chlorella", a water plant of interest to Soviet scientists for space flight, is being tested in the USSR. The rate of growth of the plant can be controlled by a regulator whose operation is based on the attentuation of a beam of light which passes through the plant and reaches a photocell. The latter, as a sensor, reacts to changes in the concentration of live cells. The regulator maintains optimum conditions with respect to illumination, content of mineral agents and percentage of carbonic acid in the water.



KEARFOTT developed

and now produces

hydraulic control systems

for the Pershing missile.

Engineers: *Kearfott offers challenging opportunities in advanced component and system development.*

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Ultrasonics Improves Fuel Loading

Principles of sonar applied to boost fueling accuracy; Titans and Saturn booster first to employ new method developed by Bogue.

by John A. Herbst
and
Edward P. Schinman
Bogue Electric Mfg. Co.

A MAJOR IMPROVEMENT in the accuracy of liquid-propellant loading of rocket motors is offered by the new technique of ultrasonic gaging.

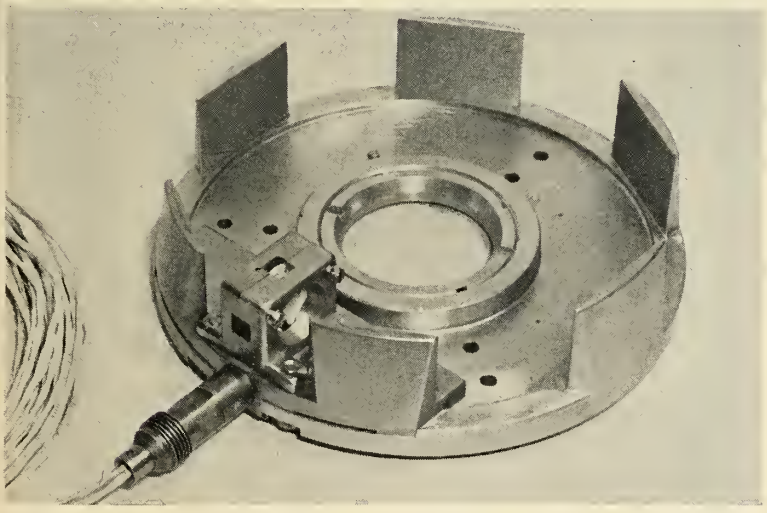
Developed by Bogue Electric Mfg. Co., the ultrasonic system—using the principles of radar and sonar—is reported to be simple, reliable and low in cost. It provides a rapid-response control device for fast automatic loading, as well as an instantaneous visual readout for monitoring.

The result of 10 years of research and development, one Bogue system is being used for automatic loading of the *Titan* ICBM. Another is being built to handle UDMH and nitric acid loading for the *Saturn*.

One principal advantage of the system is its precision. Accuracies of better than 0.1% have been achieved in total weight loading of cryogenic and other missile fuels.

Another advantage is simplicity, particularly of the transducer used in the tank. Simplicity is particularly important in the gaging of highly corrosive fluids, since simple parts can readily be made to resist or be protected against corrosive action.

The transducer is small and light—two obvious advantages in missile applications.



TRANSDUCER, located in bottom of fuel and oxidizer tanks, is simple and small (6x2 in.). Unit is all that is required in missile itself for ultrasonic system.

• **Similar to sonar**—The basic principle of ultrasonic gaging is similar to sonar, or radar. A pulse of energy, transmitted by a transducer in the bottom of the tank, travels until it reaches the surface of the liquid. Here, a portion of the energy is reflected and returns to the transducer. The elapsed time between transmission and return indicates the height of the liquid.

In a simple ultrasonic gaging system, the basic components are a transducer, a receiver-computer, and an indicator.

In operation, a repetitive pulse of predetermined width and amplitude is coupled to the transducer element, which produces a sonic pulse. This pulse is transmitted into the liquid, where it travels to the junction between the liquid and the air or vapor above and is reflected and returned to the transducer in the form of a sonic echo.

(Continued next page)

The Dividends from Accurate Loading . . .

ACCURACY IN FUEL LOADING can be critical. As an example, consider the case of a missile requiring a minimum of 100,000 lbs. of propellant to reach its target.

Loading this amount to a 1% accuracy would mean that the actual amount was between 99,000 and 101,000 lbs. Consequently, the load command would have to be increased to 101,000 lbs. to assure the minimum. However, this means that the actual weight loaded would be between 100,000 and 102,000 lbs. The propulsion system is therefore penalized: it must be capable of accelerating an additional 2000 lbs. which might be on board.

Increasing the loading accuracy to 0.1% would reduce this 2000-lb. figure to 200 lbs. The 1800 lbs. saved could be used for additional range, additional pay load, more reliable guidance and controls, etc.—or the size of the missile required for a given mission could be greatly reduced.

Loading by level alone is not sufficiently accurate, particularly in the case of cryogenics. Liquid oxygen changes its density by approximately ½% per degree Kelvin. Consequently, in the example given, if loading were done by level, such as by point sensors, a penalty of 1000 lbs. would result even if the average temperature of the liquid oxygen throughout the tank were known to within a total accuracy of one degree (or plus or minus ½ degree). ⁂

(Continued from page 21)

The transducer then converts the sonic echo into an electrical signal.

The time between transmit and the first echo is converted into level information for readout or control functions. The conversion is made by the computer, which compares the elapsed time with the velocity of sound through the liquid.

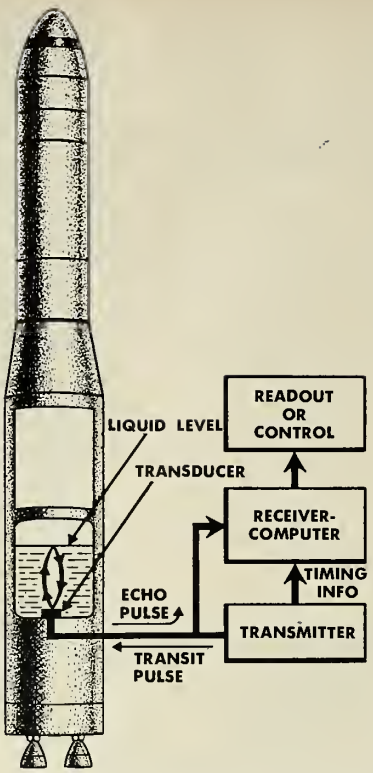
Obviously, the accuracy of the measurement depends not only on the accuracy of the echo time measurement, but on the velocity information. The latter is obtained by continuously sampling the propagation time over a precisely known distance. This is accomplished by a second, or "calibrate" transducer with a precisely fixed reflector mounted in the same unit as the measure transducer. Thus, continuous velocity information is available to the computer; levels can be accurately measured without presetting precise velocity information into the computer.

• **Corrected for density**—The liquid level can thus be precisely gaged and controlled. However, in loading a missile, the weight rather than the level should be the governing factor, since total weight determines the total propelling energy available.

The computer in the system calculates liquid volume on the basis of height and cross-sectional area. The cross-sectional area, a known factor determined by the geometry of the tank, is programed into the computer and multiplied by the instantaneous height of the liquid. The volume quantity obtained is multiplied by the specific density to obtain total weight.

The velocity of sound through a particular liquid varies with its density. Thus, if the computer is programed with a known velocity corresponding to a known density, any change in density can be detected. The computer compares the velocity as measured by the calibrate transducer with the programed standard and, in effect, multiplies the volume by the resultant to obtain the instantaneous weight. These measurements and calculations are performed many times a second, providing virtually continuous information for readout and control.

• **Better accuracy attainable**—Since measurements may be made with accuracy within a fraction of a millionth of a second, a system can be designed to any accuracy desired. Ultrasonic systems presently in production integrate temperature and density variations, allow for variations in tank construction, and provide for measurements within a few inches of the bottom and up to the top of the tank with an overall accuracy of better than 0.1% by weight. This system is fully automatic and provides for rapid automatic loading of multistage missiles.



ULTRASONIC gaging system measures liquid level in missile tanks by same principle as sonar. Time required for the transducer signal to travel to the surface and return is measured and computed to yield actual volume (and weight) of the propellant loaded.

While guaranteed accuracies of 0.1% by weight of liquid oxygen is expected of the Bogue system, measurements indicate that it can provide accuracies as close as 0.05%.

The system can also be used to accurately indicate the temperature of the liquid being measured.

Since the ultrasonic system is insensitive to pressure variations and not affected by acceleration, it can also be successfully used for inflight measurements.

The system offers further advantages. Each stage of a multistage missile can be individually gaged and loaded simultaneously. Also, the errors caused by condensation on the exterior surface are eliminated. Repeatability and, therefore, absolute control is attained.

The Bogue ultrasonic system being used for automatic loading of the *Titan* allows for rapid filling up to a selected point, then slow filling up to slightly more than the desired weight. This "overfill" condition is maintained by a proportional control signal which controls a valve to admit LOX as required to replace the boil-off loss.

Shortly before launch, a signal is given which bleeds down the tank to the exact weight desired. An alarm circuit is activated if the level falls below 99.9% of the desired weight. Another circuit indicates the satisfactory functioning of entire system. The system also provides voltages for indicating and recording the instantaneous percentage of the desired weight in the tank. ⁂

Commercial Satellite Developed by Hughes

AN EXTREMELY SMALL and lightweight commercial communications satellite with life expectancy of over one year and several hundred channels has been developed and built by Hughes Aircraft Co. The cake-shaped payload will use 2700 solar cells mounted on its sides as power supply, and will handle both telephone and television communications.

The payload is reportedly in such an advanced stage that flights tests may begin next year, with the first launch testing telephone linkage and the next one checking television capabilities. Sources indicate that cooperation from the government or another interested company would be necessary before flight testing begins.

• **Cake-like**—Still lacking an official designation, the payload is referred to by some Hughes officials as *"ComSat"* and was developed entirely with company funds. The firm is reluctant to discuss details of *ComSat*, but it emphasizes that it has already built one complete unit.

ComSat is a cake-shaped device, 29 inches in diameter and weighing 32 lbs. It is an immediate-relay device with no storage features. Solar cells will be mounted on the sides only, leaving the flat surfaces free for electronic sensors and antennas.

The payload will go into orbit with the solar cells facing the earth. Nitrogen gas jets will flip it into an attitude where the antenna-equipped flat side is facing earth. Then nitrogen gas jet will impart a spinning motion to stabilize the payload in this position.

Hughes declined to comment on the number of transmitters, transmitter power, estimated costs, the dollar-break-even point in commercial use, or other details.

The company said it has offered the payload to the National Aeronautics and Space Administration, the Army and commercial users. It would not specify which commercial users were approached. ⁂

NBS Puts Infrasonic Waves to Work

by William Beller

A NEW WINDOW facing the upper atmosphere is now being opened for students of geophysics. It is the far low end of the frequency spectrum, in the inaudible sound or infrasonic band—below 15 cycles per second.

Many events occurring in the upper atmosphere have ripples in the infrasonic band. Among these are explosions, earthquakes, tornadoes, waves set up by the sun's effect on the earth's magnetic field, and a mysterious set of very low pressure waves that might be gravitational waves resulting from the shifting of atmospheric layers of varying temperatures and wind speeds.

For what is believed to be the first time, the National Bureau of Standards has quantitatively studied the relation between the sources of infrasonic waves generated in the atmosphere and the incident sound pressure, the direction of approach of the incident wave, and the speed of the wave across the earth's surface.

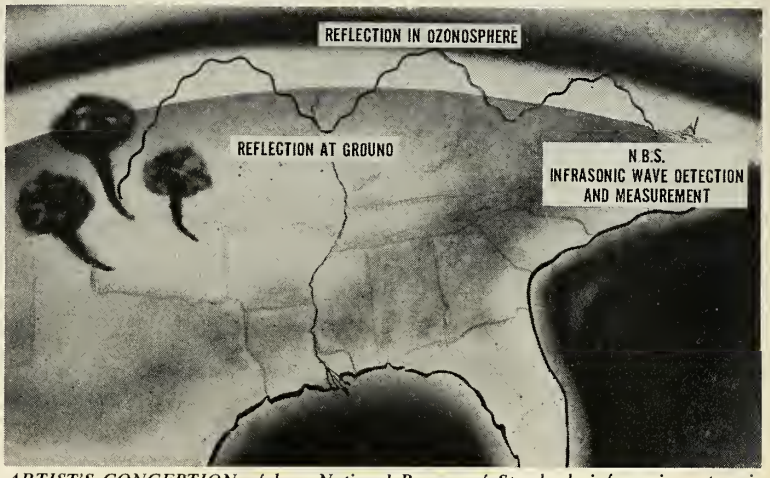
• **The shadow zone**—About the time of World War I, an odd and by now well-known anomaly was observed: the sound of cannon fire was heard within a radius of 100 kilometers of its source, then skipped about 100 kilometers before it was heard again.

The effect was caused by reflection of sound waves from an upper atmospheric layer in which the speed of sound was greater than at sea level. It was easily deduced that the layer's temperature was higher than the temperature of the air at ground level.

Having gone this far, observers began building a temperature structure of the atmosphere. They based it on the skip distances of the sound and the transit times from source to observer. The lowest audible frequencies from the source were monitored because they were the least attenuated.

The limiting condition is reached in infrasonics; here, the waves can be propagated for great distances. This stems from the fact that the fraction of sound energy absorbed per unit distance of propagation is roughly proportional to the square of the frequency.

The temperatures derived from the early work were most recently confirmed by direct observations by instrumented rockets of the upper atmosphere.



ARTIST'S CONCEPTION of how National Bureau of Standards infrasonic system in Washington can detect tornadoes spawning in Oklahoma-Kansas "twister" country.

• **Page from electronics**—For the past ten years the NBS has been developing microphones and recording systems for studying very low frequency sounds in the atmosphere. The agency says that its present system, in Washington, is "unusually reliable and flexible and is calibrated easily."

NBS scientists have designed band-pass filters that can be introduced into the amplifiers when the signal-to-noise ratio is to be changed. For example, earthquake waves are said to be studied best with a band-pass filter tuned to sounds having periods between 0.4 and 20 seconds.

The system is described as consisting of four microphones located at ground level, approximately in the same plane. To reduce the effects on the microphones of pressure fluctuations from local turbulent wind conditions, the scientists fitted each microphone with an antenna comprising a 300-meter length of pipe.

The microphones produce frequency-modulated voltages proportional to the incident sound pressures. These voltages are transmitted by telephone wires to a central location, where they are demodulated, amplified and recorded as ink-on-paper traces.

When a sound wave of sufficient magnitude is present, similar traces are produced on each of the four paper records. The direction of approach of the wave and the trace velocity are obtained by comparing the different times of appearance at the four microphones.

• **Sound of magnetic storms**—Particle streams from the sun interacting with the earth's magnetic field cause geomagnetic storms. Associated with these are waves in the low frequency range—periods greater than 20 seconds—having a velocity usually greater than the speed of sound, sometimes as high as three times as great. The waves usually come from the north and have pressures of roughly one to three dynes per square centimeter.

NBS scientists feel that the high degree of association of these waves with the larger magnetic storms is significant. The direction from which these waves arrive varies with the time of day. The direction changes from northeast to northwest between noontimes, and is approximately northerly at midnight.

By finding the origin of these sound waves and by measuring their propogation constants, NBS expects to learn more about the structure of the upper atmosphere.

In the wide view, the emerging science of infrasonics may not only be useful for listening to the sounds in our own atmosphere but also to those in the foreign atmospheres that space probes may soon be exploring. ⁂

Exploiting the Advantages of Vapo

Microcircuitry stands to profit in a big way from relative freedom of approach; how Motorola and Merck have developed techniques

by Charles D. LaFond

VAPOR DEPOSITION TECHNIQUES being developed so widely in industry are adding a new dimension to junction formation in solid-state devices.

The approach is not limited by diffusion laws—as is junction formation by diffusion, or by segregation laws—as is junction formation for alloying. Exploiting this advantage, scientists at Merck & Co. and Motorola Inc., among others, are finding many useful applications for germanium and silicon deposition in microcircuitry.

In its research laboratories at Rahway, N.J., Merck's Electronics Chemicals Division has devised methods of laying down single-crystal layers of silicon of varying type, resistivity and thickness. The resulting complex junction configurations may someday be used for fabrication of entire circuits by appropriate etching, sawing, plating, and lead attachment.

The complete microcircuit is an electronic subassembly having extremely high packing density. This is one reason for the concentrated effort to achieve production capability with such sophisticated components.

The other reason is the potential of magnitude increase in reliability.

MOTOROLA'S CHOICE

Several methods exist for vapor deposition of thin film semi-conductors. Motorola chose one that produced a product readily usable in practical fabrication of components. This method was described recently before the IRE Professional Group on Electronic Devices in Washington by G. V. Russell of Motorola's Semiconductor Products Div., Phoenix, Ariz.

To reduce germanium and silicon tetrachlorides on single-crystal substrates, commercial hydrogen is passed through a Deoxo catalytic unit, then through a bubbling bottle containing the tetrachloride.

The vapor pressure of the liquid is controlled so as to provide a definite partial pressure ratio of H_2 to $XC1_4$, Russell said. Hydrogen gas, saturated with tetrachloride vapor, is then transported into the quartz reaction tube. As a heterogeneous reaction takes place between the heated substrate surface and the reactant vapors, growth of the film commences.

Waste gases are carried off through an exit tube where the hydrogen is burned off and other gases are exhausted into a fume hood.

The entire gas handling apparatus has been constructed of quartz, according to Russell.

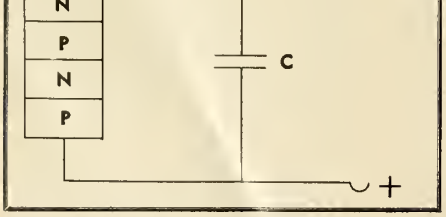
Substrates are laid down on a quartz boat supported on a graphite strip. The strip is heated by means of a 10-kw, 450-kc. r-f generator. Temperature of the substrates is measured with an optical pyrometer, and appropriate temperature corrections are applied to the observed readings.

All films of germanium and silicon were grown on single-crystal substrates of the parent material. The substrates were <111> oriented wafers cut from Czochralski grown crystals, lapped, mechanically polished, chemically etched, rinsed in deionized water, and blown dry in a stream of nitrogen.

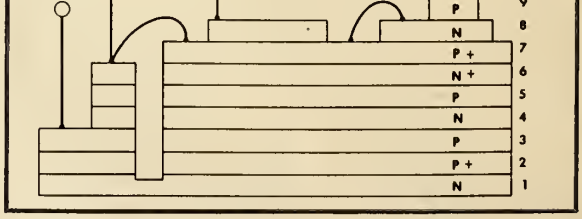
• **The vital ratio**—A necessary condition for growth of continuous single-crystal films, Russell said, is that the partial pressure ratio of H_2 to XC1, be greater than 65:1. At such low supersaturations the growth rates tried in the past were from 0.01 to 2 microns/min. Substrate temperatures for germanium were from 700-850°C, for silicon 1050-1270°C. Single crystal films were obtained over this growth rate and temperature ranges. The choice of particular operating points is governed by the parameters required for the device being fabricated.

In the research described by Russell, only silicon devices with n substrates and n films, and germanium devices using p substrates and p films were used. However, other conductivity-type films have been grown at Motorola in the fabrication of silicon p^+ p, n^+ p, p^+ n, . . ., and germanium n^+ n, p^+ n, n^+ p, . . ., structures with con-

SIMPLE OSCILLATOR designed by Merck to demonstrate laminar structure for microcircuitry. Elements are a pnpn switch, back-biased diode (for capacitance), and a photodiode (for resistance).



A. Schemat for proposed relaxation oscillator circuit using layer structure.



B. Side view of plan for one-piece construction comprised of nine distinct layers.

Deposition

EVAPORATION PRODUCTION techniques yield pairs of gold and aluminum stripes on a 0.025-in.-square germanium wafer for mesa transistors at Motorola's Semiconductor Products Division in Phoenix. When the wafer is cut, each pair of stripes will become one transistor.

trolled resistivities and film thicknesses.

• **Etch-pit density**—The control of etch-pit density, said Russell, is governed principally by the cleanliness of the substrate surface. In the case of silicon, the removal of surface oxides is achieved readily during the period prior to growth by heating the substrate in a dry hydrogen atmosphere.

Surface oxides of germanium, if present at this stage, are not removed so easily, said the Motorola scientist. Thus the control of etch-pit density becomes a much greater problem with germanium than with silicon due to surface oxides acting as nucleants for disordered growth.

If correct cleaning procedures have been employed, the etch-pit density then is controlled predominantly by substrate temperature and degree of hydrogen supersaturation with the tetrachloride.

Excessive supersaturation, which results in too high a growth rate, will lead to polycrystalline film deposits in the extreme and down the line from high etch-pit density to what might be called the "intrinsic etch-pit density" (i.e., that of the substrate). At this stage the etch-pit density is strictly a result of direct copying from the substrate.

Studies of etch-pit densities have been made by Motorola using numerous etchants. The etchant giving best results, according to Russell, is a mixture of potassium ferricyanide, potassium hydroxide, and de-ionized water.

Film thicknesses were measured by delineating the change in resistivity between the substrate and the film; pulse-plating was used to delineate this change.

MERCK'S APPROACH

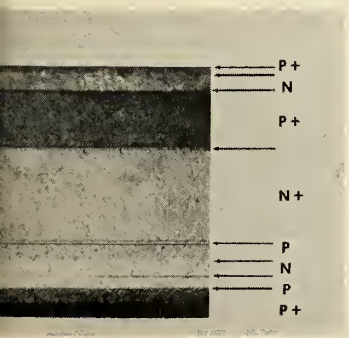
The Merck process is similar to that employed at Motorola, although much of the company's recent work has involved the introduction of controlled concentrations of impurity atoms during the crystalline growth of silicon single layers.

Merck's research has centered on the addition of volatile acceptor or donor impurity precursors during the growth process. The goal, of course, is formation of electrically active regions bounded by junctions of varying layer thicknesses, carrier concentrations, and junction profiles.

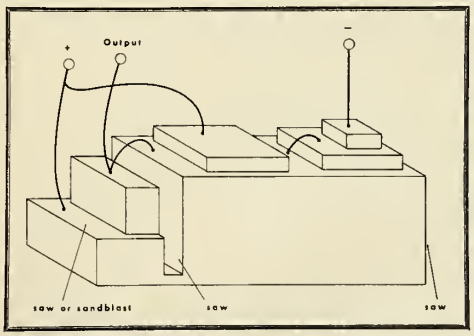
Reactions temperatures from 700-1300°C at growth rates from 0.25 to 5.33 microns/min. have been employed successfully.

Merck researchers also believe the substrate surface to be a variable of great importance in the growth process. But the substrate itself can be in many forms: filaments, rods, slabs, or sheets.

• **Orientation**—One early objective of Merck's studies was the effect of substrate orientation on single-crystal



C. *Etched specimen (magnified 100X) reveals deposited layers.*



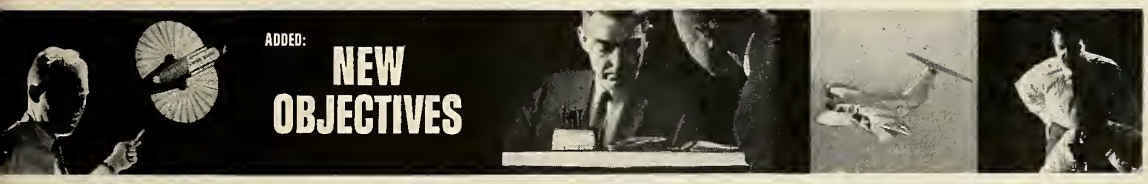
D. *Perspective view shows isolation of various junctions, lead attachments and terminals.*

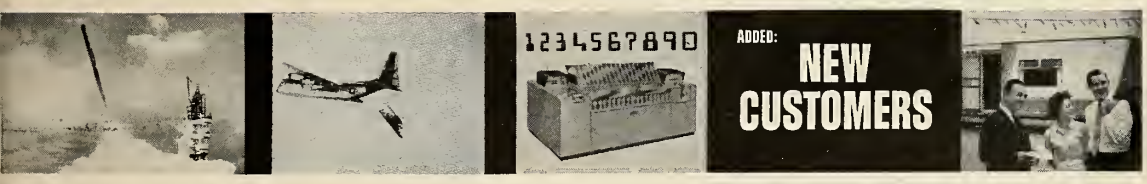
E. *Final specimen from which device properties were measured.*


NEW NAME.

CHANCE VOUGHT CORPORATION

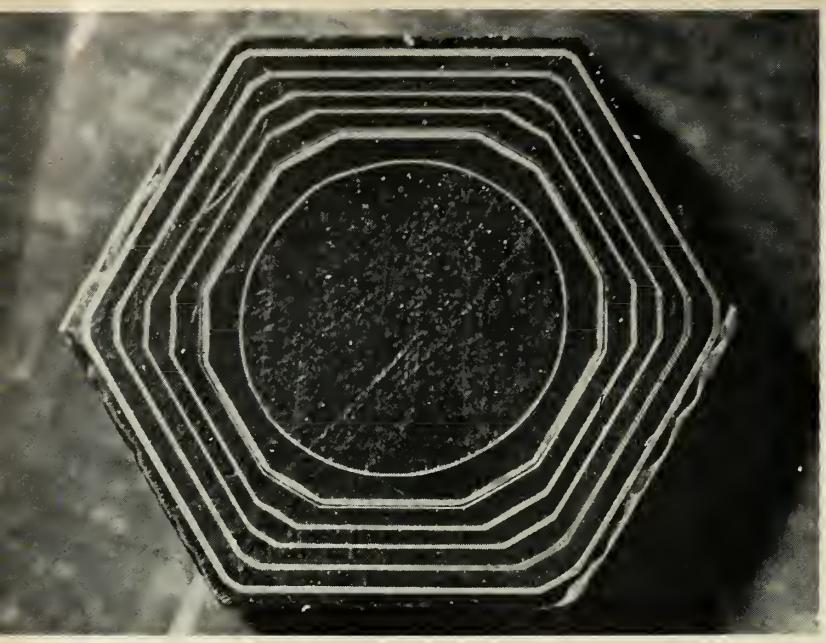
The name used to be Chance Vought Aircraft, and it fit the company perfectly. No other name is more closely associated with aviation's growing years and great hours. Vought aircraft . . . a parade of over 40 different models . . . have served the U. S. continuously since 1919. Now, with the Crusader fighter helping to maintain the Free World's border watch, and with a newly developed all-weather version enroute to join the 700 Crusaders already delivered, aviation remains a vital interest at Vought. But today, Chance Vought has expanded beyond its traditional field into other market areas both military and industrial • The Aeronautics Division, which supplies the new all-weather Crusader to the Navy and is at work on other aircraft and missile projects, is also headquarters for a company-wide anti-submarine effort • The Astronautics Division — deep into studies for manned space flight — is prime vehicle contractor for the NASA Scout and a key contractor on the Air Force Blue Scout Junior, both research rockets • An aggressive Electronics Division supplies components and systems to major U. S. defense and research programs • Vought Range Systems is a world-wide service organization with space-tracking, range instrumentation and many other responsibilities • Vought Research Center feeds basic knowledge to all divisions • A subsidiary — Vought Industries, Inc. — is the nation's leading producer of mobile homes • Another subsidiary — Information Systems, Inc. — produces industrial automation and process control equipment • National Data Processing Corporation, in which Chance Vought owns a majority interest, specializes in business data processing equipment particularly in the banking field • Now, under Chance Vought Corporation, these diverse activities are associated in name as well as in skills and resources to serve both old and new customers better.





CHANCE VOUGHT

Aeronautics • Astronautics • Electronics • Range Systems • Research • Mobile Homes • Industrial Automation • Business Data Processing



CROSS-SECTION of a <111> oriented silicon crystal, grown by vapor deposition at Merck & Co. with alternating p and n layers.

growth. This centered on an attempt to obtain single crystals with growth planes having maximum surface free of imperfections. From the observations made during this study, researchers found that:

(1) Substrate crystallographic orientation had a pronounced effect on the relative preservation of single crystallinity during the growth process.

(2) It was not concluded, however, that under different growth conditions one could not propagate equally well on all orientations.

(3) Under the growth conditions used in the experiments, the crytallographic planes that continued growth in single-crystal form were the $(\bar{3}21)$, (111), $(\bar{2}11)$, and $(1\bar{1}0)$ planes. The susceptibility to disoriented growth increased from left to right.

The substrate orientation that produced the highest yield of usable single crystal areas was the [111] oriented substrate. This orientation was used predominantly in the Merck study of the formation of electrically active layers and junctions.

• **Even growth**—The next step investigated was the introduction of impurity atoms to form controlled electrically active regions while continuing a contiguous single-crystal growth.

Experiments showed that boron trichloride for p-type doping was conveniently handled, easily controlled, and caused no adverse effect on the single-crystal growth of silicon—even with concentrations giving resistivities as low as 0.004 ohm-cm.

The n-type doping was accomplished satisfactorily with halides of either arsenic or phosphorous of known concentrations.

EMERGING TECHNOLOGY

Both companies have reached the point in process development where products are now being marketed.

Motorola epitaxial mesa transistors —germanium and silicon—were recently put on the market. More will be marketed soon, a company spokesman says, as production capabilities and reliabilities of new items equal those now available.

Merck is now supplying two-layer junction configurations in wafer form to other manufacturers of epitaxial transistors. And it has prepared and distributed sample quantities of more complex solid-state configurations.

Both companies have long stressed their belief in the application of vapor deposition techniques for future microcircuitry. Their research has shown that crystal growth from the vapor phase can provide devices comparable to those produced by conventional alloying and diffusion techniques—but without the limitations accompanying those methods.

Above all, today's techniques are laying the foundation for a whole new technology of complex multilayered subsystems for truly microminiaturized and ultra-reliable electronic systems. ⁂

Memory Aid

Librascope Device is Big Computer Advance

A SILICON DISK giving a computer a permanent memory capacity of 70,000 bits of information per cubic inch has been developed by the Librascope Div. of General Precision, Inc.

It provides a solid-state, non-rotating, permanent program storage, is capable of complete automatic production with selection and switching circuits, and has high radiation resistance and wide temperature limits.

The new device was incorporated in a proposal made recently to a government agency, said Robert R. Williamson, Librascope's director of military sales. The firm specified delivery in from 18 months to two years.

Librascope is a major producer of computers for fire control and space vehicle guidance systems. Its AN/ASN 24 is likely to be the first digital computer in space for lunar and interplanetary exploration as a part of the guidance for NASA's Project *Centaur*.

Charles Foodim, the firm's Aerospace Branch projects director, described the potentials of the silicon device in terms of the magnetic drum component of *Centaur's* computer. That has a six by six-inch drum with a 50,000-bit capacity.

JPL has for some time stressed its need of a computer for guidance purposes that has no moving parts. A major reduction in drum size is viewed as a step toward that. To develop a minimum size component for the temporary memory requirement, Librascope is working on a drum using air as a bearing surface for its spinning shaft.

Temporarily named "Silicon Permanent Array Memory," the unit is now in the pre-production testing and development stage.

• **Degree of serendipity**—The material was developed during a long-range research program not particularly aimed at this specific result, Williamson said. The device was conceived at P. B. Stokes of Librascope's Applied Research Department, directed by Wayne Blackburn, who with Dr. Herman Graffe also headed this phase of research.

Displaying a sample disk .008 inch thick and one inch in diameter, Williamson said its construction required depositing pure silicon layer by layer with a molecular beam. "We almost have to deposit each atom of silicon exactly where it should be," he said. Masking the layers to deposit discrete concentrations of magnetic material without hazy edges to impair separation of "bits" also proved a problem. ⁂

First Details of Red Rocket Shots

by Bernard Poirier

INFORMATION JUST RELEASED by COSPAR shows that Russia in the first half of 1960 launched 27 rockets in a series of high-altitude experiments from a research ship in the Pacific; tests that just as easily could have been of a military nature.

Disclosure of these tests is contained in an announcement from The Hague, Netherlands, listing a total of 73 Soviet rocket experiments during the first half of this year. Details were released by the Secretariat of the Committee on Space Research.

This international organization bases its data on official information supplied by the Soviets. An analysis of its statistics reveals that the launchings originated from land and naval platforms which are identified by COSPAR as:

–"Heiss Island, Franz Josef Land, 80° 37'N, 58° 03'E."

–"From the expedition vessel Voyeikov in the Pacific."

–"From the expedition vessel Shokalsky in the Black Sea."

–"Medium latitudes of the European part of the U.S.S.R."

(Photographs of the Black Sea rocket tests have been circulating in Europe and in America since July but until now no adequate information on the actual experiments had been available).

Franz Josef Land, which is about 1400 miles northeast of Sweden, has been a favorite research preserve of the Soviet Academy of Sciences since the area's discovery in 1873 by the Payer-Weyprecht Expedition. Meteorological bases were established at Tikhaya Bay (1929) and at Teplitz Bay (1932).

The identification of Heiss Island as a rocket site is the first official admission by Russia that the spot is used for that purpose. During the first three months of 1960 a series of 24 rockets were fired. Each launching was at midnight.

• **Reds provide test data**—The Russians claim to have measured the distribution of air temperature in this Arctic area and the stratospheric pressure. Instrumentation included electric resistance thermometers and therman and membrane manometers. It is assumed, however, that some of the tests measured electron density in the atmosphere in connection with the strong aurorae famous throughout the area from Sweden to Franz Josef Land, and that there also were experiments on magnetic field changes.

The Swedish Committee on Space **Research is planning** similar experiments in addition to special measurements of the strong absorption of radiowaves at high altitudes, which in this area of the earth start only a few hours after a strong solar flare.

The remaining Heiss Island shots were less frequent; there were only three in April, three in May and the last on June 9 for an overall total of 31. From April 19 on, the firings took place at 3 A.M.

Meanwhile, in the Pacific, scientists aboard the Voyeikov launched a rocket almost daily between Jan. 17 and Feb. 13. Double launchings occurred on Jan. 28 and 30 and Feb. 5 and 13. Most were fired between 10 P.M. and 11 P.M.; two were launched in late afternoon. Significantly, this ship was firing rockets daily at the time the Russians lobbed their first big missile

Swedish Test Missile

ROBOT 322, a Swedish-built experimental surface-to-air missile, is equipped with two RR 2 ramjet engines and one solid booster motor. Designed by the Guided Weapons Bureau, it is being used to test the ramjets and measure equipment.

soviet affairs

by Dr. Albert Parry

The science of rocketry changes so rapidly

that rocket officers in the Soviet armed forces should keep on learning new things all the time. So says the leading editorial in *Krasnaya Zvezda,* organ of the USSR's Defense Ministry, for Nov. 24. Similar exhortations appeared in that newspaper on Oct. 18 and Nov. 12 and 29, but the Nov. 24 editorial is the most explicit and urgent.

Entitled "The Engineer-Rocketeer Is a Fighter for Things New," it calls on the officers of the Red rocket detachments to work incessantly to improve their technical knowledge through "participation in military-scientific work, in inventiveness, and in the rationalization" of the devices and methods used in the Soviet rocket service. The article praises a certain Comrade Grebenyuk, who "has within a recent period put into practice nearly 80 suggestions" to improve his unit's rocket performance.

But there are also laggards

in Red rocket units, and these are castigated by *Krasnaya Zvezda.* The case of an officer named Turovsky is cited: "Having graduated from his institution of higher learning, he depended on his past knowledge, and gave little thought to his further training. The result was that the young specialist soon found himself behind in many respects. Now he is not only unable to give his men a service lecture fruitfully, but even fails to guide them in their technical work. What sort of authority is such a specialist to his men?"

Some Russian rocket officers flatly refuse

to train their soldiers, says *Krasnaya Zvezda,* and "lock themselves into the shell of purely technical tasks." The editorial quotes them as saying, in effect: "Our job is looking after the equipment, while the education and training of soldiers is the worry of other commanders." They particularly refuse "to develop the political awareness" of their men—that is, to lecture them on the virtues of the Communist Party. But more and more often a rocket engineer in a Soviet military unit is that unit's top commander. As such he cannot leave the Party assignment to others; he himself must prove constantly his "active participation in the Party's political work" in the USSR's armed forces.

The number of engineers and technicians is growing

in the Soviet armed forces, the editorial notes. As early as January, 1959, the proportion of engineers and technicians among commanding personnel in the USSR's military service had tripled since the end of World War II. By November, 1960, "the wide introduction of the most complex rocket technology increased this ratio yet higher," and the process is continuing.

One evidence of this is the stepped-up frequency of articles in *Krasnaya Zvezda* and other Soviet military publications, directly addressed to rocket troops. The Soviet leadership is clearly courting its military rocket officers—yet keeping a wary and stern eye on them, too. The Kremlin is anxious to have them both well trained and politically reliable.

Missiles and Rockets publishes fifty-one times a year. Readers are reminded that there will be no issue on December 26.

Season's Greetings—The Editors

into the Soviet impact area set aside in the South Pacific.

This may be more than coincidental. At least seven Pacific shots preceded Heiss Island shots by local time, but on the basis of corrected time most were within an hour or so of the other. In at least one instance, they may have been fired simultaneously—although separated by thousands of miles. Moreover, a meteorological rocket was fired at 3 A.M. local time from Heiss Island the day *Sputnik IV* was launched into orbit.

• **Worldwide sites planned**—The purposes and instrumentation of the Pacific and Black Sea tests are the same as those listed by the Russians for their Arctic experiments. The Russians do not provide the coordinates pinpointing their naval launchings.

(It is interesting to note that on the occassion of Khrushchev's Indonesian tour, the Red leader requested permission from that country to establish a Soviet research station on Amboina Island in the Bana Sea. It was inferred that the site would be used to support meteorological studies.)

Only five shots are admitted as being fired from the Shokalsky in the Black Sea, two on June 9 and three on June 10. Launching times are given as:

June 9 07h. 20m.
June 9 18h. 55m.
June 10 07h. 00m.
June 10 10h. 00m.
June 10 23h. 00m.

As long as three months ago, there were published reports asserting that Western radar had tracked these Black Sea shots and that the peak altitude reached by some was 20 miles and by others, 125 miles.

Photographs of some of the rockets used in the Shokalsky launchings show a nose cone configuration, which suggests the Russians also experimented in re-entry body problems.

The "medium latitude" shots from a site in European USSR follow the pattern established for those previously described with the exception of the fourth in the series of 10. The series started on May 26 and extended through June 30 with double headers on the 22nd, 29th and 30th.

Data for the fourth experiment, carried out at 3:42 P.M. on June 15, provides the most interesting details. This rocket carried a UHF radio-interferometer to measure the concentration of free electrons in the atmosphere and a radio frequency mass spectrometer to determine the ion and neutral composition of the atmosphere.

The payload was apparently quite heavy. It included cameras to photograph cloud systems, other instruments to measure the "electric field" along

the rocket shell's surface, and infrared radiation instruments for earth surface studies and ionized upper-atmosphere cloud studies. Apparatus was also carried aloft for ultraviolet registration spectrograph measurements, as well as pressure and air density studies.

• **Aerospace biometric studies**—The payload was detached at 137.2 miles and the Soviets admit, in passing, that "medical and biological experiments were conducted simultaneously with geophysical studies." No further details were provided.

These experiments could have taken place in Poland. What the Russians call European USSR could mean the westward extension of the Russian border or an area in a satellite country. However, according to the Polish Academy of Sciences in Warsaw, 13 meteorological sites have been established in Poland.

Many of the sites were built to support Russian earth measurement studies essential for rocket military strategy. Examples are the Borowiec site sponsored by the Pozáan Astronomical Center. The Poles identify it as an astronomical station constructed at a latitude common with a station located at the Russian missile site near Irkutsk. Another coordinating station is situated along the 107° E Meridian in Vietnam and sponsored by the Polish Academy of Sciences.

Moreover, Polish research rockets of the *RM* series had been able to reach similar altitudes with instrumented payloads during the International Geophysical Year and were reportedly launched near Serco, about 20 miles north of Warsaw. Two meteorological stations are located closeby—at Legionowo and Barowa Gora. A third is in Warsaw itself. ⁂

Fellowships Offered by Guggenheim Foundation

Eighteen fellowships for graduate study in rockets, jet propulsion, space flight, and flight structures are being offered by the Daniel and Florence Guggenheim Foundation.

The fellowships provide tuition and stipends ranging from $1500 to $2000 depending on the level of advancement of the student. They are to be used at the Guggenheim Jet Propulsion Centers at Princeton University and California Institute of Technology and at the Institute of Flight Structures at Columbia University.

Applications are due March 1, 1961. Only residents of the United States or Canada who have outstanding technological ability and leadership qualities and intend to make a career in rockets, jet propulsion, flight structures or astronautics are eligible.

Low-Cost Nuclear-Powered TV Forecast

LEFT—*Satellite power supply, SNAP 10 (0.3 KW), available in two years.* **CENTER**—*SNAP 2 (3 KW) and SNAP 8 (35 KW) units available 1963-5 for 24-hour communications satellite.* **RIGHT**—*Nuclear system (1967) to power electrically-propelled vehicle.*

THE FIRST ESTIMATE of the cost of a global television system powered by nuclear energy, is $30-50 million. The figure, arrived at by a key Atomic Energy Commission official, is far lower than the cost of comparable systems powered by conventional means.

The nuclear-powered system could be ready by the mid-1960's. Its price includes the cost of launch vehicles as well as of three "stationary" satellites needed for the TV coverage.

Lt. Col. G. M. Anderson (USAF) said in San Francisco last week that 10 or 15 video channels could be telecast if the 35- or 70-kilowatt versions of SNAP 8 were combined with the *Atlas-Agena B* or the *Atlas-Centaur* space vehicles in a 24-hour orbit. Anderson is AEC's Chief of Systems for Nuclear Auxiliary Power (SNAP).

Home television receivers could be adapted to the global system by adding to each set a simple UHF converter and a six-sq.-ft. mesh-type antenna directed toward the stationary satellite. Estimated cost to the citizen is under $50.

Anderson stated that the 3-kilowatt SNAP 2 is able to furnish enough power for one or two video channels covering the entire United States. He added that SNAP 8 at 35 kilowatts could furnish five to ten channels over the United States, or one or possibly two channels over the hemisphere. This capability would be doubled if the 70-kilowatt version of SNAP 8 were used.

• **One two-hundredth the cost**—Suppose a 4500-lb. *Agena-B* satellite were placed in a 300-mile orbit. Then to spiral the satellite out to a stationary orbit—22,600 miles altitude over the equator—would take about three weeks if a 35-kilowatt SNAP 8 were powering the electric propulsion system.

The weights called out by Anderson for the satellite are 1500 pounds for the SNAP 8 unit, 300 pounds for the electric propulsion system, and probably 1500 of the remaining 2700 pounds in orbit for the communications system payload.

Assuming that the satellite located over the United States would power five to ten channels simultaneously for a year, Anderson derives a cost of approximately $300 per channel-hour. He says that this figure compares drastically with current transcontinental broadcast costs which run in the neighborhood of $60,000 per channel-hour.

"Even further reductions in the cost of a channel-hour would be realized when the *Atlas-Centaur system* becomes available; for the ITVB (International Television Broadcasting) system will then have at its disposal 70 kilowatts and a 2000-pound payload for the communications equipment," he says.

The SNAP 2 system is designed to generate 3 kilowatts of useful electrical power continuously for one year (see M/R, Aug. 22, p. 39). A prototype of the reactor for the system, called the SNAP Experimental Reactor (SER), was built by Atomics International Div., North American Aviation, and put into full-power operation in November, 1959.

The second SNAP power reactor, called the SNAP Development Reactor (SDR), is scheduled for startup next month. The results of SER operations brought changes in fuel composition, number and size of fuel rods, and reflector design—all of which led to a 20% weight reduction in SER.

The SDR will operate the first complete version of the power conversion system. All components in this series of tests will be designed for flight. The first flight tests of the SNAP-2 system are scheduled for early 1964.

The SNAP 8 power reactor is a larger version of SNAP 2; however, the reactor will produce 35 kilowatts with one power conversion unit and 70 kilowatts with two power conversion units coupled to the same reactor.

NASA says SNAP 8 will be used not only for long-range, long-lived communications from lunar and interplanetary missions but also for powering early electric propulsion devices.

The first SNAP 8 experimental reactor will go critical early in 1962. Flight tests will be several years later. ⁂

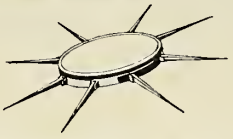
NASA program-highlights

NEXT DECADE IN SPACE

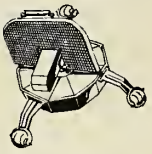
Year 4 to 14 of the Space Age

Project Mercury—U. S.'s first manned satellite.

Project Surveyor—First soft landing on moon. Conduct observations from stationary position.



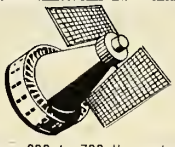
Project Prospector—Soft landing on moon and exploration of area within 50 miles of landing point.



Solar Observatory—350 lb. Large flywheel and extended arms rotate to stabilize. Under construction.

Project Mariner—600 to 1200 lbs. First U. S. Planetary missions to Venus and Mars. Modified craft for hard landings on moon.

Project Voyager—Orbit Mars and Venus and eject instrumented capsule for atmospheric entry and perhaps landing.

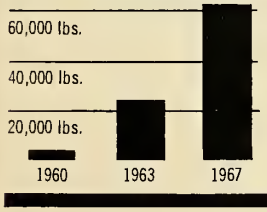


Nimbus—600 to 700 lb. meteorological satellite series. Stabilization system will keep cameras pointed earthward.

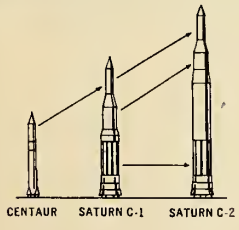
Orbiting Geophysical Observatory—1000 lb. geophysical research satellite designed for a near earth circular polar orbit or an inclined highly elliptical orbit.

Project Aeros—24-hour stationary weather satellite. Launched in equatorial orbit. Three satellites could permit continuous observation of most of earth's surface.

Orbiting Astronomical Observatory—Standardized, 3500 lb. satellite, for several experiments with different scientific sensors and specialized devices.



Anticipated Growth of NASA Spacecraft in terms of weight of individual near earth satellites.



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NASA Langley Research Center • Hampton, Virginia

NASA Lewis Research Center • Cleveland 35, Ohio

NASA Marshall Space Flight Center • Huntsville, Alabama

NASA Wallops Station • Wallops Island, Virginia

National Aeronautics and Space Administration

NASA

be the *Rover* nuclear rocket. Many in industry believe the time is ripe for vehicle development concurrent with engine R&D, scheduled to begin with the award of a contract in the spring.

Major space contracts to be awarded in 1961 include R&D for the *Apollo* three-man spacecraft, the 800,000-lb.-thrust S-II *Saturn* stage, the *Surveyor* lunar soft-landing spacecraft and, if not awarded before the end of 1960, the standardized Orbiting Geophysical Observatory *(OGO)* satellites:

NASA will begin procurement action on what may be its biggest contract of all—the production job on *Saturn* boosters. Only the first 10 vehicles, during the R&D phase, will be produced at NASA's Huntsville, Ala., facility.

• **Toward manned flight**—Competitive six-month studies of the *Apollo* spacecraft are in progress at Convair, General Electric's Missile and Space Vehicle Division and The Martin Co. NASA is expected to choose one of them to begin R&D during the summer. The job will take about three years. Manned flights are expected to begin when *Saturn* vehicle reliability proves adequate.

The big *Saturn* stage will be developed for the four-stage C-2 *Saturn,* which will be the second version to fly. The first *Saturn,* designated C-1, will have three stages. The big new stage will be inserted between the first and second stages of the C-1. The four-stage vehicle is to be operational in the 1966-7 time period.

Competitive studies of *Surveyor,* an unmanned craft to be boosted by the *Centaur* launch vehicle, are in progress at Space Technology Laboratories, McDonnell Aircraft, North American's Missile Division and Hughes Aircraft. The R&D contractor will be chosen early in the year. First flight is expected in 1963.

If the new administration decides to speed the civilian space program, the chances are it will ask for more money for *Mercury* and *Saturn,* in addition to the nuclear vehicle development.

To fill the gap in lunar exploration between last week's scheduled *Atlas-Able* and the 1962 *Ranger* shots, some are proposing that one or more *Atlas-Delta* vehicles be obtained for 1961 moon attempts.

Depending on the results of a multi-agency study now under way, funds may also be requested for establishing an operational weather satellite system,

Major Missile/Space Developments During 1960

Manned Space Flight

Russia launched three 10,000-lb. prototype spacecraft, two of them carrying dogs and other life specimens May 15, Aug. 19 and Dec. 1. One craft recovered from orbit with dogs alive Aug. 21.

U.S. Air Force launched two black mice to lower edge of Van Allen belt, at altitude of 600 miles or more Oct. 14, recovered them unharmed in Atlas nose cone.

Mercury development fell many months behind schedule as result of failures in booster and booster-capsule mating systems and extreme caution of capsule designers attempting to attain high reliability. Controversy arose over program's future.

Unmanned Space Flight

First recovery of an object ejected from an orbiting satellite (USAF's Discoverer XIII)—Aug. 11.

First recovery from orbit of a capsule containing life forms (Russia's Sputnik V)—Aug. 20.

Successful launching of 18 satellites and one space probe—15 satellites and a space probe by the U.S. and three satellites by Russia.

First launching of two satellites with one launch vehicle (U.S. Navy's Transit II-A and Greb)—June 22.

Military Applications

U.S.S. George Washington, first Polaris submarine, went on station under the ocean surface within 1200 miles of Soviet targets—about Nov. 15.

First complete Atlas squadrons become operational at Vandenberg AFB, Calif., early in the year and Warren AFB, Wyo., in August.

First successful launchings of Transit navigational satellites—April 13 and June 22.

First successful launching of Courier delayed repeater communication satellite—Oct. 4.

U.S. decided to proceed with B-70 Mach 3 missile-launching bomber.

Civilian Applications

Tiros I and II proved feasibility of TV transmissions of cloud-cover pictures to earth from a satellite so as to improve weather forecasting accuracy; other weather satellite research speeded; U.S. Weather Bureau was assigned primary responsibility for use of operational weather satellite data.

Echo I, Courier I and moon bounce demonstrated use of satellites for passive and delayed active repeater communications techniques; NASA Administrator T. Keith Glennan invited U.S. industry to team with government in developing commercial satellite techniques; AT&T requested FCC channel assignments so it might launch a communications satellite.

Space Sciences

Solar flares emerged as major radiation hazard of manned space flight, exceeding even that of Van Allen belt, leading to speculation major manned missions may have to be scheduled only in time of solar quiet.

NASA gave Grumman and Westinghouse contracts to develop orbiting astronomical observatory—Oct. 10.

Pioneer V tracked and telemetered for 108 days, to a distance of 22.46 million miles—March 11 to June 26.

International

Britain cancelled Blue Streak; series of mergers occurred in British missile/space industry.

Ten nations formed committee for promoting European space research cooperation. Several nations accelerate sounding rocket programs.

NATO requirement for a solid-propellant IRBM stirred competition between land version of Polaris and uprated Pershing; proposal for independent NATO nuclear striking force sparked controversy.

Industry

Douglas Aircraft Co. position improved with victory in competition for Saturn S-II and Navy Missileer contracts and establishment of Astropower Inc., a subsidiary for long-range propulsion research.

Convair vice president Thomas G. Lanphier was forced to resign following his blunt public attacks on President Eisenhower's defense policies.

Air Force formed non-profit Aerospace Corp. July 1 to replace Space Technology Laboratories; STL entered industry competition for contracts.

Lockheed Aircraft Corp. acquired half-interest in Grand Central Rocket Co.

Propulsion

New Soviet launch vehicle, capable of orbiting more than 10,000 lbs., passed two series of flight tests, achieved operational status.

Trend to solids accelerated in the U.S. as Polaris became operational, Scout reached midpoint in vehicle development program and Minuteman neared first flight. Air Force and NASA authorized design studies of multimillion-lb.-thrust boosters.

First series of Saturn static tests proved feasibility of liquid engine clustering.

Air Force ordered development of storable-liquid Titan II.

NASA, following successful completion of Kiwi-A reactor tests, decided to begin R&D of Rover nuclear engine.

First restart in space achieved by Able-Star in Transit 1B launch April 13. Restartable Agena B fired successfully for first time in Discoverer XVII Nov. 12.

Materials

Filament-wound plastic motor cases achieved complete acceptance; metal pressure vessels show continued improvement.

Pyrolitic graphite emerged as a high-

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which would use *Tiros*-type spacecraft.

There will be moves to increase the rate of investigation of the problems of orbital rendezvous. And development of the *Nova* all-chemical launch vehicle will be pushed as the logical successor to *Saturn*.

• **Picking space chief**—Probably the most newsworthy development of the year will be the impact of the new administration on America's space program. President-elect Kennedy, with Cabinet selection cleared away, can be expected to get down to work soon on selection of a NASA administrator.

Although some have proposed that Kennedy retain the present incumbent, T. Keith Glennan, most observers doubt that he will do so. Democrats familiar with the new administration's thinking agree with Glennan supporters that the administrator was about as effective as could reasonably be expected under the circumstances. They note, for example, that Glennan refused to accept a Budget Bureau figure of about $650 million for the 1961 NASA budget and eventually obtained $915 million.

Nevertheless, Democrats feel that Glennan has become publicly identified with a go-slow space policy because of the necessity of making speeches and other public statements in support of the Eisenhower program.

Space advisers to the new administration want, above all, a NASA administrator who will be the nation's No. 1 salesman of space exploration, something Glennan has been unable to be under Eisenhower.

What other qualities should a NASA administrator have? Here are the views of Abe M. Zarem, president of Electro-Optical Systems Inc. and a director of the American Rocket Society:

"He should be a missionary—an evangelist, with a keen sense of some sort of national rendezvous with destiny and how his job relates to it . . .

"He should be an effective manager of the space program. . . .

"He must be suave, a man of exceptional social manners, unusually winning ways—particularly for briefing Congress. . . .

"He must understand human beings—so as to keep in effective operation people of extremely diverse personalities. . . .

"He must understand the relationship between scientific knowledge and industrial might. . . .

"He must know generals and admirals, to maintain good relations with the military services. . . .

"He must know that spaghetti bowl, the Pentagon, how it works and how to get around it. . . .

"He must understand the workings of the Budget Bureau."

Zarem, who has been mentioned himself for the post, said he knows at least 10 people in the United States who fill the bill. He declined to name any names but said one is a college president, another heads a foundation and a third is a general. ⌗

temperature material in sizes and shapes once thought impossible.

Beryllium and molybdenum fabrication improved rapidly, leading to growing use in operational systems.

Technology of columbium and vanadium-based alloys improved to point where they are being considered for operational use.

GSE Electronics

Side-looking high-resolution radar developed and demonstrated by Texas Instruments.

Ruby optical masers (lasers) demonstrated by Hughes and Bell Labs.

Low-noise receiving system developed, with traveling-wave maser and largest parabolic horn antenna by Bell Labs.

First commercial 2200 mc equipment built by several companies.

Digital system use increases with spread of Digilock, Telebit and PCM.

GSE Facilities

Mistram, new GE super-accurate tracking system, started at Cape Canaveral.

Industry, government speeded construction of large space simulation chambers.

Construction began on 330-ft. Saturn gantry and launch pad at Cape Canaveral.

Field transporter, erector, launcher for Army's Pershing passed series of tests.

Air Force Minuteman train prototypes demonstrated.

Navy authorized feasibility study of Autec, Atlantic underwater test and evaluation center.

Antisubmarine Warfare

Navy began development of hydrofoil vessels to outpace nuclear missile-bearing submarines. Air-cushion skim craft tested.

Asroc underwater missile unveiled.

Navy completed Project Artemis study of ideas for setting up an ASW warning net, perhaps similar to Air Force DEW line.

Missile Master Completed

The Army announced successful completion of the Missile Master network of electronics centers coordinating air defense of the nation's major industrial and population centers.

The last of the system's centers was dedicated at Los Angeles last Wednesday. Previously completed were centers in the areas of Washington, Baltimore, Seattle, Boston, New York, Buffalo, Detroit, Pittsburgh, Philadelphia and Chicago. The Martin Co. is prime contractor and program manager.

Tory II-A Test Near

(Continued from Page 16)

tural behavior of the core design in a ramjet application; study of the aerodynamic behavior of the core/air heat exchange system; study of the reactor neutronic behavior and acquisition of experience in reactor operation on the program.

Initial tests will aim at intermediate objectives using fixed power, temperature and airflow rates, gradually building up to full power and temperatures. As in any test program, instrumentation is extensive. Thrust, however, is not a consideration in the Tory II-A-1 tests, and project personnel say it is not being measured.

They estimate, however, that thrust for such a system would be about 5000 to 10,000 lbs.

Original design parameters such as the determination of amounts of fissionable material needed to sustain a chain reaction were determined at LRL's Livermore facility in October. The reactor was brought to criticality there, and will be re-checked after installation in the test unit at the Nevada Test Site.

AEC pointed out the unconventional qualities of the Tory II-A reactor cores. Operating as a heat source, the reactor must have a very high power density with minimum weight and size. Half the reactor must be open for air flow. Temperature of the core reaches 2300°F, requiring exceptional core materials and nearby structural materials.

The reactor must also be able to withstand widely varying pressures and severe thermal stress caused by extreme temperature changes. Materials must operate in a high radiation flux, which in turn presents heat transfer problems.

• **Core materials**—The core assembly is constructed of about 100,000 beryllia tubular fuel elements, and measures about 30 in. in diameter by 45 in. long. Tubular tension rods running the length of the core act as structural support. The fuel elements are hexagonal rods measuring 4 in. long and ¼ in. across the flats. A center hole to allow for air passage is ⅛ in. in diameter. One half of the reactor core cross section is fuel elements and the other half is void for air passage.

Fuel elements are arranged so that each hole operates at about the same power and therefore imparts equal temperature rise to the airstream.

Designed as a heat exchanger, the reactor core has been divided into the small tubular sections described in order to minimize danger of breakage through thermal stress. Fuel elements

(Contnued on Next Page)

Sustaining chain reaction . . .

(Continued from Preceding Page)
fit together snugly within the structure.

Bundles of fuel elements are held together in a matrix of unfueled beryllium oxide links forming a hexagonal shape. These BeO links assist in preventing dislocations and displacements, and in assuring a uniform load distribution. They also take the bulk of the weight of the core, and are held together by 72 nickel alloy tubular tie rods running the length of the core, and located at the interstices of the BeO matrices.

A molybdenum base plate at the rear of the reactor holds the tie rods leading from the front support structure. The tubular tie rods are water cooled.

Dr. Harry L. Reynolds of LRL pointed out reasons for the strong support structure in the reactor. "Air pressure drops from 300 psi to about 200 psi after passing through the reactor," he said, "and we have a total of 100,000 pounds of pressure being exerted on the face of the reactor. To hold the thing together, we must have a support structure to withstand this push at 2300°F and in a high radiation field."

The thrust of the air pressure drop in the core is carried downstream to the rear of the reactor, where it is picked up by the base plate and transmitted to the tie rods.

The entire core and tie rod assembly is supported within a cylindrical metal shroud attached to the relatively cool forward end of the main air duct.

• **Control system design**—Basically, the 30 in. diameter of the core is not sufficient to sustain a nuclear chain reaction, due to the escape of neutrons. Therefore, a method of reflecting neutrons and preventing their escape has made the system workable. A graphite reflector surrounds the core, and some of the elements within the core are unfueld, also to act as reflectors.

Controls for the reactor are presently located in this graphite reflector, but future models will have the controls directly in the core. The neutronics of the core for flyable versions will presumably be such that no reflector, or at least a smaller one, will be included.

The beryllia tubes in the first 10 inches of the core length and those in the last two inches at the rear end contain no uranium fuel. These are reflectors for the neutrons.

The main reflector is an annular shield of graphite, two feet thick and supported outside the air duct.

The control system, within the shield, is in several forms. Each of the eight sections contains a control element, either a vane or cylinder, of graphite, rotatable by a control actuator. Near the periphery in a sector of each cylinder are a number of stainless steel tubes loaded with boron. Rotating the cylinder changes the position of the boron tubes and thereby controls the reactor by governing the degree of reflectivity of the shield.

A high degree of reflectivity keeps neutrons from escaping, and thereby sustains a chain reaction; allowing neutrons to escape through the vanes, or cylinders, reduces the power level a corresponding amount.

Another facet of the control system is four sliding boron steel rods placed about the inner portion of the reflector, closer to the core than the main control rods. Each of the 12 control elements in the shield is moved by a separate hydraulic actuator, set up so that normally the eight rotating cylinders move in unison.

In event of an emergency, the reactor can be "scrammed" by rapid actuation of the control elements to immediately stop the reaction within the core. The four rapid rods in the shield can be completely scrammed in ⅕ second, while the other four rods take ½ second.

• **Air supply**—The air supply at the test site is from a bottle system with a capacity of 120,000 lbs. of air at 3600 psia. Held in a system of large steel pipes, the supply will allow a full power run on the reactor unit for about 90 seconds.

Before entering the reactor, the air is heated in a stored-energy unit consisting of a large bank of steel tubes stacked in a cell, and preheated by an oil-fired furnace. The steel raises the temperature of the air to about 1060°F at the reactor inlet, thus simulating the inlet temperature of a Mach 3 ramjet.

After passing through the reactor, the air is directed upward through a 38° nozzle angle. The throat of the nozzle, where air velocity is Mach 1, holds pressure against the exit face of the reactor core.

By producing the sonic speed exhaust stream, the nozzle assists in raising the air to sufficient altitude so that radioactive residue is not deposited on the ground immediately behind the test area.

• **Environmental considerations** — Problems with reactors under extremely high stresses are expected to be ironed out with units such as the Tory II-A series, among them are aerodynamic and acoustic factors.

AEC and LRL do not want air flow within the test unit to reach above Mach 1, due to negation of nozzle advantages by sonic shock waves within the engine. If air were to reach to great velocity in the engine, its dwell time in the reactor would be too short for it to acquire heat. Shock waves would choke the nozzle and render it ineffective. Additionally, there is the possibility that the shock waves could damage the fuel elements in the core.

Another consideration in the design is that of acoustic damage to fuel elements and other components.

The test setup at the Nevada Test Site is an attempt to simulate conditions for a vehicle moving at Mach 3, ambient air pressure 14 psi and ambient air temperature of 100°F.

• **Safety**—A carefully laid out safety program is part of the Pluto project, due to implications of having a nuclear ramjet flying around the world dropping fallout on everything. Officials say exposure to the exhaust would be about 40 REM for nearby personnel, and would drop to a fraction of that for people standing directly under the exhaust if the vehicle passed over at 1000 feet altitude.

According to Brig. Gen. Branch, thirty flights of an *SLAM* vehicle with a nuclear ramjet would release 1/260 of the strontium 90 resulting from one 20 kiloton nuclear explosion.

• **Pluto facilities**—Cost of facilities for the Pluto program has thus far amounted to a total of $28,300,000. Installations at the Nevada Test Site amount to about $10 million of this, and those facilities at the Livermore laboratory total about $3,100,000.

Congress has also authorized additional funds for Tory C facilities, mainly in the air supply system.

• **Contractors**—Numerous companies are handling major portions of the Pluto program, under direction of Lawrence Radiation Laboratory. The Marquardt Corp. is under AF contract to develop non-nuclear components of the ramjet system.

Other companies include Atomics International Division of North American, basic materials research and development; General Electric, fuel element fabrication; ACF Industries, test vehicles; National Carbon Co., graphite reflector; Brush Beryllium, beryllium oxide and BeO parts; Coors Porcelain Co., fuel elements; Bendix Corp., special components.

In addition to the work on Pluto reactors, Air Force has awarded, through its Wright Air Development Division, two contracts to Chance Vought for navigation and radar systems for vehicles such as *SLAM*. One contract is for a "Fingerprint" navigation system, and the other for a terrain-avoidance radar to allow a vehicle to operate at a constant 1000-foot altitude, or other specified level.

Aircraft and Astronautics Application Panel, Nat'l Academy of Sciences

(See story of panel's report, p. 12)

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Soft Radiation Detector

A portable survey meter capable of detecting extremely low levels of radiation, particularly designed for use around radar and microwave installations and X-ray laboratories, is being marketed by The Victoreen Instrument Co.

At the heart of the unit's transistorized circuitry, is a new type of vibrating capacitor. The instrument will operate over 100 hours on one set of flashlight "D" batteries.

The Victoreen 440 will detect and measure radiation of less than 1 milliroentgen an hour by picking up currents generated as the radiation enters an air ionization chamber through a very thin "mylar window." It covers an energy range of 6.5 kev to 1.2 mev and its read-out dial can be set for one of five sensitivity ranges which encompass from zero to 300 milliroentgens per hour.

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Small Center Lapping Unit

J&S Tool Company, Inc. is marketing a center lapping machine, made especially for lapping centers in small parts. The unit makes it possible to lap standard as well as recessed center holes from 1/16 in. diameter and larger, at a highly increased rate of production.

Designed to lap both centers simultaneously in pieces up to 8 in. long, machine has two opposing precision high-speed spindles which are individually driven by 10,000 r.p.m. motors with reversible switches.

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Subcarrier Discriminator

A Subcarrier Discriminator for analog data systems, completely transistorized and designed for higher sensitivity, compactness, and versatility, is available from Data-Control Systems, Inc.

The Model GFD-3 Transistorized Subcarrier Discriminator, with its associated tuning units, filter networks, etc. saves space, requires less power and eliminates separate adjustment of each channel.

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ASW Cable

Boston Insulated Wire & Cable Co. is marketing cable which prevents the passage of water through from one compartment to another, even though the cable be severely damaged or cut on the seaward side of the bulkhead. Pressures on the exposed end will withstand 1000 pounds per square inch in conformance with hydrostatic test of MIL-C-915A, Amendment 8. Multiconductor and coaxial constructions are available for all deep water applications.

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Digital Signal Simulator

An electronic digital signal simulator for PCM systems in the field or in the development laboratory is available from Telemetrics, Inc.

Designated the ESS-500, the Telemetrics' unit simulates the digital output of an airborne or ground multiplexer and digitizer for both calibration and checkout, presenting serial data.

Interchangeable coding modules which plug in flush with the front panel enable the ESS-500 to generate any type of code, including binary, bcd, excess 3, biquinary, hexidecimal, 1224.

Circle No. 229 on Subscriber Service Card.

Phosphorescent Analyzer

An instrument capable of exciting, measuring, and recording phosphorescence of innumerbale compounds is available from American Instrument Co.

The instrument, the Aminco-Keirs Spectrophosphorimeter permits excitation of compounds and measurement of resulting phosphorescence throughout the ultraviolet and visible regions. An additional capability of the instrument is to quantitatively analyze phosphorescent compounds.

Circle No. 230 on Subscriber Service Card.

Hypersonic Gas Meter

MHD Research, Inc. is producing a V-Meter for measuring the velocity of luminous hypersonic gas flows. The instrument incorporates a single, adjustable control that provides the operator with instantaneous and continuous direct readout of velocity over a range from 2,500 to 50,000 fps. The fast response of its optical transducer allows accurate measurement of time intervals to 2 microseconds.

Circle No. 231 on Subscriber Service Card.

Miniature Cryogenic System

A self-contained miniature cryogenic electronic cooling system is available from Air Products, Inc. The closed cycle system uses nitrogen to provide one watt of refrigeration at 80°K.

This system is unique in that no gas or liquid supply is required. Systems previously available have required bulky cylinders of gas or elaborate storage containers for a liquid supply. This 16-lb. system is designed to run continuously for 500 hours between maintenance periods.

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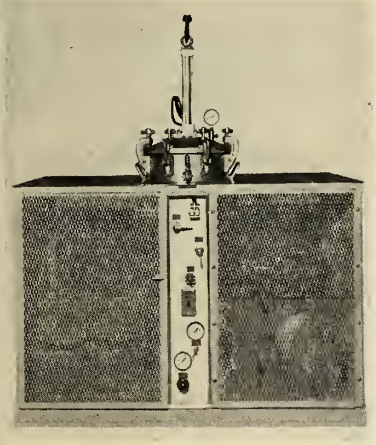
Vacuum Impregnating Unit

The National Sinter-Seal Co. has available a method and a corollary unit for sealing powdered metal parts.

The Sinter-Seal process consists of a completely self-contained, low-cost impregnating unit which uses a specially formulated resin. After the technique of sealing was evolved, together with the resin, this unit was engineered specifically to implement the Sinter-Seal process.



The Sinter-Seal unit accommodates up to 5400 cubic inches per hour. The simple four step process is completed in 10 minutes or less. The clean operation of the unit ensures minimum waste of impregnant; automatic solenoid valves guarantee smooth positive operation.

Circle No. 233 on Subscriber Service Card.

Bonded Transit Caser

Transit cases completely bonded together are available from Zero Manufacturing Co. The bonding eliminates welding and riveting.

Standard laminated aluminum panels are cut to size and assembled using standard hardware, corners, extrusions, fittings and an epoxy resin. The whole unit is then cured at room temperature.

Circle No. 234 on Subscriber Service Card.

new literature

INSTRUMENT SUMMARY BROCHURE—A 20-page summary brochure designed for handy reference to their instrument line is available from the Instrument Division of Bourns, Inc. The brochure contains basic specifications on pressure transducers, position instruments, accelerometers and instrument/systems. Thirteen new instruments are introduced in this brochure including three new accelerometers, two new position instruments, two new pressure transducers plus a whole new field of instrument/systems.

Circle No. 200 on Subscriber Service Card.

FLAT GLASSES—Corning Glass Works has published a bulletin detailing the properties and characteristics of several flat glasses, covering both Pyrex brand and Vycor brand flat glass products. The bulletin gives charted information on physical properties, chemical durability and working pressures. It contains transmittance curves.

Circle No. 201 on Subscriber Service Card.

TRANSISTORIZED POWER SUPPLY—A 4-page illustrated brochure describing an ultra-high regulation transistorized D.C. power supply has been published by Krohn-Hite Corp. The brochure fully describes the instrument's unusual features and design innovations, and includes complete technical specifications and ordering information for all models of the Krohn-Hite transistorized power supply.

Circle No. 202 on Subscriber Service Card.

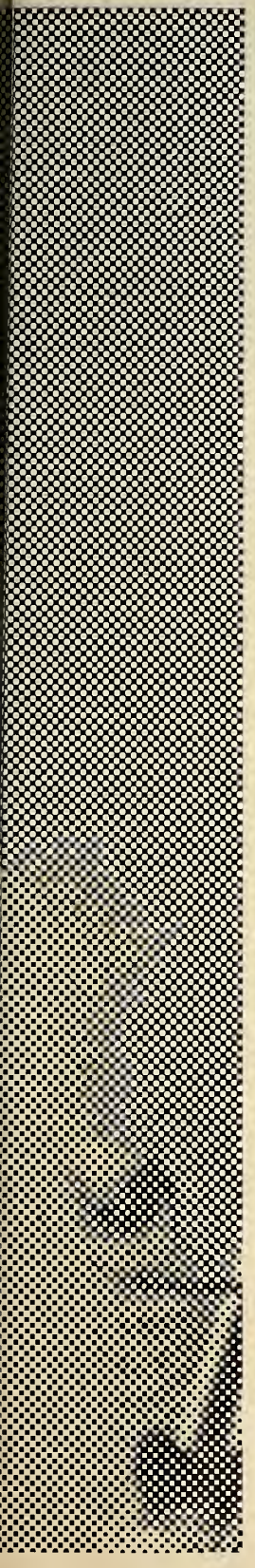
DIGITAL MEASURES—A special applications section is featured in the new 12-page, two-color bulletin available from Non-Linear Systems, Inc., on its Industrial Series digital measuring instruments. The section covers 17 uses of the NLS 481 digital voltmeter and the NLS 781 digital ohmmeter with individual photos and descriptive material. The booklet also includes a 2-page color spread on 481 digital voltmeter features, comparisons of the 481 digital voltmeter features.

Circle No. 203 on Subscriber Service Card.

O-SEAL VALVES—A complete line of O-Seal valves and fittings for 6000 psi liquid or gas service is described in Catalog 60 available from Combination Pump Valve Co. The valves are designed to operate at temperatures from –20°F. to 275°F. and are available in all standard piping sizes from ¼-in. to 2 in. The line includes globe, angle, needle, check and relief valves.

Circle No. 204 on Subscriber Service Card.

Computer-listed master catalog of engine parts reduces production lead time at Rocketdyne.



Keeping the cost of space down to earth

Behind the thundering performance of Rocketdyne's engines, a significant reduction in the cost of power for America's missiles has been quietly achieved. Today, Rocketdyne engineering skill and efficient production methods make it possible to power two missiles for the cost of one in 1957.

Rocketdyne, the pioneer in rocket science, was first with power for America's long range ballistic missiles—first with power for outer space. In establishing this technological leadership, Rocketdyne developed new management concepts at every level of operation, from early design through final testing. The result is outstanding technical achievement at the lowest possible cost.

In data processing alone, advanced techniques are saving engineers hundreds of hours of experimentation and testing and have contributed to a 37 percent reduction in Atlas engine costs for the Air Force. An intracompany communications network links test stands and research laboratories in Missouri, Texas and California; gives management the daily status of every program—whether it's on schedule, what parts are in short supply, how the production line is performing.

Through research, engineering, and management, Rocketdyne is constantly at work not only to increase thrust performance and develop new propulsion techniques, but at the same time to reduce costs all along the line.

25 of America's 28 successful satellites and space probes have been launched by Rocketdyne engines.

FIRST WITH POWER FOR OUTER SPACE

ROCKETDYNE

DIVISION OF NORTH AMERICAN AVIATION

Canoga Park, California; Neosho, Missouri; McGregor, Texas

—contracts—

NAVY

Kaiser Engineers, Oakland, Calif., for preparation of construction plans and specifications for the new probe missile launch complex to be constructed at the Pacific Missile Range. Amount not disclosed.

$34,000,000—General Electric Co., Pittsfield, Mass., for design and fabrication of advanced fire control systems for *Polaris* firing submarines, designated Mark 84.

MISCELLANEOUS

$1,750,000—Ling-Temco Electronics, Inc.'s Temco Electronics & Missiles Co., for antisubmarine warfare weapon system work. Subcontract from Lockheed Aircraft Corp.

ARMY

$204,280,000—The Martin Co., Orlando, for *Pershing* missile system.

$27,770,000—J. A. Jones Construction Co., Nello L. Teer Co., and D. W. Winkelman, Charlotte, N.C., for construction of missile launch facilities, *Titan II*, Phase I, near Davis Monthan AFB.

$1,139,675—Thiokol Chemical Corp., Bristol, Pa., for *Pershing* motor parts.

$1,037,169—The Martin Co., Orlando, for components for the *Lacrosse*.

$1,000,000—General Bronze Corp., Garden City, N.Y., for metal shipping and storage containers for the *Hawk*. Subcontract from Raytheon Co.

$400,000—North American Aviation, Inc., Downey, Calif., for repair and overhaul of *GAM-77* parts and components.

AIR FORCE

Minneapolis Honeywell Regulator Co., prime contract for first-phase development of the inertial guidance system for the *Dyna-Soar* vehicle. Amount not disclosed.

$12,000,000—Stromberg Carlson Div. of General Dynamics Corp., Rochester, N.Y., for communications systems for *Titan* missile bases.

ARPA

Convair-Astronautics Div. of General Dynamics Corp., San Diego, for building three experimental satellite payloads to investigate deep space conditions. Amount not disclosed.

Missiles and Rockets Editorial Index

Readers are invited to save the following six-month index covering M/R issues of July 4 through Dec. 19, 1960, as a reference guide to the major news and technical articles published during the second half of the year. The six-page section may be detached from the magazine as a unit for handy reference.

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FRICTION RESEARCH GRINDS TO HALT; Frictional behavior of metals in space environment is barely known, consistent theory of friction still undiscovered, by William Beller,* 8/29/60, p. 23.

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The Solid Gold Moon Truck

THE FIRST POSITIVE STEP toward the creation of a nuclear-powered propulsion unit which would take a man to the moon and back was taken recently when NASA and the AEC asked American industry for proposals on the development of a nuclear rocket engine.

The purpose of the first nuclear rocket engine would be to power the third stage of an advanced *Saturn* vehicle and give it certain interplanetary capabilities it cannot accomplish with chemical fuels.

A bigger nuclear engine riding on a more powerful booster would provide the means of sending a man to the moon and back.

Harold B. Finger, manager of the AEC-NASA Nuclear Propulsion Office calls a moon vehicle the "Solid Gold Truck."

Finger is the man who invited the proposals and by so doing made the first move to get the U.S. nuclear space program off dead center. It has been resting there since it originated in 1954 as an idea of the von Neumann committee and was initiated by the Air Force as a study contract in 1955.

Six U.S. companies, some new and some old giants of the U.S. aerospace industry, are said to be preparing the proposals. The contract will probably be let in early 1961.

To an extent much greater than those not close to the program know, U.S. industry has accumulated a very solid and even reasonably extensive base for the nuclear rocket program, which would greatly magnify our capability of sending massive loads into space.

Pump, nozzle and reactor control technology is well advanced and in good depth. What remains now, as Finger points out, is development by logical stages—ground testing, flight testing, development of sufficiently large reactors and a continuing program of advanced systems.

It is with the fourth phase we concern ourselves here—the continuing program of advanced systems.

It will avail the U.S. space program little to push forward with the development of a nuclear space engine unless we *at the same time* start a concurrent program to develop the system which will contain the engine.

The concept of concurrency is simply a way of saving time. For the *Rover* rocket engine it would mean creation of a third-stage rocket case simultaneously with the development of *Rover*. It would mean solving some of the hundreds of problems connected with the enterprise at the same time instead of waiting until the engine is proven. It would mean, among other things, solving some knotty difficulties of hydrogen storage during flight, of the effect of radiation on materials and equipment.

TO QUOTE THE AEC-NASA Nuclear Propulsion Manager:

"The problems that face us in the development of vehicles to land the first man on the moon are the same as the ones that are faced by any other nation intent on landing men on the moon. The only differences that may arise in the accomplishment of such missions are related to the national determination to do the mission and to do the detailed engineering and technology that must be developed within the framework of the basic scientific tools; within the framework of the formulas that express natural scientific phenomena."

Solving the problems leading up to an eventual moon flight will, however, take time. It is this time which we can buy through the application of concurrency. Neither the cart nor the horse, in this case, can be placed ahead. They must be available simultaneously.

Clarke Newlon

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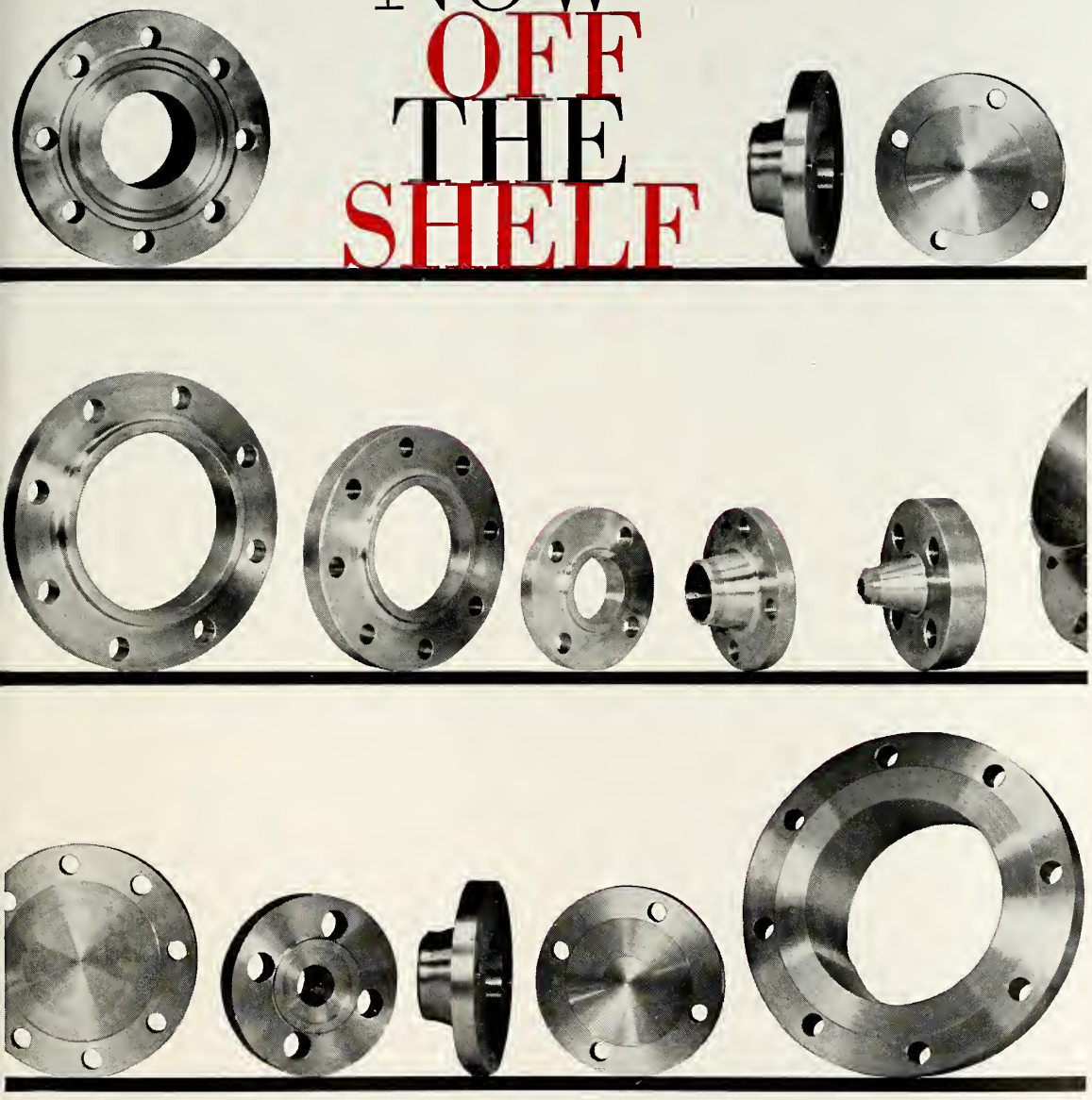

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