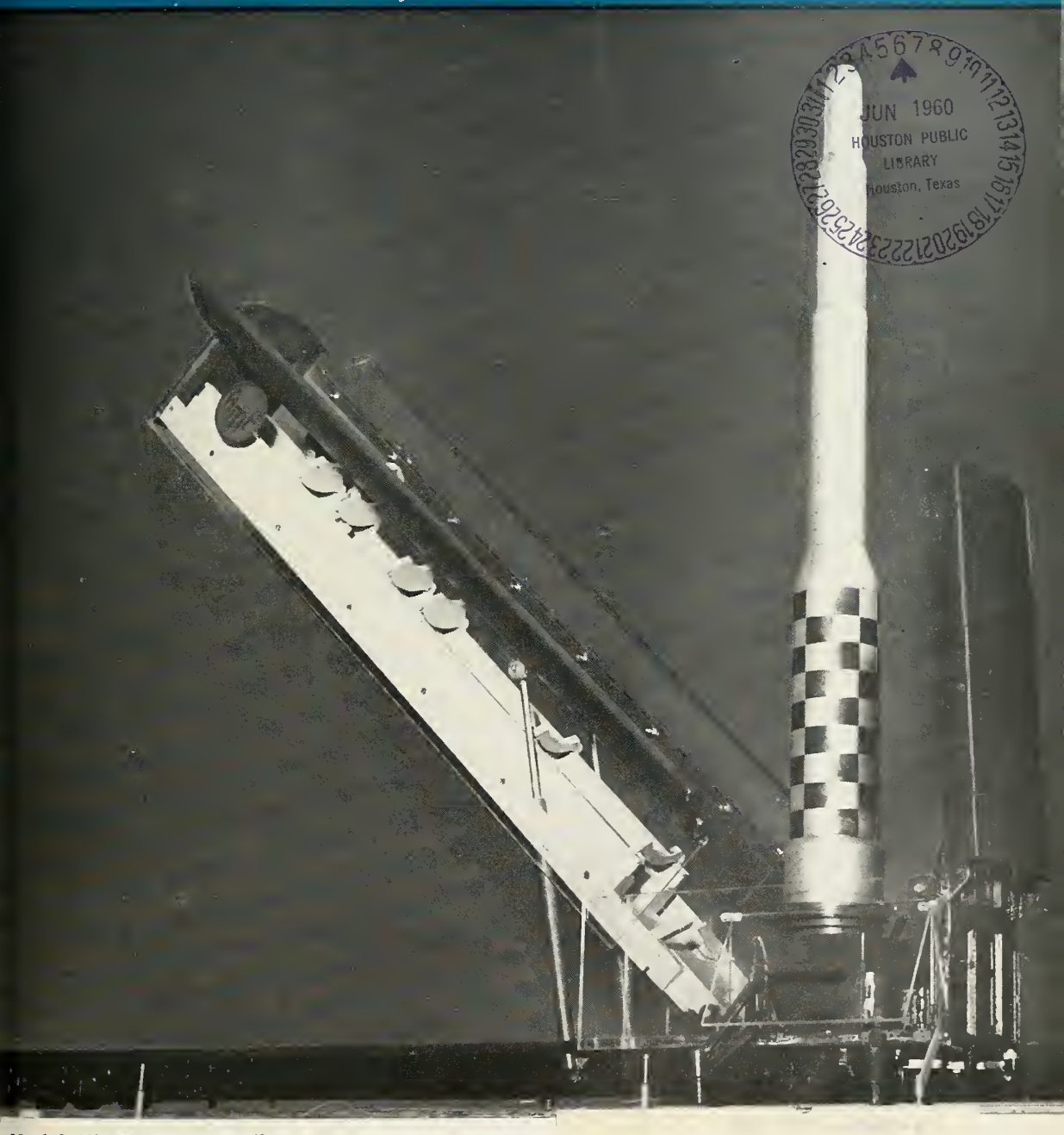
June 6, 1960

missiles and rockets

THE MISSILE/SPACE WEEKLY



Model Minuteman on Rails

SPECIAL REPORT:

Minuteman—Biggest U.S. Missile P

To Get 600 on Launchers by '65 10

AN AMERICAN AVIATION PUBLICATION

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Operations Research positions are now open at SDC's Lodi, New Jersey and Santa Monica, California facilities for scientists at several levels of experience. Please send your inquiry to Mr. R. W. Frost, SDC, 2414 Colorado Avenue, Santa Monica, California.

"Application of Computer Simulation to Production System Design," a paper by Allen J. Rowe, is available upon request. Send request to Mr. Rowe at SDC.

SDC

SYSTEM DEVELOPMENT CORPORATION

Santa Monica, California • Lodi, New Jersey

THE MISSILE / SPACE WEEKLY

missiles and rockets

June 6, 1960 Volume 6, No. 23

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THE COVER

Minuteman model rises on its transporter-erector, being developed by AMF and ACF industries. M/R was given an exclusive demonstration of its operation. See p. 40.

SPECIAL REPORT ON MINUTEMAN

JUNE 6 HEADLINES

ELECTRONICS

PROPULSION ENGINEERING

ADVANCED MATERIALS

ASW ENGINEERING

GROUND SUPPORT EQUIPMENT

INTERNATIONAL

DEPARTMENTS

29,974 copies this issue

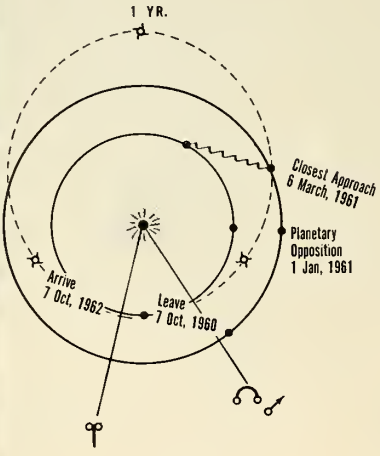
letters

Mars Probe Proposal

To the Editor:

In choosing flight trajectories for interplanetary probes, the formulation of mission objectives is generally so complex that a strict mathematical optimization process becomes hopeless. And even after locating what appears to be an acceptable orbit, it is usually worthwhile to explore nearby alternatives as well. One often discovers new factors which might provide a more desirable overall trip, even though it is not "optimal" in the strictest sense.

Reports appearing in the press and in many trade journals indicate that a Mars probe flight may be attempted this fall, about October 1, when the orbital positions of the earth and Mars combine to offer two local minimum-energy trip possibilities. The departure requirements for these particular trips indicate a speed of about 39,600 ft./sec. necessary for the shorter trip (about 209 days), and about 38,600 ft./sec. for the longer one (about 360 days).



If, however, the launching is delayed for about one week, then a number of orbits are available for which only modest increases in departure speeds over the minimum values will permit trips having several very desirable compensating characteristics: (1) short transit times to Mars, (2) the possibility of continuing unaided on a nominal orbit beyond Mars and eventually reaching earth again—that is, a nonstop round trip, (3) relatively short communication distances from launching until well after arrival at Mars*, and again for several months while returning to earth, (4) an approach speed back at earth which is low enough to encourage the attempted recovery of an instrumented package.

Nominal data for a typical such trip are as follows:

Departure date from earth, Oct. 7, 1960.

Date of closest approach to Mars, March 6, 1961.

Arrival at earth, Oct. 7, 1962.

Trip time on first leg, 150 days.

Total trip time, 2 years.

Departure speeds:

(a) Hyperbolic excess, 3.27 mi./sec.

(b) Equivalent ballistic launch speed at earth's surface, 40,500 ft./sec.

Relative asymptotic departure directions:

(a) Equatorial right ascension, measured eastward from the vernal equinox, 95°.

(b) Declination relative to equator, +37°.

Transfer orbit eccentricity, .37.

Semi-major axis, 1.6 A.U.

Inclination of transfer plane to ecliptic, +3°.

Aphelion/perihelion, 2.17 A.U./1.0 A.U.

Relative speed at closest approach to Mars*, 4.64 mi./sec.

Communication distance to vehicle at its closest approach to Mars*, 1.03 A.U.

Arrival speeds at earth:

(a) Hyperbolic excess, 3.27 mi./sec.

(b) Equivalent surface ballistic arrival speed, 40,500 ft./sec.

Although round trips involving either shorter travel times or lower relative speeds may be found, this particular orbit seems to strike an exceptionally harmonious balance among the various parameters associated with missions of present-day capabilities.

*We assume that the vehicle remains far enough removed from Mars that the trajectory is unperturbed by it (which may simplify the midcourse guidance problem). If the approach is closer, a minor correctional impulse may be employed to regain the nominal orbit.

Stanley E. Ross, Tactical-Strategic Systems
Missiles and Space Div., Lockheed Aircraft Corp.
Sunnyvale, Calif.

Post-Cycling Firings

To the Editor:

In the April 11, 1960 issue of "Missiles and Rockets," Page 35, there is reported the successful firing of a solid rocket grain at –68°F after repeated temperature cycling from –75°F to +165°F. Weight of the grain was not reported, but from the context one might assume it was a laboratory scale unit. It is further reported that prior to this firing "no really high-performance rocket motor had ever been made that could be fired successfully at low temperatures after temperature cycling."

Without detracting from this achievement, I should like to report that Olin Mathieson Chemical Corporation has successfully fired a number of high-perform-

ance, solid rocket engines after the engines were heated and cooled several times over the range of −65°F to +160°F. All of these engines were large enough to be operational. Most were prototype units weighing less than 500 lbs. But, to prove the point we have gone to much larger grains for a few firings. We would be glad to furnish more details to those interested. All firings, even those made at temperature extremes, were normal with no malfunctions due to the severe shock cycling conditions. The propellant used in each case was an inexpensive, easily processed fluid type, developed jointly by Olin Mathieson, Redstone's Ordnance Missile Laboratory Division, and Rohm & Haas Redstone Laboratories.

John D. Ireland, Huntsville Rep.
Olin Mathieson Chemical Corp.
Huntsville, Ala.

We'd like to ask both Olin Mathieson and Grand Central Rocket Co., which accomplished the firing reported April 11, to express in numbers what they mean by "high performance." We suspect the answers are classified.—Ed.

ARC Shares Credit

To the Editor:

In your April 18, 1960 issue you published a short description of the plastisol binder system for solid propellants developed at the Atlantic Research Corp. To avoid any misinterpretation of the facts, I would like to state that polyvinyl chloride resins produced by a number of different companies, among which is Union Carbide, have been and are currently utilized in this process. We acknowledge with thanks the assistance given by various resin, plasticizer, and other raw material suppliers who have cooperated with us in adapting and extending the plastisol concept for the manufacture of solid propellants.

M. G. Deffries, Solid Propellant
Div., Atlantic Research Corp.
Alexandria, Va.

'Well Done' for Admiral

To the Editor:

I would like to add my congratulations, along with those of so many others, on the inauguration of your new ASW department. Perhaps your readers would be interested in knowing that Admiral Harry Sanders, your consulting editor for this department, has written a superb 1900-word article on "antisubmarine warfare—" for McGraw-Hill's forthcoming Encyclopedia of Science and Technology (publication scheduled for autumn of 1960). Admiral Sanders' article is one of the very best—and certainly one of the most important—articles which I had the pleasure of editing.

K. W. Perkins
Physical Science Editor
McGraw-Hill Encyclopedia of
Science and Technology
Charlottesville, Va.

Due Credit to a Source

To the Editor:

Your coverage of optical instrumentation on Project DAMP (M/R April 18, p. 22) was excellent, but I wonder why you did not credit your source. Barnes Engineering Co. is prime contractor to ARGMA for optical and infrared measurements aboard the USAS American Mariner. This fact, plus the fact that you made liberal use of the DAMP Instrumentation Manual (to which I contributed) makes me wonder why due credit was not given to Barnes as well as other possible sources.

Robert E. Buckley, Head
Field Measurement Section
Barnes Engineering Co.
Stamford, Conn.

M/R did use the Barnes manual as source material. Omission of credit was an oversight—and not intentional—Ed.

AutoLite Article Pleases

To the Editor:

We have read your article on Electric AutoLite Company (M/R, April 25) and I certainly want to congratulate you on the very fine, well written article.

George Spaulding,
Director of Research
The Electric AutoLite Company,
Toledo 1, Ohio

When crews of SAC's 1st Missile Division successfully launched the USAF ICBM Atlas from Vandenberg Air Force Base, September 9, 1959, the world became aware that the United States had brought into being a formidable retaliatory power for peace. Within four months after the first operational launch, the Air Force doubly underlined this missile's capability. On a single day, January 26, 1960, the 16th and 17th consecutive successful Atlases were fired intercontinental ranges to predetermined targets from both Atlantic and Pacific bases.

After only five years of intensive development, including concurrent research, testing and fabrication under this nation's top military priority, Atlas is extremely versatile as well as powerful. It was the Project Score satellite vehicle and is scheduled for use in Project Mercury, the Man in Space Program, and in other space exploration missions. Thus, used as a booster for space projects, Atlas provides the nation with a key capability in scientific as well as military applications.

Space Technology Laboratories provides the systems engineering and technical direction for the Atlas as well as other portions of the Air Force Ballistic Missile Program. Much of what was learned in building Atlas has helped cut the lead-time in the development of such other Air Force Ballistic Missiles as Thor, Titan and Minuteman.

Among the industrial organizations which have worked in concert in developing Atlas are such major contractors as: Convair, Division of General Dynamics Corp. for airframe, assembly and test; General Electric Co. and Burroughs Corp. for radio guidance; Arma, Division of American Bosch and Arma Corp. for inertial guidance; Rocketdyne Division of North American Aviation, Inc., for propulsion; General Electric Co. for re-entry vehicle; Acoustica Associates for propellant utilization.

America's first intercontinental ballistic missile...is helping to bear the burden of today's power for peace

ATLAS

The continuing development of Atlas as well as other USAF missiles and related space probes, has created important positions on STL's technical staff for scientists and engineers with outstanding capabilities in: thermodynamics, aerodynamics, electronics, propulsion systems, structures, physics, computer technology, telemetry, and instrumentation. If you believe you can contribute in these or related fields and disciplines, you are invited to send your resume to:

SPACE TECHNOLOGY LABORATORIES, INC.

P. O. Box 95004, Los Angeles 45, California, Attention: Richard A. Holliday

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The Countdown

WASHINGTON

Budget Battle (cont.)

Odds are considered good the Senate will follow the House in voting more money—over Administration objections—for the missile-packing B-70 bomber, *Polaris* submarines and possibly more *Atlas* ICBMs. Where the Administration and Congress stand on what DOD should be spending is reflected in the following FY 1961 funding breakout (in millions):

	Administration Request	House Passed
Samos	$199.9	$233.7
Midas	106.8	117
Discoverer	45.1	55.1

NASA's Slip Shows

Timetable for the *Mercury* man-in-space program is slipping badly. The manned ballistic test aboard a *Redstone,* originally set for early this year and subsequently re-scheduled for mid-summer, is now expected to take place in late fall. Manned orbital launch is at least 15 months away.

U-2 Nevermore

Very shortly NASA will disavow itself of all future connection with U-2 spy planes. As the "cover" for the craft downed in Russia, NASA suddenly found itself in an acutely embarrassing position with neutral countries upon whom the space agency is counting for tracking sites. Some of these countries have been made suspicious of NASA's "peaceful" aims by the U-2 incident.

Cobra Decision Nears

Both the Army and the Marines will decide within the next two weeks whether to buy the West German-made *Cobra* anti-tank missile. Both are on deadline for FY 1960 procurement—if they feel they need it. The Seventh Army in Germany in an evaluation fired 80 *Cobras,* some in competition with *SS-10s,* and had only two malfunctions.

Redstone Reorganizing

A reorganization is now underway at Redstone Arsenal in anticipation of the July 1 creation of NASA's Marshall Center (for the *Saturn* project). Delmar Morris, veteran Atomic Energy Commission administrator, is being transferred to handle the paperwork of the new center being headed by Dr. Wernher von Braun.

INDUSTRY

Power Contract Due

Look for ARGMA-Huntsville to award a contract soon on a 3KW-8MW DC power supply for a big new plasma-jet test facility. The facility, which will use World War II surplus generators from a destroyer escort, will permit the measurement of radar cross-section of missile models in high-temperature, high-velocity gas stream. One obvious application would be to pinpoint incoming missiles for *Nike-Zeus.*

STL-NASA Tieup

Chances are good, Space Technology Laboratories will form closer ties with NASA—when and if it severs its connections with Air Force BMD. STL already has developed payloads for such satellites Pioneer V and Explorer VI, to NASA's satisfaction.

On Mahogany Row

A merger is in the works between General Instrument Corp. ($41 million sales in 1959) and General Transistor Corp. ($10 million sales in 1959) . . . General Precision Equipment Corp. is combing operations with its principal subsidiary, GPE Controls Inc. . . . and Hughes-Fullerton has just establshed a computer lab with a staff of 600 persons.

Marketing Costs Soar

With the present rugged competition, Manager Jim Bowles of Ampex's Computer Products Division says marketing costs equal or exceed all technical costs for any company trying to break into the computer field. Yet, the market and the industry are growing rapidly.

On Pad Training

More than 40 SAC missilemen are now in training at Cape Canaveral on the Martin *Titan* ICBM. For the first time, on May 27, one of them acted as test conductor for a successful R&D shot of the *Titan* which is expected to be operational at Vandenberg AFB by the end of the year.

INTERNATIONAL

Hydrofoil Gap Next?

The Soviets are boasting that the U.S. is playing around with small 100-ton ASW hydrofoil ships while they already are carrying passengers up and down the Volga on a much bigger hydrofoil called the Meteor. Moreover, a Soviet source told THE COUNTDOWN the Russians are building an even bigger one called Sputnik which also will be river-going—not ocean-going.

Canadair Gets Research Rocket

Prime for the new Canadian research rocket—*Snow Goose*—is Canadair Ltd., Montreal. The contract involves both the design and environmental testing.

Maruca Pleases French

Fired from the bow of a ship, the French surface-to-air *Maruca* is reported to have hit a CT-10 target drone up to 10 miles away. The missile has four SEPR solid boosters and a nitric acid and aniline sustainer.

NATO Eyes Mauler, Redeye

Some of the NATO countries are expected to buy the Convair *Mauler* and *Redeye* battlefield missiles. Convair recently stepped up its European sales activities for missiles. There is also speculation that Thiokol will receive the propellant contract for the antimissile/aircraft *Mauler,* soon to go into production.

Man Over Instrument

I. Shevlyakov, a Moscow Planetarium official, writes in Pravda that the Soviet space program is now based on the theory that "automation will never be able to replace man completely in space."

ON EXPERIMENTAL TRAILER, operational configuration *Minuteman* is readied for silo test shot.

600 on launchers by '65

Huge Minuteman Buildup Starts

by James Baar

Air Force plans for the *Minuteman* ICBM today call for the greatest and fastest missile buildup in military history beginning in mid-1962.

Informed sources make clear that the Air Force is preparing to:

• Scatter some 450 *Minutemen* in hardened silos across the continental United States—ready to be fired in less than a minute.

• Deploy some 150 *Minutemen* on 50 missile trains that will roam more than 80,000 miles of the nation's railroad network.

All apparently can be on their launchers ready to fire by the end of 1964 at the latest—if present schedules are met.

The total number of *Minutemen* involved—some 600—equals all the *Atlas, Titan* and *Polaris* missiles for which the Administration has authorized deployment or has announced plans to authorize deployment.

The advent of *Minuteman* will tip for the first time the balance of SAC's forces in favor of missiles rather than manned bombers. The missile will be king.

Cost estimates vary widely. However, many Air Force officials do not expect the total *Minuteman* price tag to exceed $2 billion at the most.

This figure is based on an estimate of about $2.4 million for each *Minuteman* in the ground and $4.8 million for each *Minuteman* on a train.

Plans call for deploying silo-based *Minutemen* at previously unheard of speed. At the peak of the buildup, 50-missile *Minutemen* squadrons are expected to become operational at a rate of one a month.

The buildup of missile trains will be slower, but still very rapid. At its peak, plans call for deploying as many as four or five trains a month. Each will carry three or possibly five *Minutemen.*

The first silo-based *Minutemen* are scheduled to become operational at Malmstrom AFB near Great Falls, Mont., in mid-1962. The first train-based *Minutemen* are scheduled to be operational about six months later.

• **Men at minimum**—The *Minuteman* will be the closest that man has ever come to the science fiction nightmare of pushbutton war.

Unlike all other U.S. strategic missiles, silo-based *Minutemen* will not be manned or even guarded except through remote controls.

Each of the approximately 60-ft. *Minutemen* will be deployed in simple underground shafts topped by huge concrete hatches weighing more than 10 tons. Nearby will be a locked manhole cover that will lead to a checkout console, but not to the silo itself. Each silo and checkout shaft will be situated somewhere in a two-acre site that will

The Air Force's *Minuteman* program, as detailed in this comprehensive report, promises to be the nation's largest missile effort in the '60s. To obtain all the information available about this undertaking, M/R editors interviewed scores of project officials at the Pentagon, the Air Force's Ballistic Missile Division and the major contractors, including Boeing Airplane Co., Thiokol Chemical Corp., Aerojet-General Corp., and American Machine & Foundry.

be surrounded by a high steel fence.

That is all: No guards. No missilemen. No buildings.

The missile will be launched by two officers stationed in an underground launch control post miles away. Security guards located at the launch post will travel by helicopter to a *Minuteman* site if detection alarms signal that unauthorized persons have entered the area.

"That cover is built to withstand an H-bomb blast," one man closely associated with the program has said. "It won't be easy to pry open even with the help of a little dynamite."

Nor does the checkout room pose any threat to the missile. The room will contain only a checkout console for identifying trouble areas. It will not give access to the silo.

One launch control post will launch 10 of the approximately 50 missiles in each squadron. However, any one of the five launch control posts in a squadron will be capable in an emergency of launching all 50 missiles.

• **Pullman accommodations**—To date no firm decision has been made on how many missiles each train will carry. The figure varies from three to five, depending upon strategic requirements and cost. Each mobile *Minuteman* squadron will be comprised of 10 trains.

The trains will have eight or more cars: A launching car for each missile, one or two power cars, a communications car, a launch control car and several Pullmans for the missile crews.

The trains will move in apparently random patterns along nearly half of the nation's railroad network, stopping periodically at preselected sidings. Special gyrocompasses developed by Autonetics will enable the missilemen to pinpoint their position for launching their *Minutemen*. However, the missiles could be launched from any position along the right of way with less accuracy.

The Air Force is considering two plans for moving the trains from siding to siding. Under one, engines with regular trainmen would be permanently assigned to a train. Under the other, missile trains would "hitch-hike" by prearrangement: The missile train would be attached to passing passenger or freight trains.

The "hitch-hike" system would be cheaper, but it has the obvious drawback of not keeping an engine available at all times. Probably both systems will be used.

The groundwork for the deployment of *Minutemen* will begin this winter with two important events:

• The first *Minuteman* fully-powered test missile is scheduled to be

ICBM 5-Year Plan Today

ATLAS

Total squadrons	13
In soft and semi-soft sites	7
Hardened	6
Sites announced	11
(Warren AFB, Wyo., has 3 squadrons)	
Missiles per squadrons	6 in the first
	9 in each of next six
	12 in each of last six
Total missiles	132
Number operational	about 8

POLARIS

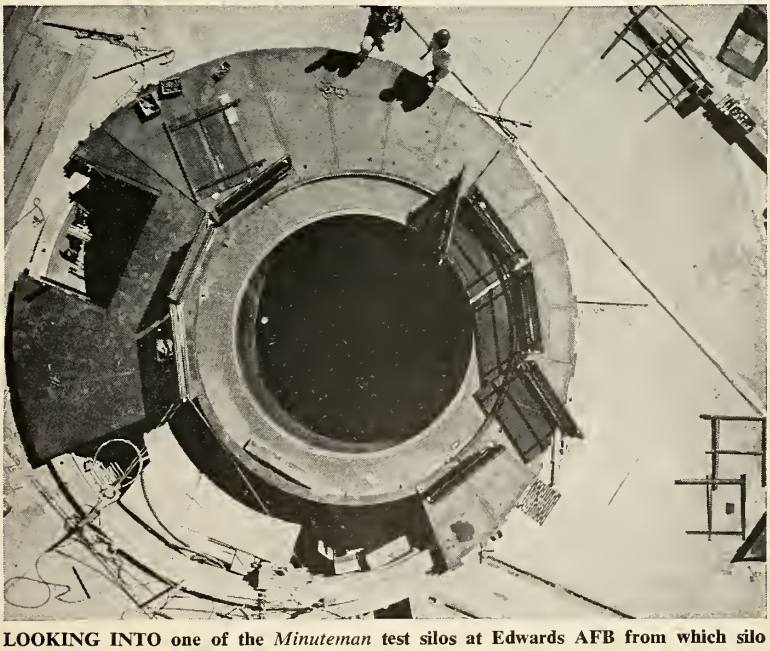
Total submarines	21
Ships built, funded or to be funded	12
Long-lead items only	9
Missiles per submarine	16
Total missiles	236
First operational	Fall 1960

TITAN

Total squadrons	14
In hardened sites	14
Sites announced	7
(Three have two squadrons each)	
Total missiles	126
Missiles per squadrons	9
Total missiles	126

MINUTEMAN

Total squadrons	about 14
In hardened sites	9
On trains	about 5
Missiles per silo-based squadron	about 50
Missiles per train-based squadron	30 to 50
Trains per squadron	10
Total missiles	about 600
First operational	Mid-1962



LOOKING INTO one of the *Minuteman* test silos at Edwards AFB from which silo development test models of the ICBM were fired in a program now completed.

launched from Cape Canaveral in December.

• The first construction contract for the first 50-missile *Minuteman* squadron of Malmstrom is scheduled to be let in January. Construction for the squadron is expected to take 15 to 18 months to complete.

Test launchings from the Cape may average as many as four a month between January and mid-1962 when the first *Minutemen* are scheduled to be deployed at Malmstrom.

Meantime, a series of six missile train tests will begin June 20 on the railroad lines around Ogden, Utah. Fourteeen railroads are taking part. Later tests will begin at Des Moines, Iowa.

The railroad tests are designed to work out communications systems and other operational matters. The test train commander will be in radio communication with Hill AFB at Ogden and the SAC Command Post at Offutt AFB, Neb. No missiles will be carried aboard the train in the initial tests.

Minuteman Statistics

Stages	3 plus warhead
Propellant	solid
Guidance	all inertial
Height	about 60 ft.
Weight	about 160,000 lbs.
Booster diameter	about 10 ft.
Range	more than 6300 statute miles
Speed	more than 15,000 mph
Payload	nuclear

The *Minuteman* program officially got under way in 1957. However, two years earlier the Air Force Ballistic Missile Division began laying the basis for the program by opening a small office for studying possible solid-propellant weapon systems.

The Air Force concept for the *Minuteman* called for several major developments along with numerous improvements that would be beyond anything that had been done before:

• The missile would be fired directly from an underground silo rather than ejected like the Navy's *Polaris* from a submarine. This has the advantages of cheapness and simplicity. But many doubted that a missile could live in the blazing environment that would be created in the silo as soon as the missile was ignited.

• The missile would use the biggest solid-propellant motors ever built.

• The missile would be steered by swiveling nozzles rather than jetavators similar to those used by *Polaris*.

• The missile would be test-launched from the beginning from Cape Canaveral.

• The first mission to be test-launched from Canaveral would be all-but-operational prototypes. Previously all large missile programs first called for launching something less than an operational prototype.

The silo launchings which began last fall were immediately successful and the number of tests was cut from 18 to seven. Time also was saved in

Much of Advanced Minuteman Testing Shifte

Major portions of the advanced testing of the Air Force's *Minuteman* ICBM have been shifted from Edwards AFB in California to the Atlantic Missile Range in Florida. Initial shipment of *Minuteman* rocket motors for checking out launch facilities have already been received at Cape Canaveral, and flight tests of the solid-propellant missile are expected to begin late this year.

Tests at AMR will include launching from both silo and railway car facilities. Meantime, Air Force personnel at Edwards will conduct tests to check out destruct systems, motor reaction to fire, and such things as bullet holes. Individual engine tests will also be done at Edwards.

The missile will be assembled at AMR in a building now under construction. This phase will differ from normal final assembly in that test instrumentation will also be installed at AMR.

• **Testing**—The Boeing plant in Seattle will do much of the systems testing for integration and compatibility; the program is currently under way. A full-scale silo will be built, as well as a rail spur. The first prototype rail command car has arrived at the Boeing plant for installation of electronics equipment.

Space performance of the *Minuteman* motors will be tested at the Arnold Engineering Development Center in Tullahoma, Tenn. Pre-Flight Rating Tests (PFRT) on the motors are also due to begin shortly.

Flight proof tests of the guidance system are secheduled in the near future at Autonetics and at Holloman AFB, N. M. Some testing of guidance components has already been carried out on rocket sleds at Holloman, and further tests are scheduled—including a test soon of a complete prototype guidance system.

Subsystems testing by contractors is increasing in tempo. Test activity at Vandenberg AFB is expected to be in high gear by the end of 1961, with a dual purpose: in addition to providing the same emergency war capability represented by the *Atlas* and *Titan* pads at Vandenberg, final system demonstration of *Minuteman* will be carried out there, culminating in actual firings both from a silo and railway car. The latter procedure will take advantage of the Southern Pacific Railroad tracks which run through the California base.

In addition to these, the Strategic Air Command will train its *Minuteman* launch crews at Vandenberg, as is now done on other large ballistic missiles.

• **Cut-grain shots cut**—One of the drastic slashes made in the test program came with the reduction of cut-grain silo test shots from 18 to eight. This was due to extreme success achieved in the launches. The primary objective of these silo launches was first to check out the silo configuration (depth, diameter, wall thickness, etc.) and the effects on the missile itself. By the end of the seventh such test, the Air Force found that it had either solved all the problems which it had expected, or had found them insignificant. The program was then terminated after the eighth test.

Before attempting the first full-scale silo shot last Sept. 15, the Air Force and Boeing conducted 5200 sub-scale tests with 1/30 and 1/20 scale models at Edwards and Seattle. These consisted of about 3800 cold flow tests and 1200 hot flow tests to determine pressures. The remaining tests were used in studies of acoustics, heat dissipation, and other parameters.

Following these low-cost studies, tests were carried out on 1/3-scale models placed in horizontal simulated silos.

As seemingly simple an item as a silo presented all sorts of theoretical problems during the program, mostly in the area of hot exhaust gases. It was widely feared that these would cause great damage to the missile, and that a "W" or "U" shaped silo would be needed to expel the hot gases. Air Force decided, however, to put a simple hole in the ground, fire the missile and see what would happen.

The result was that a simple hole in the ground proved adequate.

the achievement of early successes in the testing of various components. The overall result was that a year could be cut from the program and the operational date was moved to mid-1962.

Problem areas still remain before the first launching in December—particularly the perfection of the nozzles and the attainment of sufficient consumption of propellant. However, people associated with the program feel certain that the present schedule will be met.

Two major arguments are being put forth in support of making *Minuteman* America's major deterrent weapon in the 1960's. One is *Minuteman's* low cost. The other is its relative ability to survive a nuclear attack even when deployed in hardened fixed bases.

• **Cost trend reversed**—Since the beginning of the Missile Age, the cost of ground support equipment for missile systems has steadily increased. For the first time, the trend will be reversed with *Minuteman*.

The Air Force contends that construction and all ground support equipment for one 50-missile *Minuteman* base will cost only $20 million. The figure is astounding. Construction and ground support equipment for one nine-missile *Titan* base, for example, costs about $80 million. A *Polaris* submarine which is capable of launching 16 missiles costs about $100 million.

So far, an estimated half-billion dollars has been made available for the *Minuteman* program. The Administration has requested another $415 million for FY 1961— about $300 million for R&D and the rest for procurement.

Using Air Force figures, another $1 billion or so will be needed to complete the program and deploy the missiles in fixed sites and on the more costly trains.

• **Destruction-proof?**—The argument for the relative invulnerability of the *Minuteman* systems is based on what it would cost Russia to destroy them in a nuclear attack.

Successful random bombing of the railroad network with Soviet ICBM's would call for a Soviet striking force of 10,000 to 20,000 missiles. A successful attack on the fixed *Minuteman* sites would call for many thousands more unless the Soviets are capable of making a major advance in their guidance systems.

Finally, the Soviet problem can be made even more difficult by the building of cheap decoy *Minuteman* sites.

The conclusion of the argument is that train-based *Minutemen* are all but impossible to wipe out and silo-based *Minutemen* will put the United States in the strategically desirable position of having a deterrent weapon that is far cheaper to build than for Russia to destroy.

Nothing marks the changing composition of SAC and the Air Force so much as *Minuteman*.

Present plans call for the deploy-

o Canaveral

HOT LAUNCHING OF ***Minuteman*** **begins in the silo and the specially painted bird must fly through its own flames. (1) Artist's conception of silo; (2) Flame appears first at Edwards AFB tethered launch; (3-4) Missile fires, is yanked back.**

ment of a total of 258 *Atlases* and *Titans*. This, added to the some 600 *Minutemen* now planned, will bring SAC's total force of ICBM's to about 850—more than SAC's combined bomber fleets of B-52's and B-58's.

The *Minuteman* will be complemented with the Douglas *Sky Bolt*—the 1000-mile-range air-launched ballistic missile. These will unquestionably be deployed not only on bombers but even more likely on tankers and transports.

And, finally, the *Minuteman* program may be expanded beyond 600 missiles to a total nearer the 1200 expected last year.

Minuteman and her sister missiles —not bombers—will be SAC's major weapon.

TURN TO PAGE 39 . . .
for more of the *Minuteman* Special Report, including articles and pictures on the rail launcher, propulsion system and contracting.

Tiros Rockets Fired After 56 Days in Orbit

Two tiny rockets on the *Tiros* weather satellite have shown it is possible to ignite and fire rockets by ground command successfully after they have orbited the earth for more than 56 days.

The solid-propellant rockets, manufactured by Atlantic Research Corp., were ignited on command from Ft. Monmouth, N.J., May 27 during *Tiros'* 819th orbit, so as to increase the satellite's rate of spin.

The satellite must be kept spinning at a rate of 9 to 12 rpm to maintain stable orientation. Three pairs of the Atlantic Research rockets were installed on the satellite to maintain the rate. It was expected when the satellite was launched April 1 that the spin rockets would be fired every 20 days to overcome slowdown resulting from magnetic drag.

However, it was not until May 27 that the spin had slowed to 9.4 rpm. This would indicate that the satellite will have a useful life longer than the three months originally planned. After launching its perigee was 435 miles and its apogee was 468 miles. Now they have fallen to about 433 and 465 miles.

The spin rockets each produce 5 lbs. of thrust for 0.3 seconds. After they were fired, the spin rate was 12.85 rpm.

When the satellite was launched, somewhat larger rockets spun up the third stage to 136 rpm to maintain a stable trajectory. But when the payload was separated from the third stage, the spring mechanism reduced the rotation to the required rate.

Irvine Proposes Single Service, Top Planning Group

Lt. Gen. C. S. ("Bill") Irvine, retired, former deputy chief of staff materiel, USAF, and now a vice president of Avco Corp., last week advocated a single service "National Defense Force" as a solution to the nation's military problems.

Speaking before the Purchasing Agents Association in Los Angeles, Gen. Irvin declared that accelerated technology has completely outmoded our traditional military concepts. Science, he said, has pushed us well beyond the time when the land, sea and air mediums of the present organization represent a realistic appraisal of modern and advanced military procedures and objectives.

A National Defense Force would, he said, "provide operational and logistical flexibility so that the Secretary of this Defense Force could assign military missions to appropriate commands and know that reasonable compatibility and capability existed. It would help eliminate duplication and parochial rivalry."

It would also, Irvine declared, permit a 50% reduction of present DOD personnel and then "the 50% of the military in the Pentagon headquarters that spend their lives in frustrating coordination could then return to operations or logistics with the combat forces."

The former Air Force officer also called for closer cooperation between government and industry, championed the incentive-type contract and suggested a Defense Planning Group whose members would include top civilian and military scientific and DOD procurement officials.

• **Cost of mediocrity**—Recognizing that incentive-type contracts are frequently criticized as non-competitive, he declared:

"Such contracts have to be premised on the soundest target estimates relating to cost performance characteristics, reliability criteria and time of availability. Incentive payments should be made only when these targets are fairly surpassed.

"These estimated targets should be set up in a most ambitious manner. Then if better management or better engineering results in superior performance, better than marginal reliability, time savings or cost reductions—the incentive is earned. Cushions are for the weak at heart. And we cannot afford mediocrity, even if it comes from our own home town."

Gen. Irvine pointed out the cooperation between the Air Force Ballistic Missile Division and industry as an excellent illustration of good military-industry relationship and team effort.

• **For more brain power**—"I am suggesting here," said the General, "that we have within the defense establishment a legally constituted board, authorized by Congress and integrated within the total defense procurement setup, to plan, recommend and direct specific actions regarding weapon system research, development, procurement and production.

"Such a group would serve a dual purpose. It would provide the needed input to the Government on what industry anticipates in the way of breakthroughs or potential applications of new knowledge. In addition, it would enable the Government to use some of our top brainpower, not now being gainfully applied, to the best interests of the nation.

"The people chosen from the industrial side should not be in an active management of corporations. Rather they would be highly knowledgable men who are the recently retired senior management people and no longer associated with specific companies but with broad knowledge of our industrial and scientific activities.

"Such an approach would enable the military services in general to stay abreast of technical advancements and of major breakthroughs. On the other hand, it would enable the industrial forces to see immediate potential applications of every new discovery. The promising results of such an effort would be obvious."

—news briefs—

ROCKET STRIKE ORDERED—Soviet Defense Minister Malinovsky said he has ordered missile forces to strike any base which any surveillance plane might use to violate Russian air space. At the same time he boasted that Soviet antiaircraft rockets "are able to hit targets not only at an altitude of 20,000 meters but much higher."

SAMOS-MIDAS PADS READY—The Navy has completed the two *Samos-Midas* surveillance satellite pads costing $6 million at the Pacific Missile Range's Point Arguello. They will be used for polar orbits (see M/R, Dec. 28, '59, p. 13).

DOD Defends Incentive Contracting with Figures

Detailed evidence has been handed a Special House Armed Services Procurement Subcommittee by DOD to prove the dollar worth of incentive contracting. The information is intended to head off legislation introduced by Chairman Carl Vinson (D-Ga.) to curb the use of these contracts.

Figures given the subcommittee show "under-runs" of $219,703,000 on $6,316,528,000 worth of Air Force incentive contracts negotiated between 1952 and 1959. An under-run is the difference between the estimated production costs and the target price negotiated by DOD and the contractor. Normally savings are shared on a basis of 20% to the contractor and 80% to the government.

There were some over-runs turned up in the incentive contracts studied, but the overall average showed Air Force contractors' prices running 3.5% below the target price. The Navy figures show an average of 2.7% under-run on $2.5 billion worth of business.

G. C. Bannerman, director of DOD procurement policy, told the subcommittee that the percentages give an incomplete picture of total savings. He said savings realized when the prices fall below the legal "ceiling price"—as distinguished from the target price—do not show in the statistics.

The Air Force revealed that the Lockheed Marietta division experienced a $67,842,000 under-run on two contracts totaling $211,294,000 or 24.3% below target. Lockheed's Burbank division experienced a $2,851,000 under-run on 11 contracts worth $124,587,000, or a 2.3% under-run.

Convair, San Diego, experienced a $15,210,000, or an 11.5% under-run, on a $132,124,000 contract. Boeing Airplane Co.'s Seattle division had .9% over-run on a series of contract worth $837,120,000, but its Wichita division experienced a 6.9% under-run on 12 contracts valued at $1,417,309,000.

On a group of six contracts, Douglas Aircraft Co. had an under-run of $1,343,000 on a $6,968,000 total. A $6,457,000 under-run on a $57,432,000 contract was credited to Fairchild Engine & Airplane Corp., Hagerstown, Md.

General Electric, Evandale, O., had a $1,386,000 under-run on a $35,895,000 contract. A $9,965,000 under-run on three contracts totaling $337,959,000 was attributed to Martin Co., Baltimore. McDonnell Aircraft Corp., St. Louis, has a $3,377,000 under-run on a $100,129,000 contract.

The Air Force said North American Aviation, Los Angeles, experienced a $13,210,000 under-run on $637,649,000 worth of contracts, while its Columbus, Ohio, division had a $6,171,000 under-run on a series totaling $168,367,000.

Northrop Corp. had a $7,098,000 under-run on four contracts valued at $209,851,000. A $1,482,000 under-run on seven contracts totaling $946,665,000 was credited to Republic Aviation. Temco Aircraft Corp., Dallas, had a $383,000 under-run on a contract for $8,609,000.

UTC Gets NASA Award For Conical Solid Engine

United Technology Corp. has received a National Aeronautics and Space Administration contract for a feasibility study of a conical-shaped solid rocket engine. UTC will design, fabricate and test three experimental motors under terms of the contract. The sum involved was not disclosed.

Russian Press Denies Sputnik IV was Manned

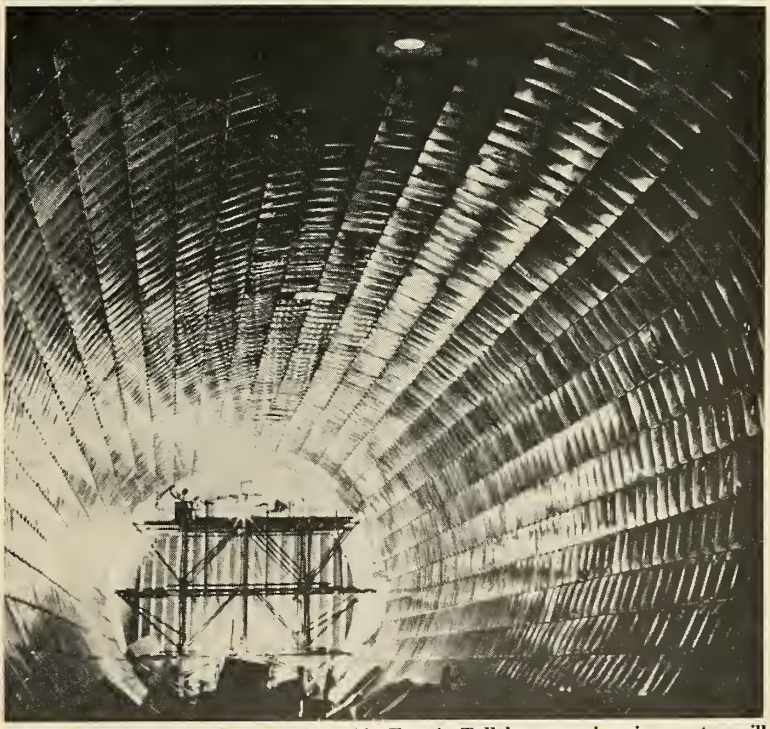
The Soviet press claimed recently that the *Sputnik IV* space ship's life support system functioned satisfactorily. But it denied that the vehicle was manned.

Prof. V. B. Parinyy of the Soviet Academy of Medical Sciences, in an article in Trud, May 17, denied rumors that the craft had a man aboard. He said no manned flights would be scheduled until there is confirmation of conclusions drawn from the *Sputnik II* experiment with the dog Laika.

A Tass wire service article appearing in Izvestiya May 21, said *Sputnik IV* produced these results, among others:

- The launching and orbiting equipment of the carrier rocket was proved to be reliable and accurate (this contradicts CIA reports that one of these boosters may have blown up at launch).
- Reliable guidance and orientation was achieved for several days.
- Necessary conditions for manned flights were maintained throughout.
- Retransmission of voice messages was noisy and greatly distorted.

Tullahoma's New Tunnel



NEW SUPERSONIC wind tunnel at Air Force's Tullahoma engineering center will create temperatures up to 650°F and noise levels to 155 decibels. Walls of 1790-ft.-long, 27-to-62-ft.-diameter tunnel were made of thousands of 24 x 24 x 2 in. stainless steel panels covered with glass fiber cloth, many of them formed in a deep-drawing process by McDowell Mfg. Co., Pittsburgh.

Saturn Vibration Not a Big Problem

First tests by ABMA damaged stand and snapped rivets on booster, but troubles are less than expected

HUNTSVILLE, ALA.—First tests of the *Saturn* booster and its static test stand show that vibration is a problem but engineers say it is not a major one.

Karl Heimburg, director of testing for the Army Ballistic Missile Agency group directing the clustered rocket, reported that the second and third tests of the eight-engine cluster shook bolts loose on the stand. Others said that some rivets were snapped on the missile itself.

Heimburg said he originally planned ned the third test May 26 for 50 seconds but cut it back to 35 seconds after inspecting damage to the stand from a 26-second test the previous week. He said the bolt holes would be changed to slots in heavily vibrating areas of the stand.

Another problem is distribution of the water used to cool the stand, Heimburg said. Even though 40,000 gallons are sprayed across the big flame deflector during each minute of testing, some spots still are not cooled enough. As evidence, Heimburg showed visitors a crazy-quilt pattern of paint on the deflector after the May 26 firing—painted spots cooled sufficiently and rusty spots needing more cooling.

No such problem was encountered in the first eight-engine test late in April, which ran 8 seconds. But the cluster was run for 26 seconds on May 17. It was then that the vibration trouble began.

Nevertheless, Heimburg declared that progress to date is encouraging. "We anticipated more trouble," he declared. "We are considerably more optimistic now."

To reduce the possibility of vibration buildup at the start of burning, the engines are ignited by twos. In the third test, the ignitions were programmed 300 milliseconds apart. The first two pairs were the interior engines. They cut off by fours, 200 milliseconds apart. The timing is controllable to a tolerance of 100 milliseconds.

• **Added assurance**—In the first test of 8 seconds, the engines were ignited in fours. It was switched to twos for the second test. They were programmed 150 milliseconds apart but the intervals averaged 100 milliseconds in the firing. To provide assurance, the interval was increased to 300 milliseconds in the third test.

Hans G. Paul, director of propulsion and mechanics for the ABMA group, which will be transferred to the National Aeronautics and Space Administration July 1, said Rocketdyne will deliver engines by midsummer for the second *Saturn,* which will be the first flight vehicle. Some work is already in progress on construction of the flight vehicle. Heimburg said the flight vehicle will be static tested at Redstone before the end of the year and flown from Cape Canaveral in 1961.

In early tests, including the 1961 flight, the individual H-1 engines will run at 165,000 lbs. thrust, making a total of 1.32 million lbs. By 1962, Paul said they will be uprated to 188,000 lbs. to bring the total to the planned 1½ million lbs.

Paul emphasized that individual engines on hand at Redstone Arsenal have already been run at 188,000 lbs. thrust. But they are being held down, Paul says, "because we want to prove that clustering will work—not that the H-1 will run at 188,000 lbs."

The improvement in the turbopumps—mainly the use of a stronger alloy—is the same as what was done to lengthen the range of *Atlas* and improve the *Thor* for space missions. However, the H-1 does not have the fiber glass wrapping around the thrust chamber that was used to lighten the *Atlas* booster. H-1 retains the steel bands used on earlier engines.

"The reason is primarily reliability," Paul said. "Each change is always a risk and the weight saving is not so important to us. The *Saturn* booster is not so weight sensitive. In upper stages, this is a different matter."

If the fiber glass wrapping develops a long history of reliability, Paul said, it is possible it will be used on later *Saturn* versions a few years from now.

The propulsion specialist declined

Rocketdyne to Power Saturn Top Stages

Rocketdyne Division of North American Aviation—the apparent low bidder—was chosen to develop the 200,000-lb.-thrust hydrogen-LOX engine that will power upper stages of later versions of the *Saturn* vehicle.

The National Aeronautics and Space Administration estimated development of the new engine under Rocketdyne's bid of $44 million will take about three years. (Two of the other major bids were Aerojet-General Corp. —$60 million and Pratt & Whitney—$80 million.) Design and qualification of the engine will take about four and one-half years.

At the same time, NASA disclosed a possible change in previously announced plans for an 800,000-lb.-thrust second stage for *Saturn.* The NASA statement said the 200K engine might be used in clusters of either two or four.

Whichever cluster is chosen for the new second stage will be inserted between the first and second stages of the *Saturn* C-1 vehicle. That vehicle consists of the eight-engine *Saturn* cluster as booster, the 80,000-lb.-thrust Douglas S-4 as second stage and a slight modification of the Convair *Centaur* as the third stage. The Pratt & Whitney LR-115 liquid hydrogen-LOX engine powers both the S-4 and the modified *Centaur,* which is designated S-5 in the *Saturn* system. There are two LR-115's in the *Centaur* and four in the S-4.

Latest NASA calculations show that the *Saturn* C-1 configuration will be capable of putting 25,000 lbs. in orbit or accelerating 9000 lbs. to escape velocity. The contract-award aannouncement said that the insertion of a 400,000-lb.-thrust second stage would increase payloads by 50% and an 800,000-lb.-thrust stage would double them.

No time schedule was announced for decision on which stage would be developed. There remains, of course, the possibility that both stages will be developed. The optimum payload with a *Saturn* booster would be realized with an 800,000-lb. second stage, a 400,000-lb. third stage and the S-4 and *Centaur* atop these to make a five-stage vehicle.

There is also a possibility that stages based on the new 200K engine will be used in *Nova,* the liquid-propelled vehicle based on the Rocketdyne F-1 engine, which is to follow *Saturn.* However, decisions on the nature of the *Nova* vehicle are several years away.

Altogether, five companies bid on the 200K contract. In addition to Rocketdyne, they were Aerojet-General, Pratt & Whitney, General Electric and Bell Aircraft.

to say what variation in thrust had been noted among the eight engines on early tests. Variations of a few hundred pounds one way or another are not important at this stage of the game, he said. The guidance allows for an error of up to 3% in the thrust of individual engines—that is, the error can be corrected by guidance if the thrust of an individual engine varies by less than 3%.

Even if an engine should fail completely after igniting, he said, almost all of the propellant will be routed to the other engines. Only the small amount needed to provide a head to the fuel pumps in the dead engine would go to waste.

• **Small starters**—Rocketdyne reported that the H-1 engines used small solid-propellant motors as starters. The start engines are produced at Rocketdyne's Solid Propulsion Operations in McGregor, Tex.

Each starter uses about 6 lbs. of a low-cost ammonium nitrate propellant, which supplies 1500 horsepower for one second. When the starter is ignited, its exhaust spins the main engine's fuel and LOX turbopumps up to 5000 rpm and simultaneously the flame ignites the converging propellant streams in a bootstrap operation.

Rocketdyne said the solid-propellant units, originally developed and tested in an experimental engine for the *Thor* missile, were later applied to the MA-3 *Atlas* engine and the H-1. They have achieved a reliability of 99.6% and have resulted in weight savings of 120 lbs. on large liquid engines, the company said.

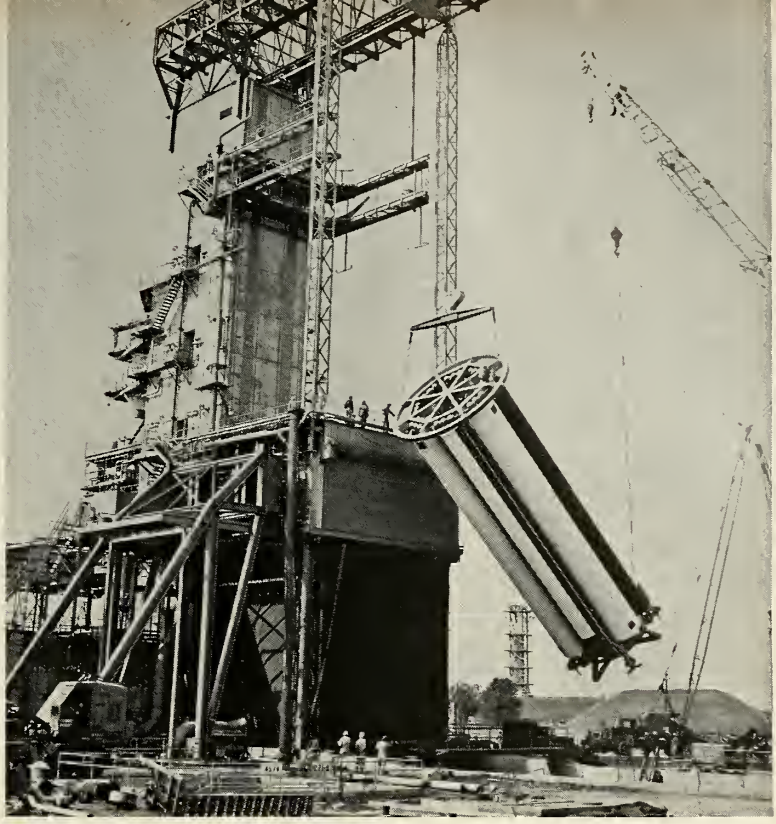
The most important changes in the H-1 engine are in the direction of simplicity, Rocketdyne said. The H-1 has less than one-tenth the number of major components that were used in engines for *Jupiter*, *Thor* and *Atlas*.

The May 26 firing was the first to which the press was admitted. About two dozen newsmen and photographers watched from a hillside 2200 feet from the old *Jupiter* test stand at Redstone, which has been modified for tests of the *Saturn* cluster.

A blown fuse in an instrument recording nitrogen purge of the LOX dome caused a 4½-minute hold less than a second before the countdown reached zero. Recheck showed the purge itself was operating properly.

A thunderstorm had drenched watchers a few minutes before but the rain stopped in time for viewing. Heimburg said the firing would have gone on regardless of the weather. The rain resumed 10 minutes after the firing, while some of the visitors were atop the tower.

Because of the low cloud ceiling, the sound volume at the observation point was greater than in the two previous tests. A volume of 126 decibels was recorded, one above the level at which medical men say discomfort normally begins for humans. Heimburg said 140 decibels is a danger level above which no one should subject himself without first taking a physical examination. The ground at the observation point vibrated more than the street above a subway train.



BIG LIFT of *Saturn* booster onto test stand at Redstone Arsenal preceded current series of static tests. Men give indication of rocket's size.

The visible flame appeared to be about 125 feet long—about 50% longer than the booster itself. The measured time was 35.16 seconds. During that time, 820 measurements were made. These included 360 of pressure, 185 of temperature, 40 of flow rate, 55 of force and strain, 60 of vibration and 120 miscellaneous.

• **New stand sought**—In another development, the NASA group at Huntsville, which on July 1 will be designated the George C. Marshall Space Flight Center, announced that bids have been requested on construction of a second *Saturn* test stand at Redstone Arsenal.

The new stand, to be known as a "dynamic test facility," will be used to check mechanical erection of the *Saturn* vehicle. It will not be used for engine firings. The new stand will allow determination of the natural bending characteristics of the vehicle, effects of cryogenic liquids when held for various lengths of time and the effect of simulated flight vibrations on the various stages.

Bending and vibration tests can be conducted when the vehicle is fully fueled to the liftoff weight of 580 tons. Other tests will include wind effects, fueling techniques, ground crew training and assembly methods. The stand will have means for carrying spilled propellants to remote holding ponds to minimize fire hazards.

The stand will include a structural steel test tower 204 ft. high containing about 600 tons of steel, a reinforced concrete control building with a floor area of 700 sq. ft., an electric elevator with a 190-ft. lift and a 75-ton stiffleg derrick with an 80-ft. boom and a 50-ft. mast.

The steel superstructure will provide lateral support for the vehicle and working platforms. The plan also calls for power, water and other utilities; and a road and hardstands. Test date will be recorded with equipment in an existing blockhouse.

Bids were requested for NASA by the Mobile District, U.S. Army Engineers, and will be opened in Mobile, Ala., June 15.

Congress Studies DOD Procurement

Three different subcommittees of Congress this last week were involved in activities affecting the procurement regulations and policies of the Defense Department. Committees and activities were:

House Small Business Subcommittee: considered a reply from G. C. Bannerman, DOD Director of Procurement Policy, to charges made by industry at recent hearings that proprietary rights are inadequately protected. Bannerman agreed that present policies need changing and proposed that proprietary data be defined as any data "not readily revealed by the product itself."

The present definition states that data is not proprietary if "it is not disclosed by inspection or analysis of the product itself" and often leads to expensive and long engineering analysis by the government just to discover if such is the case.

Special House Armed Services Subcommittee on Procurement: heard Perkins McGuire, Assistant DOD Secretary for Supply and Logistics, plead for a softening of the Vinson bill to amend present procurement laws. The new law, said McGuire, would curb incentive contracting, limit negotiated procurement and require written or oral discussions with prospective bidders.

McGuire declared incentive payments are desirable for those contractors who have demonstrated they can cut costs by skill, efficiency and ingenuity. He said all purchases should be made by formal advertising "when practicable." He thought discussions with all bidders would simply permit them to pad early bids.

Chairman Vinson agreed to consider and discuss proposed DOD substitutions in his measure.

Senate Small Business Monopoly Subcommittee: Chairman Russell B. Long (D-La.) introduced a bill which would give the U.S. exclusive rights and title to any invention developed with government research money. It would, he said, make the results of government research open to all our citizens instead of just a favored few. A waiver involving proprietary rights could be ordered, he said, when a contractor's contribution outweighed that of the government.

mergers and expansions

CUNO ENGINEERING CORP. stockholders will vote shortly on an offer for acquisition by American Machine and Foundry Co. The move has already been approved by the boards of directors of the two firms.

No changes in personnel, operations or marketing policies of Cuno are expected. The Meriden, Conn. firm manufactures a line of industrial filters used in chemical, atomic energy, aircraft and guided missile fields, in which AMF already is active. Cuno also has plants in Stafford Springs, Conn., and Windsor, Ontario, Canada.

Export and foreign manufacturing operations are conducted by the Olin-Cuno Filter Corp., jointly owned with Olin Mathieson Chemical Corp., with a subsidiary in France.

AMF's most recent acquisition is the Emhart Manufacturing Co.'s Maxim Division at Hartford, Conn., noise suppressor manufacturers.

KOLLMORGEN OPTICAL CORP. of Northampton, Mass., is merging with Inland Motor Corp. of Radford, Va., and Pearl River, N.Y.

General headquarters will be maintained by the new company, to be known as the Kollmorgen Corp., at Northampton, with divisional headquarters at Radford. Inland will be operated as a division. No change is anticipated in production facilities.

UNITED CONTROL CORP. has acquired all outstanding stock in the Electro Development Corp., both of Seattle. Electro, holding contracts for instrumentation systems in *Polaris* and *Minuteman,* will be maintained as a separate company. United Control Corp. just recently established Palomar Scientific Corp. in Palo Alto, Calif.

NEW YORK RESEARCH & DEVELOPMENT TEAM has been created by six independent technical companies in the New York area. They include an engineering-computational firm, a physical research group, a radiation and chemistry research group, a testing laboratory, and a systems research group. The team hopes to be operating as a coordinated technical team by mid-summer, according to group leader Cyrus Adler, President of the Manhattan Physical Research Group, Inc.

HAVEG INDUSTRIES, has announced plans to enter the blow molding field with the purchase of the equipment and inventory of the Blow-O-Matic Corp. of Bridgeport, Conn. President Soren Graae will join Haveg as manager of the facility, which will be known as Blow Molding Division of Haveg Industries, Inc. The existing building will be maintained.

MEKTROL LABS, INC. is undergoing a $250,000 expansion program in Alta Loma, Calif. The new facilities will enable the firm to provide eight more testing services to bring its number to 24 available services in electronic, chemical, and physical testing and analysis.

CONTROL DATA CORP.'s Computer Division has formed a Programming Research Group to increase its efforts in Automatic Programming and other related programming efforts for the Division's line of digital computers.

ULTRASONIC INDUSTRIES, INC. of Long Island has joined forces with Industrikeme A/S, of Denmark, for mutual distribution of their products in the metal finishing equipment field.

financial news

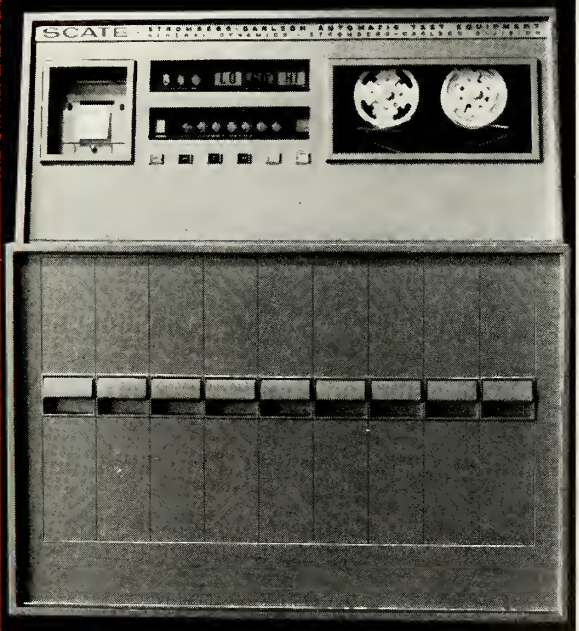
The Board of Directors of the Summers Gyroscope Company have forecasted a "reasonable" operating profit for Fiscal Year 1961 for the first time in several years.

Unaudited first quarter figures show sales at approximately $5 million and net profit at $269,608. Last year's total sales were only $7.5 million, of which some $3.6 million were under loss contracts. Over-all operating loss for the FY was held to $364,000. The company expects sales near $14 million for the year ending Jan. 31, 1961.

Summers suffered an operating loss of $4 million for the fiscal year ended Jan. 31, 1958, reduced to $992,000 for the year ended Jan. 31, 1959, and further reduced to an operating loss of $364,000 for the fiscal year ended Jan. 31, 1960.

Present backlog of orders is close to $5 million, expected to be increased by the end of June.

A TALENT FOR WEAPONS TEST EQUIPMENT



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- Follows weapons system from prototype to operational status.
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- Detailed fault location down to the smallest resistor.
- Provides rapid HI-GO-LO and numerical evaluation as well as permanent printed record.
- Reduces cost and time of designing test equipment for each individual requirement . . . because most modules are standard.
- In a typical case, SCATE has reduced a 12-hour manual testing program to less than 5 minutes—a reduction of over 99%.

Today's SCATE system—currently in production for an advanced weapons system—is equally applicable to those of tomorrow.

H. C. Sager, Manager of Sales, is available to discuss your specific application. Literature on request.

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Technical Countdown

ELECTRONICS

WWV Adds Time Code

Bureau of Standards has added an experimental timing code to regular WWV broadcasts to provide a standard time base for scientific observations. The 36-bit 100-pps binary code designates hour, minute, and second in universal time, and indicates WWV broadcast accuracy within one millisecond.

Batteries Fail in Space

Failure of *Pioneer V's* power supply was reported to be due to deterioration of batteries caused by leakage of gas in the hard vacuum of space.

Electrons Make the Scene

First films showing the interactions of electrons within a microwave tube will be shown at the International Tube Conference in Munich this week. The movies are part of a paper presented by Dr. Joseph Hull, manager of Litton's electron tube research lab.

Electronic Industry Becoming Giant

Electronics will be the third largest U.S. manufacturing industry by 1965, according to Harvey Riggs, president of International Electronic Research Corp. He predicts that within five years electronics would rank behind only the automobile and steel industries.

GROUND SUPPORT

Sky-spy Uses Borrowed Pad

Midas was launched from modified *Atlas* Complex 14, one of two at Canaveral modified for multistage space vehicles. Gantry heights were increased to 130 feet and towers added for upper-stage umbilicals. Later launchings will be from Point Arguello.

GSE Directory Revised

DOD has revised its directory of military agencies responsible for development of missile GSE (PB 161535—"Technical Resources Directory—Missile Ground Support Equipment No. 2"). Copies may be obtained for 50¢ from OTS, Dept. of Commerce.

3-D Radar for Navy

Navy has just awarded a $14-million contract to General Electric for production of AN/SPS-30 long-range height-finder radars. One of the longest-range radars ever developed for Navy, the new unit will provide 3-D capability for detection of missiles and high-speed aircraft.

PROPULSION

Plasma Gets Boost

An "electromagnetic plasma accelerator" developed by Litton Industries uses electromagnetic fields to make a gas electrically conductive and accelerate the plasma to extremely high velocities (250,000 mph). Method is said to eliminate problems of electrode erosion, wall friction, low efficiency, and containment associated with plasma propulsion systems.

Largest Helium Plant in Operation

Daily output of the Navy's new mobile liquid-helium plant is 45,000 standard cubic feet equivalent high-purity gas. The liquifier—largest in the world—was built by Air Reduction Inc. It is the prototype of an even larger plant to be built later.

MATERIALS

Plastic Ceramic from England

Ceramic-like resins capable of resisting temperatures of 1000°C with excellent thermal shock properties are being evaluated in England. Expected applications include missiles, high-speed aircraft, and nuclear fuel element cladding.

Micrometeorite Impact Simulated

Pyrex glass beads four milli-inches in diameter are being slammed into metal test specimens at speeds up to 31,000 fps in a series of micrometeorite impact studies at North American Aviation's Missile Division. The beads are fired from an electric gun through a vacuum at aluminum and magnesium alloy targets.

GUIDANCE AND CONTROL

Magnetic Damping Stabilizes Satellite

"De-spin" of *Transit* satellite worked even better than the project scientists hoped for. Slung counterweights dropped the initial spin to about 4 rpm and magnets in the vehicle damped the rotation to zero.

Ceramic Gyro for Missile Guidance

New miniature ceramic gas-lubricated bearing gyro is reported to be ten times more accurate than best available today. First of its kind, the Honeywell development uses super-hard aluminum oxide ceramic for critical parts (see p. 22 this issue.)

ASW ENGINEERING

Nuclear/Fuel-Cell Power for Subs

Fuel-cell development may be directed toward combination with nuclear reactor. Promise is great for use in small killer-type antisub submarines, as well as spacecraft. Increase to 48% total efficiency is believed possible with heat-output type system.

Ceramic Gyro Ten Times More Accurate

by Hal Gettings

NEW YORK—A new space-guidance gyroscope 10 times more accurate than the best production models available today is claimed by Minneapolis-Honeywell. The new development—described as "the greatest improvement in production gyros in a decade"—uses ceramics and gas-bearings to virtually eliminate drift inaccuracies caused by conventional bearings and the unstability of other critical gyro parts.

The new gyro is similar to Honeywell's MIG (miniature integrating gyroscope) except that the spin-motor, bearings, and gimbal are all made of gem-hard aluminum oxide ceramic. Its accuracy is 10 times better than the MIG.

• **Eliminates ball bearings**—The big advantage claimed by the ceramic gyro is in the elimination of ball bearings with their wear and subsequent changing drift rates. In the new unit, the ceramic shafts of the spin-motor serve as the bearings, riding in ceramic "races" lubricated by a helium-gas film 0.000025-in. thick. The gas film—virtually friction-free—is under pressure that effectively makes it stiffer than the steel ball bearings it replaces. Vibration or bearing noise is said to be decreased by a factor of 30.1. Honeywell says that the bearings have undergone thousands of starts and stops without detectible wear.

• **Ceramic in critical parts**—Use of the ceramic in other critical gyro parts—spin-motor and gimbal—was found to considerably reduce unstability and add to the accuracy of the unit. Tests in which the ceramic was subject to temperatures of from −85 to +1500°F showed dimensional stability within two-millionths of an inch.

A further advantage claimed by Honeywell is that the ceramic parts can be cleaned with acid with much better results than conventional methods such as solvents and ultrasonic scrubbing produce.

The ceramic gyro parts are roughcast in powdered form and fired to a "green" state where they can be easily worked. After a final firing at 3200°F, the material becomes almost as hard as a diamond. It is finish-ground with diamond compounds to tolerances less than 0.000003 in.

The gas bearing principle is not new, but Honeywell contends that previous application has been severely limited by wear on non-ceramic bearings caused by starting and stopping.

• **Conventional construction techniques**—Construction of the ceramic gyro follows conventional methods except for the new materials. It is a miniature integrated gyro with floated gimbal. Flotation of the gimbal—conceived by Dr. C. S. Draper of MIT—gives suspension of better than 99% of gimbal weight and reduces friction to practically zero. (Equivalent torque level has been compared to that produced by the light pressure of a flashlight shining on a playing card hinged at one end.)

Miniature gyros play a vital part in missile guidance systems. They must be supersensitive to measure extremely small angular motions and yet not respond to other outside influences such as vibration, humidity, and shock, and changes in pressure and temperature.

• **Accuracy and reliability**—Extreme accuracies have become almost a fetish among the designers and manufacturers of gyroscopes and guidance systems. Requirements are so rigid—a shift of one micro-inch in wheel position can mean the difference between success and failure of a moon probe—that even a one-micron speck of dust can ruin a gyro. "Clean rooms," ultraprecise manufacturing methods, frequent inspections, and a high number of rejects, make costs of the units fantastically high. (Examples: One little gem that can be held in one hand costs over $12,000. Over 100 precision gyros were bought for one satellite program in order to get five acceptable units.)

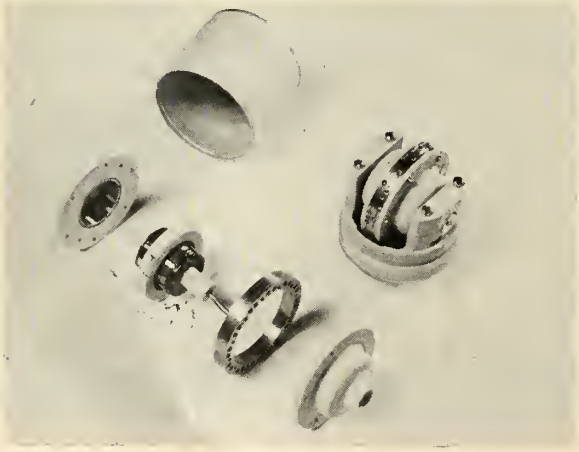
In addition to costs, the design of small, accurate, and reliable gyros involves many other headaches for the designer. Time, of course, is one especially significant factor.

The state of the art is being pushed to its limit in many areas and significant advances such as this use of new materials are urgently needed.

• **Unwanted torques big problem**—Two types of unwanted torques are of prime importance in gyro design. The first is a friction-torque that tends to mask off some lower-level gyroscopic torques to limit the angular-rate threshold capability of the gyro. The second is unbalance torques that come from other than gyroscopic action and are erroneously measured as angular motion.

Friction torques are greatly reduced with gimbal flotation suspension. Flotation of the gimbal weight has reduced friction to the order of a million times less than ball bearing. This improvement may be extended several orders of magnitude further by advanced developments in externally pressurized air suspension, hydrostatic fluid gimbal supports, and magnetic or electrostatic suspension.

The ceramic gas-bearing spin-



CRITICAL PARTS of first ceramic gyro are made of new gem-hard material diamond-honed to extreme tolerances. Spin-motor, gas-lubricated bearings, and gimbal are all made of the new ceramic. Motor stator is glass-encapsulated.

motor greatly improves the second category: unbalance torques.

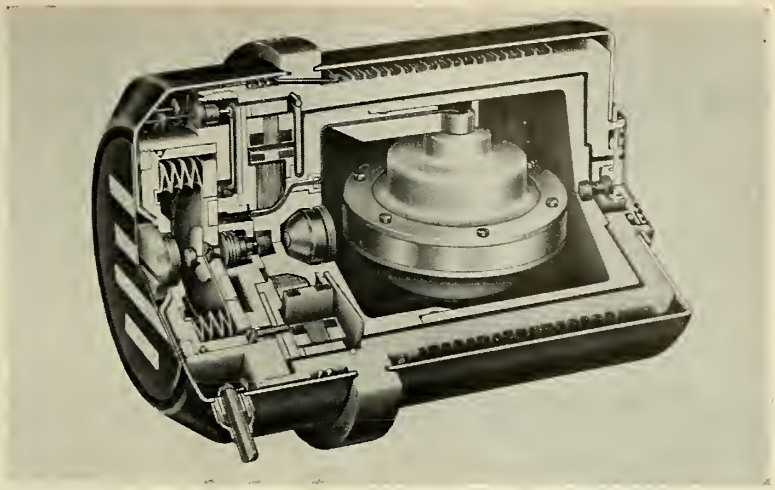
One of the most significant measurements of gyro performance is its drift uncertainty. Because the turning rate inputs to the gyro element are converted to gimbal torque, any unwanted, uncontrolled torques applied to the gimbal cause errors to be introduced in the output response.

Such unwanted torques may come from gimbal unbalance, electromagnetic reactions of pickoffs and torque generators, elastic restraint of the flex leads supplying power for the spin-motor, or from the complex responses of the gyro under vibration inputs.

There is usually a fixed amount of unwanted torque in any one gyro that is consistent and repeatable. This error can be easily balanced out by trim adjustment. Magnetic restraint and flex lead elastic restraint are typical examples of this fixed torque.

The gyro designer, however, is still left with some unwanted torques that cannot be compensated because of their inconsistency. It is these that establish the true uncertainty level of the gyro and set performance limits for gyro drift.

• **Ceramic gas-bearings offer solution**—Control of these inconsistent torques is where the ceramic gas-bearing gyro offers significant promise. According to Honeywell, it has proved to be the solution to torques resulting from movement of the ball retainers and shifts of the balls in the raceway, mechanical hysteresis effects due to material damping and ball slippage, and stress and strain of the balls under angular motions of the gyro which cause deformations that change the balance of the gyro and mechanical rectification of the vibrations set up by the ball bearings of the spin-motor.



CONSTRUCTION OF miniature gas-bearing gyro is similar to standard miniature integrating gyro. Unit is 2.75 inches long, 2.812 inches in diameter, and weighs eight ounces.

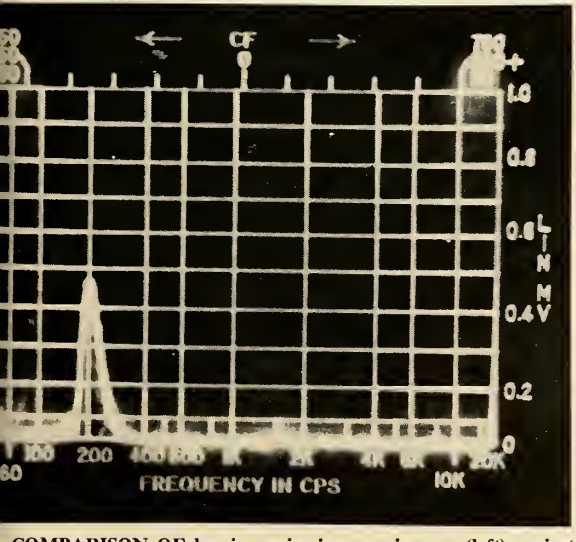
In the ceramic gas-bearing gyro the balls and retainers are eliminated, viscous damping is substituted for hysteresis damping, and deformations due to thermal expansion disappear. As mentioned earlier, vibration or bearing noise is decreased by a ratio of 30 to 1, as shown in the charts.

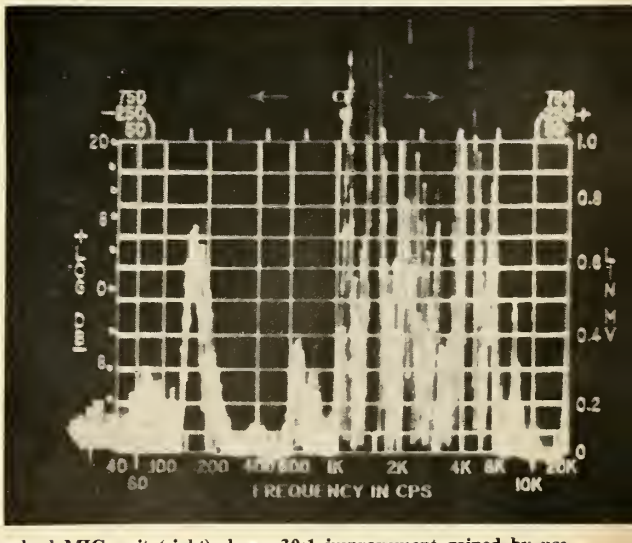
Gas—such as air or helium—has been found to be an effective bearing lubricant so long as the bearing geometry is proper. While the gas-lubricated bearing is in operation, its elements are separated by a thin film of gas. Consequently, there is no contact of the bearing elements, and wear is negligible.

Careful choice of material for the bearing is necessary to provide high reliability for a number of starts and stops. Surface finish, cleanability, hardness, and stability over time and temperature cycling are extremely important factors. It is here that the application of the new ceramic effects a major breakthrough.

Ceramics have a high modulus of elasticity and exhibit very good thermal stability and low long-term creep. These characteristics are extremely important when dimensional control and stability are prime factors.

The stability advantages of ceramics also make this material more attractive than metals for use in other parts of the gyro such as the gimbal, coil cup, and encapsulation of the spin-motor stator.





COMPARISON OF bearing noise in ceramic gyro (left) against standard MIG unit (right) shows 30:1 improvement gained by use of gas-lubricated ceramic bearings.

SOCOM to Use Solar Energy For Deep Space Communication

An optical communication system for use over interplanetary distances is well on its way toward development by Electro-Optical Systems, Inc., of Pasadena, Calif. It will use solar radiation rather than conventional radio frequency energy for transmissions.

Called SOCOM, it can be used for all forms of space communications and may, under certain conditions, be used from space station or vehicle to earth, say its developers.

The program is sponsored by the Air Force's Wright Air Development Division, ARDC, Wright-Patterson AFB, Ohio.

• **Operation**—Since solar radiation is the energy source around which the optical system is built, an accurate sun tracking mechanism is an important part of the collecting array. A radiation tracking transducer performs this function for the antenna system.

SOCOM transmitting and receiving antennas are variable orientation Cassegrainian mirror systems. These permit radiation collection from any angle. (In the Cassegrainian system, the detector is located behind the primary mirror. The receiving antenna also can employ a paraboloidal collector with the detector located at focus.)

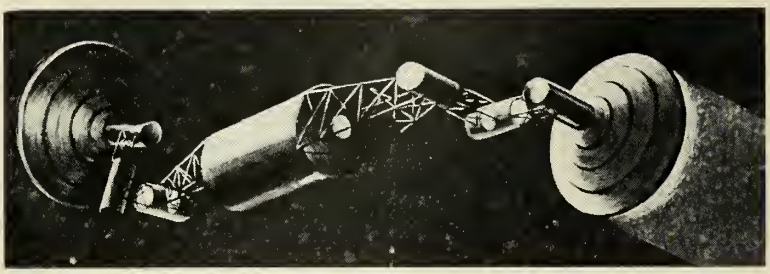
Radiation is collected, concentrated into a narrow beam, and directed through an optical modulator for coding. Coding occurs after message input is processed and sent through a modulator-driver into the optical modulator.

Coded radiation is then directed into a second mirror system for transmission through space.

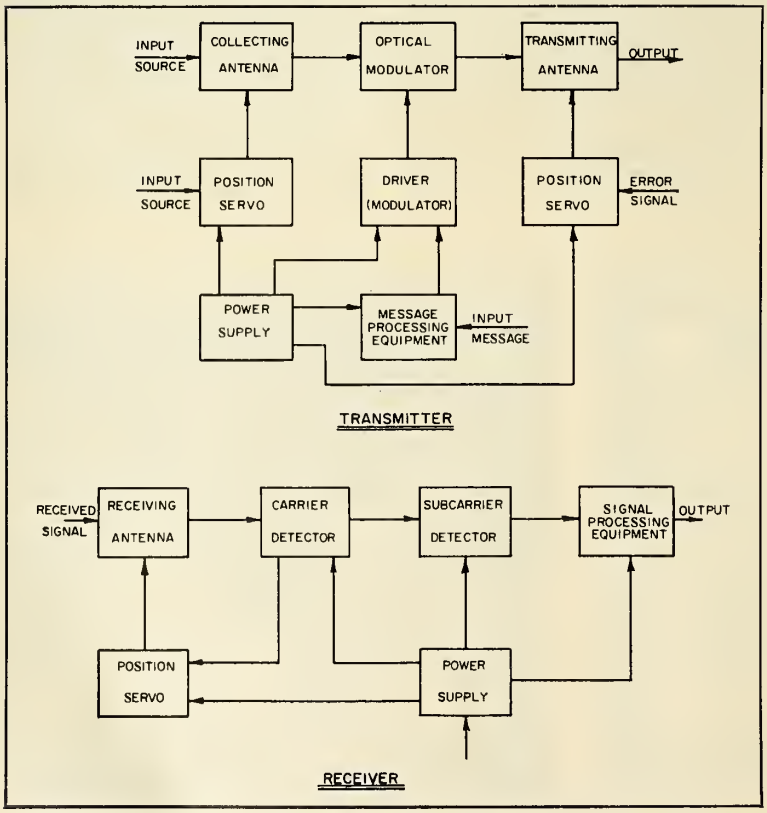
Transmitted data are collected at the receiving end by means of another mirror antenna system. The signal is concentrated on a detector at the focus of the antenna. Following detection, the signal is processed and finally read out.

The optical intensity modulation device at the transmitter has the ability to radiate away all energy absorbed from the beam, prevent overheating.

This is important to system performance because permissible power density is a function of the thermal radiation characteristics of the modulator. These characteristics also determine the maximum allowable concentration of energy in the collection system.



SOCOM, solar communications system, under development by Electro-Optical Systems, Inc. for the Air Force, may be used by space vehicles and satellites to communicate over distances exceeding 10 million miles. Solar radiation is collected by mirror antenna (left), directed through modulator for message-input coding (center), and transmitted by second mirror system (right).



BLOCK DIAGRAM shows operation of transmitter and receiver systems for solar radiation communications.

• **Characteristics**—EOS feels that SOCOM design characteristics offer many advantages over conventional radio frequency systems, including:

- Lower weight and power
- Higher reliability
- Longer range
- High signal-to-noise ratio
- Communications security (because of very narrow beam width)
- Invulnerability to jamming

Prototype equipment design so far indicates that an operational system could be developed weighing from 30-40 lbs. and requiring from 10-15 watts, excluding control-system power needs.

At 10^6 miles using 1-sq. meter mirrors and 10-cps bandwidths, S/N would be roughly 10 db. Using cooled receivers, EOS said, the S/N could be increased by a factor of ten.

With no limiting apertures beyond the collecting mirror, the transmitting antenna achieves a 53-db gain over an isotropic source.

• **Testing problem**—One problem, EOS scientists point out, is realistic system testing. A laboratory environment is impractical for determining space performance. The system, which could be ready in two years, must be satellite-tested to prove out equipment.

TASK FOR THE FUTURE

Since its inception nearly 23 years ago, the Jet Propulsion Laboratory has given the free world its first tactical guided missile system, its first earth satellite, and its first lunar probe.

In the future, under the direction of the National Aeronautics and Space Administration, pioneering on the space frontier will advance at an accelerated rate.

The preliminary instrument explorations that have already been made only seem to define how much there is yet to be learned. During the next few years, payloads will become larger, trajectories will become more precise, and distances covered will become greater. Inspections will be made of the moon and the planets and of the vast distances of interplanetary space, hard and soft landings will be made in preparation for the time when man at last sets foot on new worlds.

In this program, the task of JPL is to gather new information for a better understanding of the World and Universe.

"We do these things because of the unquenchable curiosity of Man. The scientist is continually asking himself questions and then setting out to find the answers. In the course of getting these answers, he has provided practical benefits to man that have sometimes surprised even the scientist.

"Who can tell what we will find when we get to the planets? Who, at this present time, can predict what potential benefits to man exist in this enterprise? No one can say with any accuracy what we will find as we fly farther away from the earth, first with instruments, then with man. It seems to me that we are obligated to do these things, as human beings."

DR. W. H. PICKERING, *Director, JPL*

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At 00h00m01s GMT, June 1, 1960, Martin logged its 557,544,000th mile of space flight

ICBM HARD BASE:

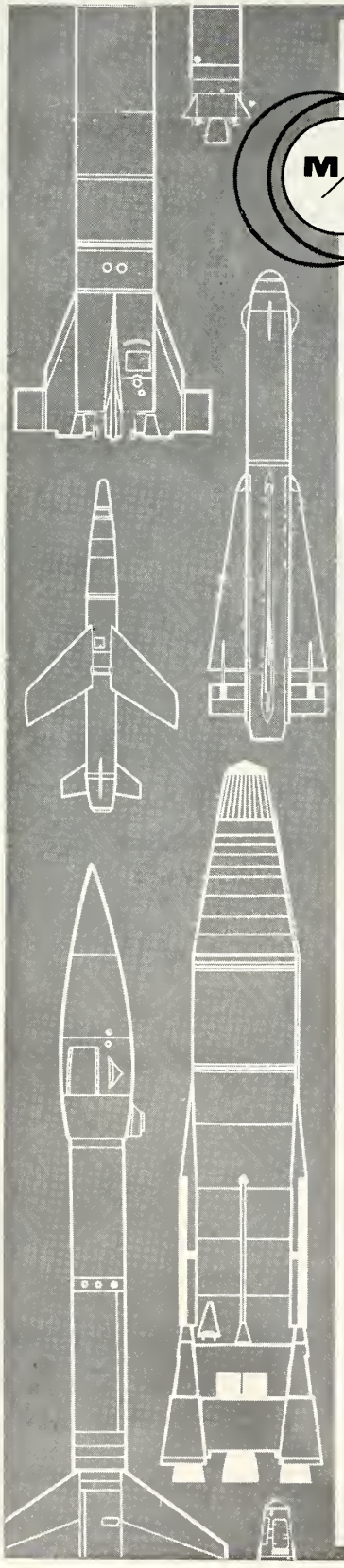
This mammoth excavation, somewhere in the United States, will soon be a "hard base"—an almost invulnerable underground launch site for the Air Force TITAN Intercontinental Ballistic Missile.

It is an important element in the United States Air Force Strategic Air Command's mission—to prevent war.

The job of this TITAN hard base—and the others like it—is to insure that we will have such devastating retaliatory power, even under concentrated nuclear attack, that no enemy will consider war.

Bases such as this cannot be built overnight. It is a credit to the foresight of our military planners that the bases will be operational concurrent with the TITAN ICBMs now in production at Martin-Denver and undergoing advanced tests at Cape Canaveral.

MARTIN



ENGINEERING PROGRESS ISSUE and the MISSILE/SPACE ENCYCLOPEDIA

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Hard-hitting articles by recognized leaders from all segments of the missile/space field have made past issues of the Engineering Progress Issue a desk-top necessity throughout the industry. Observing from key missile posts, this year's writers will give state-of-the-art coverage to astrophysics, propulsion, control, ground support equipment, instrumentation, communications, and anti-submarine warfare engineering.

THE MISSILE/SPACE ENCYCLOPEDIA

A complete anthology of today's missiles, containing pictures, diagrams and descriptions of all U.S. and foreign missiles and space craft presenting an up-to-the-latest-launching analysis of the free world's and Russia's missile/space capability, this year-'round reference has been proven invaluable to both industry and the military.

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In addition to being received by all of M/R's 29,000 paid subscribers, advertisers in the Engineering Progress Issue will get a 7,000 circulation bonus. Demand in past years for copies of the Encyclopedia has run so high, M/R now guarantees a minimum bonus circulation of 7,500 copies to prime military bases and installations.

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Forms close June 27.

THE MISSILE/SPACE WEEKLY

missiles and rockets

1001 Vermont Avenue, N.W., Washington 5, D. C.

ABL's Altair Runs Up 13-13 Record

by Jay Holmes

PINTO, W. VA.—The government last week disclosed performance details of the X248, an amazingly successful final-stage solid rocket with a mass fraction greater than a hen's egg.

The rocket—called *Altair* by the National Aeronautics and Space Administration—is produced at Allegany Ballistics Laboratory, operated for the Bureau of Naval Weapons by Hercules Powder Co. in a mountain valley near historic Cumberland, Md.

Altair, a package of 465 lbs. of double-base propellant in a glass fiber and plastic case, has given the final push to such space spectaculars as moon probe *Pioneer I*, paddlewheel *Explorer VI*, sun-circling *Pioneer V* and weather eye *Tiros I*.

Altogether, *Altair* has had 13 successes in 13 attempted altitude soundings, satellites and space probes. This doesn't include, of course, the shots in which the final stage had no chance to ignite because of failure lower down.

The rocket was one of the good things that came from the *Vanguard* program—even though it wasn't ready for any firing except the successful *Vanguard III*, which closed out the ill-starred series Sept. 18, 1959.

• **Kick for Vanguard**—Hercules joined the *Vanguard* program in April, 1956 when it was assigned the job of developing a third stage in competition with one under development by the Grand Central Rocket Co. The first produced by ABL under this program was the JATO X241, which generated vacuum thrust of 2520 lbs. for 36 seconds and had a mass ratio (propellant to gross weight ratio) of 0.85.

However, the Grand Central third stage was chosen for the first *Vanguard* firings. In February, 1958, ABL made a new design study, which produced a plan for a rocket that would give the *Vanguard* payload a 20% greater velocity kick than could the X241 and would package 23% more propellant into a container that weighed 25% less.

An important factor in the improvement was the use of a Spiralloy case. Spiralloy is a filament-wound glass fiber-reinforced epoxy resin produced by Hercules' Young Development Division. Young says the material has an ultimate strength of 130,000 psi and a density of 0.072 lb./cu. in.—which would give it a strength/weight ratio of 1,808,000 in. To perform equally well, steel would have to have strength in the neighborhood of 500,000 psi. Exclusive of nozzle, the *Altair* case weighs about 15 lbs.

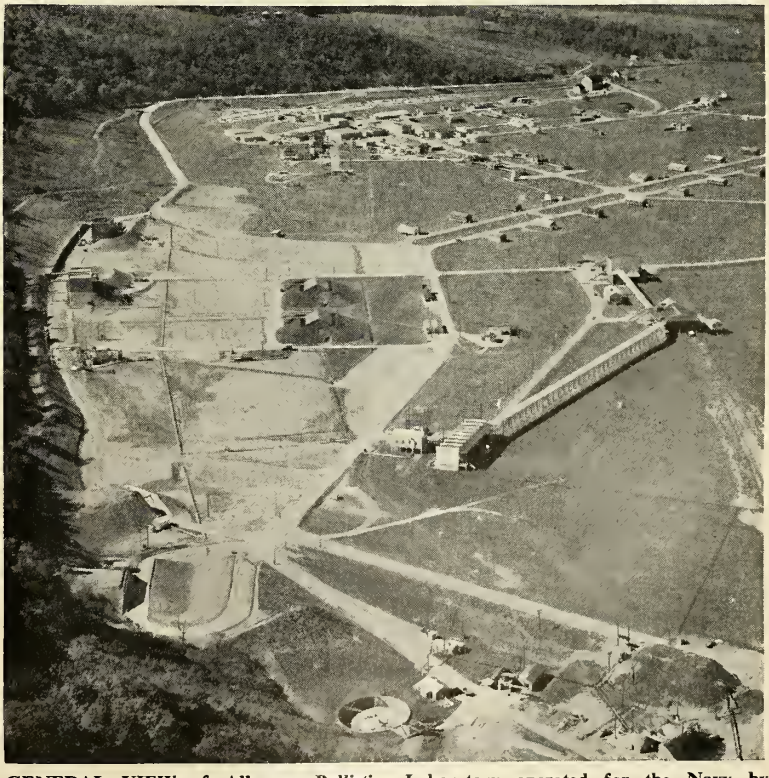
Allegany developed the new stage in nine months. Its first mission was *Pioneer I*, the moon probe attempted by the first *Thor-Able* vehicle in November 1958.

• **Description**—*Altair* has a gross weight of 507 lbs. in the X248A2 configuration used for *Vanguard III*. The gross weight varies by a few pounds from mission to mission because of the variation in attachments for connecting the rocket to the rest of the vehicle and for minor changes in the exterior chamber configuration for similar purposes. In *Vanguard III*, it generated total impulse of 116,500 lb./-seconds over 38 seconds. This amounts to an average thrust of 3070 lbs.

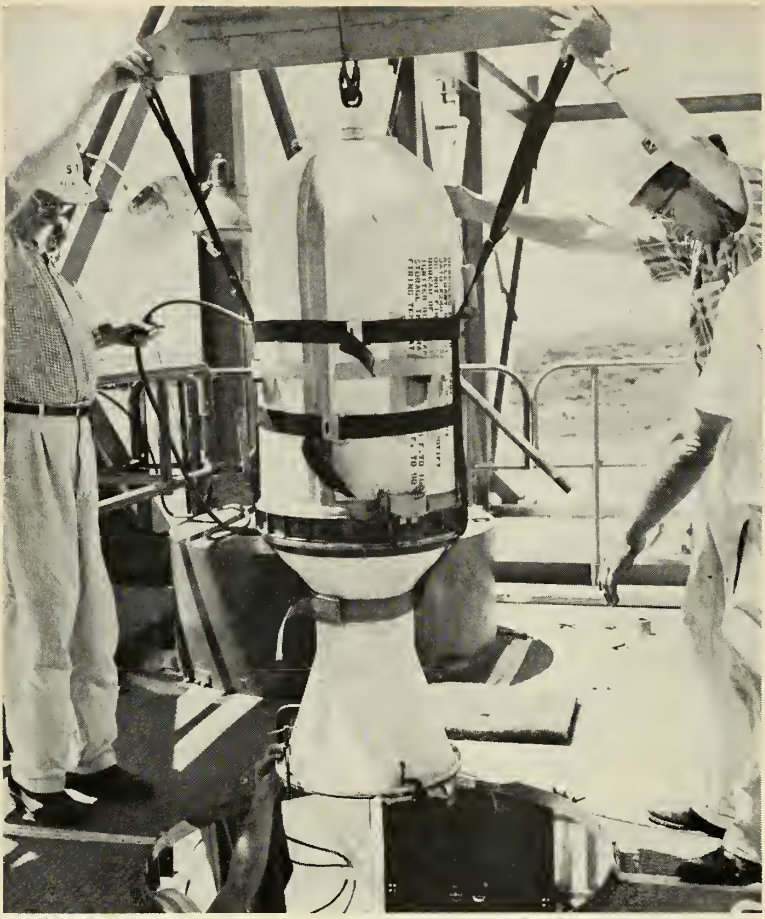
The motor specific (total impulse divided by gross weight) is 230 seconds. ABL scientists said this is one of the highest figures for any operational solid rocket in the U.S. Asked how the figure compared with com-

Motor Specifications

	X248A2 (Vanguard III)	X254A1 (Scout)
Initial weight (lbs.)	507	2285
Final weight (lbs.)	42	170
Mass ratio	0.92	0.93
Burning time (sec.)	38	35.6
Total impulse (lb.-sec.) ..	116,500	533,700
I_{sp} at altitude (sec.)	256	256
Motor specific (sec.) ...	230	233



GENERAL VIEW of Allegany Ballistics Laboratory operated for the Navy by Hercules Powder Co., taken from a neighboring mountain top.



WORKMEN GENTLY lower *Altair* into position atop *Thor-Able* vehicle that propelled *Explorer VI* into orbit on Aug. 7, 1959.

parable liquid rockets, they said they did not know.

Altair has a mass ratio of 0.92. Hercules spokesmen noted that the mass ratio of a hen's egg is 0.89. Since November 1958, *Altair* has been successful in four *Thor-Able* launchings, one *Vanguard*, four *Shotputs*, two *Javelins* and two *Argos*.

Altair is also the third and final stage of the *Atlas-Able* vehicle, which will make another attempt at a moon probe late this summer or early in the fall.

• **Biggest job yet**—*Altair* will begin its longest assignment later this year when the *Scout* program gets under way. Because of the relatively low cost of the all-solid *Scout*, NASA plans to bring the launch frequency of *Scout* satellites up to six a year by 1962 and continue at this rate at least through 1969. *Altair* will be the fourth and final stage of *Scout*.

The success of the *Altair* led NASA to decide to develop a scaled-up *Altair* as the *Scout* third stage. The new rocket, named *Antares*, is in a late stage of development at ABL. *Antares* packs 2115 lbs. of propellant into a case that, with nozzle, weighs 170 lbs. at burnout. The mass ratio of *Antares* is 0.93—one point higher than the *Altair* record. The motor specific is 233 seconds—three seconds higher.

The *Scout* system was tested for the first time April 18. It carried dummy second and fourth stages. The first-stage Aerojet *Algol* apparently performed successfully but something prevented *Antares* from firing. NASA officials said it is not certain what happened. Further tests are scheduled in the near future.

• **Alternate for Polaris**—Another project under way at ABL is an alternate second stage for the 1500-mile version of the *Polaris* fleet ballistic missile, which is due to become operational in early 1962. Aerojet-General is producing propulsion units for both stages of of the 1200-mile *Polaris*, which will be installed on nuclear submarines before the end of 1960.

Aerojet and Hercules are in competition for the second stage on the longer-ranged model—which must pack more kick into a package only 30 in. longer than the 1200-mile version. The 2500-mile *Polaris*, due to come along in the 1964-66 period, will be the same length as the 1962 1500-mile missile.

Neither the Navy nor Hercules would disclose any information about the ABL *Polaris* stage except that ABL is using a double-base propellant in contrast to the Aerojet polyurethane composite. However, Navy spokesmen did say the ABL stage is entirely different from the Aerojet stage—and not merely in propellant composition. This would indicate the ABL may be using a Spiralloy case for *Polaris* too. Aerojet makes its cases of steel.

• **Involved in Minuteman**—Another area where the *Altair* experience is paying off is in Hercules' work on the third stage of the *Minuteman* ICBM at its plant in Bacchus, Utah. A company spokesman said the record of success in the *Altair* and *Antares* programs has played an important part in the development work on the Air Force missile.

Hercules is also in competition with Aerojet on the *Minuteman* stage. In June 1959, the Air Force awarded a $15.3 million contract to the company for *Minuteman* R&D. Hercules said the contract represented the making definite of an earlier letter contract authorizing the company to begin work. It was not disclosed just when the work began.

Hercules is doing some of the supporting technical work at its propellant plant in Kenvil, N.J.

• **Background in bullets**—Allegany Ballistics Laboratory was an Army facility in 1942, operated by the Kelly-Springfield Co. for production of .50 calibre ammunition. In 1943, it was turned over to the Office of Scientific Research and Development in 1943 for use as a rocket development laboratory. George Washington University operated it for OSRD until December 1945.

At the close of the war, the Navy took over jurisdiction and contracted with Hercules to operate it. Hercules has operated the plant since 1945. One of the major accomplishments since then has been the development of casting double-base grain.

Despite recent developments in polyurethane and polybutadiene acrylic acid composite propellants, double-base propellants are still the most widely used solids in the U.S. arsenal. Among the missiles using double-base solids are the *Nike-Ajax, Honest John, Terrier, Talos, Snark, Rat, Weapon A* and the *Deacon* sounding rocket.

Hercules Powder Co. is generally acknowledged to be the industry leader in double-base propellant technology.

Weldless Steel Cases Now Possible

Republic's technique of overlapping seamless rings with adhesive bonding promises important advantages over welded types

by John F. Judge

MINEOLA, L. I., N.Y.—Solid rocket motor cases fabricated from steel—but without welded, riveted or bolted joints—are now possible through a development at the Missile Systems Division of Republic Aviation Corp.

Dissimilar metals can be incorporated into a single case as closures or as part of the main cylindrical body.

In addition, the process can realize the fullest strength potential of the normal fabricating metals used in such cases.

The motor case is essentially a series of overlapping seamless rings—joined by adhesive bonds. These structural bonds transmit the longitudinal loads from one ring to the next and are not affected by the hoop loads.

• **Attractive qualities**—Besides the lack of welds and their inherent problems, the patented laminated ring case has other advantages. When a vessel bursts under hydrostatic test, it is usually a joint failure due to metal yield. A damaged ring can be cut out and replaced. Further, the entire case can be assembled at the firing site with a minimum of effort and equipment. In addition, ring segments can be filled with propellant and then formed into a complete case on the firing site through adhesive bonding—doing away with the added weight of bolted flanges.

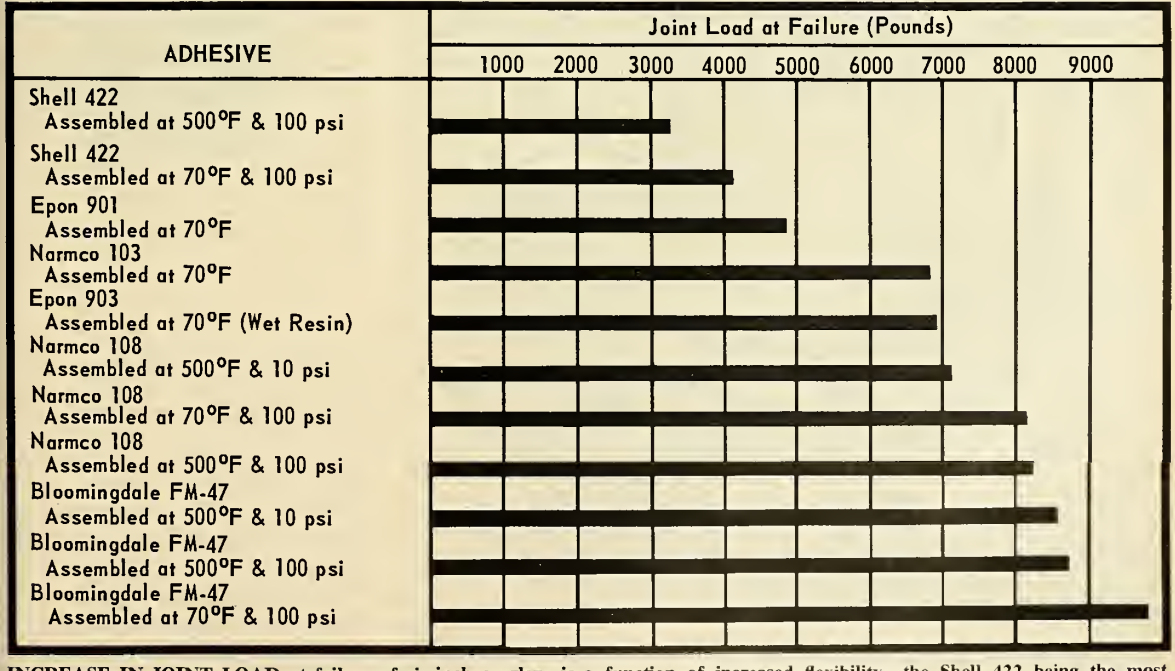
The rings used in the pressure vessel experiments were forged by the Ladish Co. from their D6A steel, and were 2 to 5% undersized in diameter. The oversize thickness ranged from 0.005 to 0.008 in. An adaptation of centerless grinding technique results in a final thickness tolerance of ±0.0005 in.

• **Aus-forming**—The ring is then run through the firm's "quench-sizing process." The ring is raised to heat treating temperatures by induction coils while mounted around an expandable mandrel. When the proper temperature is reached, the mandrel expands the ring to its final diameter and simultaneously quenches through mass contact. There is no apparent change in wall thickness although the overall length is reduced proportionately to the amount of expansion.

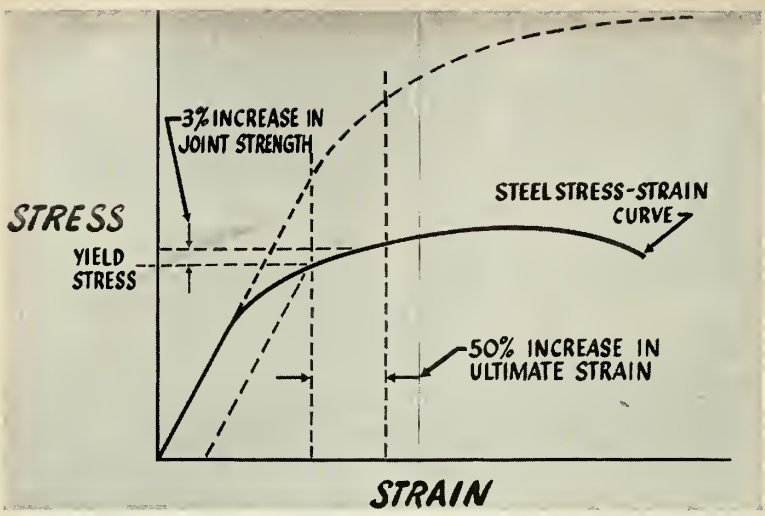
Variations in the heat-treat cycle can be made so that the work is accomplished at the exact transition temperature required for the particular metal. This aus-forming type method is almost ideally suited to realize the highest strength potential of a metal.

After quench sizing, the ring is tempered and no warpage occurs. The ring is ready for incorporation into a laminated vessel since its dimensions are now fixed.

The heart of Republic's concept is in the metal-to-metal adhesive bonding



INCREASE IN JOINT LOAD at failure of six-inch overlaps is a function of increased flexibility—the Shell 422 being the most rigid and the FM-47 least rigid.



STRAIN COMPATIBILITY chart shows that, for a given joint, a large increase in the shear strain capability of the adhesive is not required to provide an adequate margin of safety. The dotted extension of the curve illustrates the compatibility of an advance in adherend materials with current adhesives.

—a relatively underdeveloped technology. Usually, a great deal of effort is directed toward reducing overlap. But MSD scientists believe the lap should be greater than 2 in. and actually use 6 in. overlap contact.

• **More flexibility**—Early investigations showed that strong adhesives were too brittle to follow the elastic deformation of the steel. The peak stresses always occurred at the ends of the joint and "walk-in" failures started at these points. Greater load carrying capabilities in the long joint were developed by using a more flexible adhesive. Increased flexibility meant a reduction in the unit strength of the adhesive but tests proved this approach to be correct. Such an adhesive was used in one series of burst tests that resulted in bond failure at a minimum of 255,000 psi and as high as 275,000 psi within the vessel.

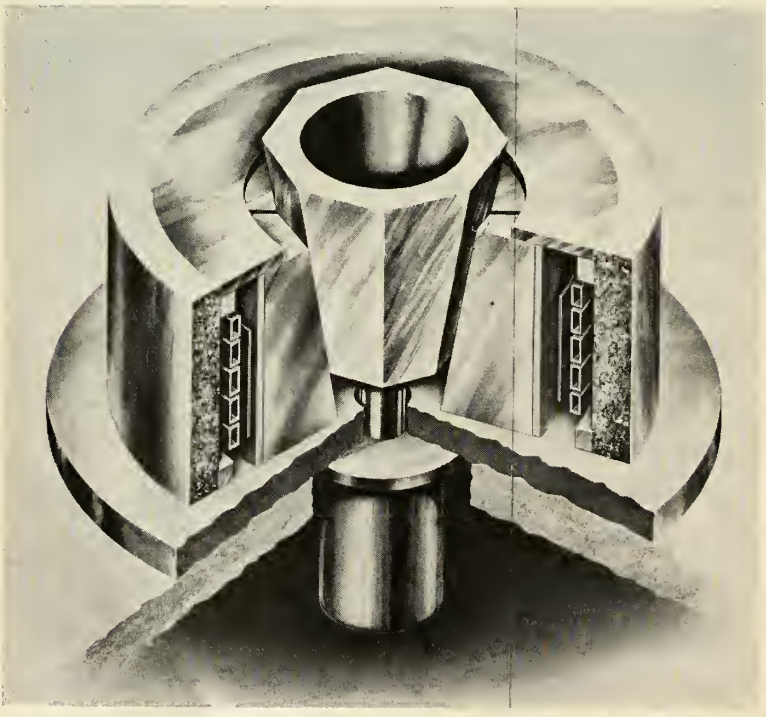
Good correlation was found between laboratory lap shear tests involving flat plates and the performance of the joints in pressure vessel assemblies. The laboratory tests, being uniaxial, had somewhat lower values than the corresponding burst tests which undergo biaxial stresses. The correlation exists only when the length of lap and type and strength level of the lap shear specimens are exactly the same in both experiments. Different joint behavior will be observed with different materials, gages and moduli changes.

From the realization that high flexibility was necessary at the joint ends, Republic went on to the concept of composite adhesives. The importance of flexibility decreases as the center of the lap approaches. A composite adhesive to fit this situation involves a flexible adhesive near the joint ends, other adhesives of progressively less flexibility but higher strength are used in succession toward the center of the lap, and the order reversed past the center to the other end of the joint. In this manner, all of the adhesive can be made to perform a function while the joint is under stress. Summing up, the technique is simply "the proper marriage of adhesive and material," according to Richard Stegler, Project Manager.

The nature of the bond failure is characteristic of the effectiveness of the adhesive. Cohesive failure means that the adhesive failed within itself while maintaining its grip on both metal surfaces. Adhesive failure means simply that there was separation from the metal surfaces. The former is actually a successful failure since it is indicative of a good bond. Republic's pressure vessel successes occurred with FM-47, a dry resin manufactured by Bloomingdale Rubber Co.

This resin was applied by wrapping an impregnated scrim cloth around one lap surface and joining the rings in a proprietary process. This "dry," flexible resin also eliminated the problem of air entrapment that existed when "wet" resins were used—and insured a positive adhesive emplacement. The scrim cloth is applicable to the composite adhesive idea. The various types of adhesives can be placed along the scrim cloth prior to actual ring bonding. Visual inspection of the scrim insures an absence of adhesive voids.

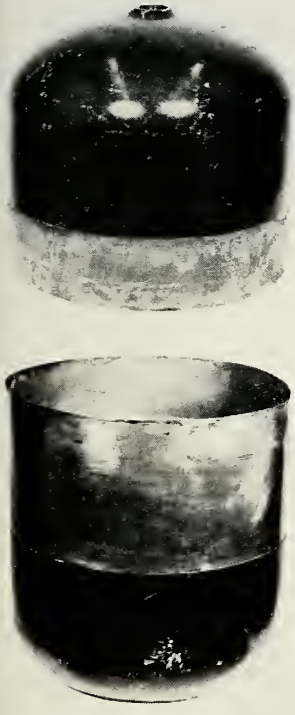
A series of experiments designed to isolate the effect of flexibility on shear strength involved a number of identical lap shear specimens using the same



QUENCH-SIZING APPARATUS developed by Republic for the expansion of pressure vessel ring sections. Work can be started exactly at the transition temperature of the metal and cooling commences at the same time.

adhesive (Epon 901)—with varying amounts of a flexibilizing agent (Cardolite) added. Joint loads at failure increased to a maximum as the Cardolite was added and then tapered off. The joint loads were greater than if Epon 901 had been used alone. In addition, with a short (0.5 in.) lap instead of the 6 in. contact allowed in the tests, the same adhesive showed a straight line decrease in strength as the Cardolite was added.

A great deal of adhesive evaluation is currently in progress at Republic. The main task is to define which ad-



THIS PRESSURE VESSEL burst at a 255,000 to 275,000 psi stress level. Cohesive nature of the adhesive failure is visible in the lap area.

hesives are effective in the flexible-brittle range and to determine where adhesive improvements will be necessary. Theorists at MSD have evolved formulae around the sheer modulus characteristics of adhesives.

The short time heat exposure characteristic of laminated structures, in general, are excellent. In this application adhesive bond is in no danger from the burning propellant because the greater mass of fuel acts as an insulator. It is the ascent heating that causes some concern. Most adhesive temperature data are functions of 10 minutes or more since these substances are sluggish to the effect of a rise in

temperature. If one is necessary, Republic has found that the most effective outside protective coating is "Thermolag," a product of Emerson Electric. Such a low temperature ablative (250°F) coating would lighten the case as it ablates during passage up through the atmosphere.

Studies are being made at Republic and elsewhere on flexible ceramic adhesives. This would alleviate any objections about temperatures. Another avenue of interest is in developing a dielectrically cured adhesive. Then it would be possible to use the metal overlaps as electrodes and cure the adhesive with a minimum of heat input. This insures capabilities of heating even though ring segments are loaded with propellant.

NRC Investigates Ultrafine Refractories for Navy

Refractory metals are being reduced to powders—particle diameters around one-millionth of an inch—under a $73,343 Navy contract at National Research Corp., Cambridge, Mass.

The actual process is a year old but was initially applied to the lower melting metals. Now ultrafine powders of tantalum, molybdenum and niobium are being investigated.

Besides potential uses as catalysts, the powdered refractories may be applicable in magnetic circuitry, liquid suspensions to produce non-ionic-conducting liquids and as additives to plastics to alter dielectric properties.

In the field of powder metallurgy, the powders may offer new, exact composition alloys with superior physical properties. Bureau of Weapons granted the contract.

Crossed-fields Step Up Hypersonic Tunnel Energies

Plasma stream energy in hypersonic wind tunnels is increased by 60% with little or no added contamination in a Crossed-Field Acceleration test prototype developed jointly by Allis-Chalmers Mfg. Co. and MHD Research Inc., at Newport Beach, Calif.

Crossed magnetic and electric fields further accelerate the plasma, allowing continuous operation at high temperatures and velocities. Many different conditions can be produced in the system. Specific enthalpy ranges and specific temperatures will be established through the power/gas ratio.

Current blow-down tunnels used in testing materials for use in missiles usually operate for short durations, on the order of milliseconds.

RUM Explores Sea 4 Miles Down

The Navy recently demonstrated an experimental remote control undersea vehicle for exploring and conducting scientific studies of the ocean bottom at depths to 20,000 ft. and at speeds up to three miles per hour.

The vehicle can maneuver on grades of 60% and climb a vertical obstacle 12 in. high.

Engineering design for a fully operational vehicle, which could be built on a production basis, has been completed by Jered Industries, Hazel Park, Mich.

The future production model would also include for clearing obstacles a vertical lift appendage, essentially an underwater helicopter, designed by Hughes Aircraft's Nuclear Electronics Laboratory.

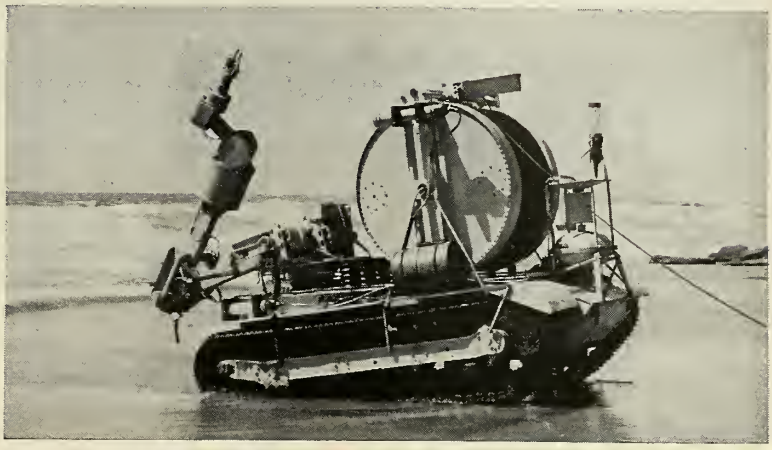
The RUM (Remote Underwater Manipulator), developed for the Office of Naval Research, was demonstrated at Scripps Institution of Oceanography, La Jolla, Calif. The vehicle is essentially a tank equipped with a long, jointed manipulator arm and hand together with specially-devised underwater television cameras which serve as the eyes of the vehicle's operator on shore.

It will observe the sea floor, collect samples and specimens and assemble and install deep bottom-mounted instrumentation.

The vehicle has the basic hull and truck assembly of an Ontos tank (an operational self-propelled rifle used by the Marine Corps.) upon which has been mounted the special manipulator arm designed and built by General Mills' Mechanical Division. The underwater television camera system was fabricated by Orbitran, Inc., Lakeside, Calif. RUM also utilizes specially adapted sonar equipment to guide its progress over the ocean bottom. Its sonar is good for 40 yards.

The vehicle is linked to a mobile van on shore by a five-mile-long coaxial cable which not only carries the television signal but also relays power for the operation of the vehicle and the cameras and mercury vapor lights as well as providing several remote control telemetering channels.

The tank's sealed hull is filled with oil to permit operation at extreme depths. Two main propulsion motors coupled through standard truck transmissions and differentials independently drive the vehicle's two tracks. These



WEIRD LOOKING RUM vehicle runs up Southern California beach after a dip to the floor of the Pacific during test evaluations.

motors are standard General Electric seven and a half horsepower series-wound 800 RPM motors which operate completely immersed in oil. Continuous control of the two motors is achieved through the use of motor-controlled Variacs in conjunction with a reversing linkage and bank of cam-driven switches.

The 11-ton tracked vehicle with the mechanical manipulator in place is capable of carrying a payload of 1000 pounds in the water. Without the manipulator the payload is increased to 2000 pounds in water. Hydraulic controls provide normal braking action. Emergency braking is automatically performed by a spring actuated friction brake.

• **Mechanical manipulator**—The boom-mounted mechanical manipulator is a modified version of the General Mills manipulator arm used in atomic laboratories adapted for underwater use. Made of stainless steel, the arm is an electromechanical device which synthesizes the motions of the human arm. It includes a two-pronged "hand" that opens and closes, a wrist that rotates in either direction, an elbow that pivots, and a shoulder that both pivots and rotates.

The hydraulic actuated boom, mounted at the rear of the vehicle, provides three additional motions—boom rotation, boom pivot, and boom flex. The boom supports the arm and enables it to reach out 15 feet in any direction. The boom also has a hook for lifting tall heavy objects, with the load capacity ranging from 170 pounds to over 5000 pounds. Both the boom and the mechanical arm are operated by toggle switches from the control van.

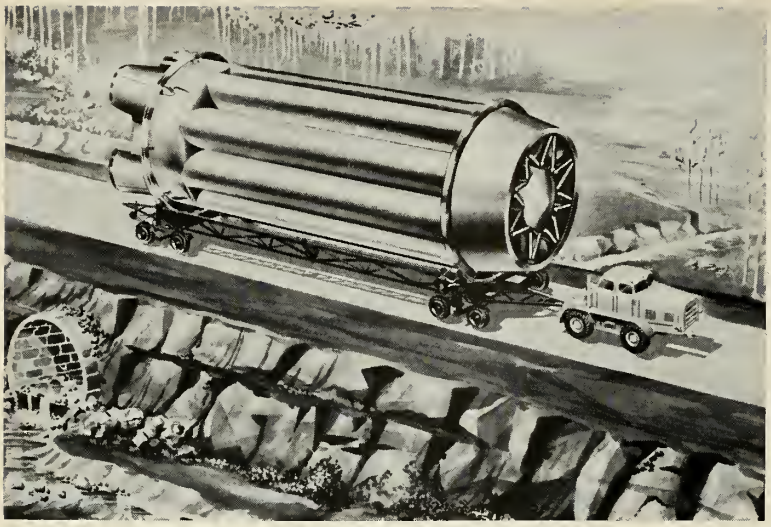
• **Television system**—Four cylindrical television cameras, each housed in half-inch steel casing capable of withstanding a depth of 36,000 feet, constitute the closed-circuit television system which enables the operator to guide the seacrawler.

Each miniature transistorized camera is three inches in diameter and 14 inches long. A two-line, conical lucite window is sealed in front of the steel housing to protect the vidicon tube. Two TV cameras view the ground at the rear of the vehicle and two monitor the manipulator arm from the front and rear. TV is good at a maximum of 30 ft. It has 48 different switch channels for control.

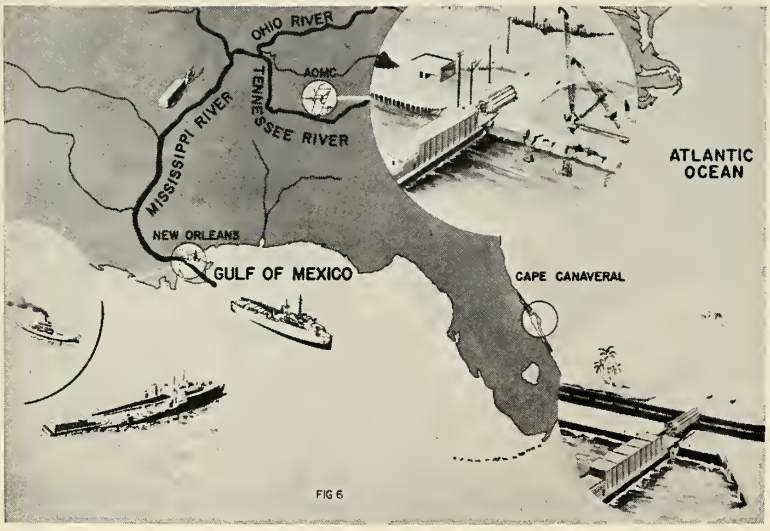
The Orbitran system can transmit two- and three-dimensional views. Through a central control unit the image of one camera can be transmitted at the rate of 15 scans per second.

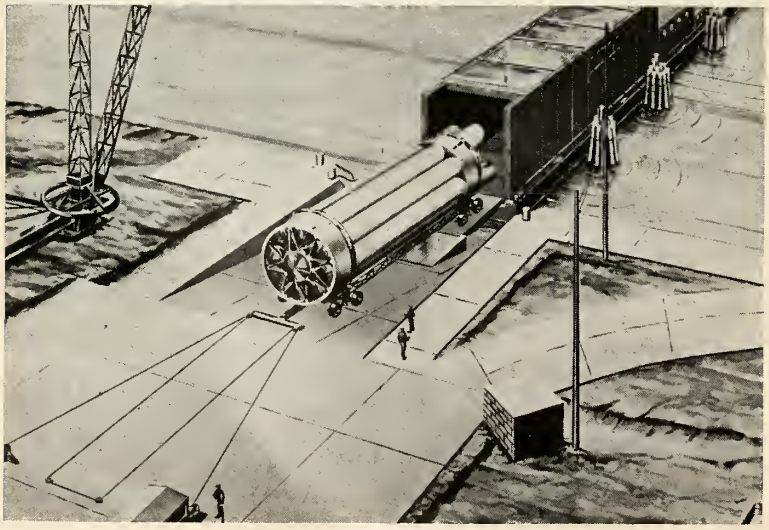
A three-dimensional view can be obtained by intermittently transmitting the images of two cameras at seven and a half scans per second. Either low resolution images, resulting in a 250-line picture, or high resolution images, producing a 530-line picture, can be transmitted. The phosphorized, "long-persistence" monitor screens are fitted

(Continued on page 47)



Saturn Travel Plans: Unique, Stupendous





Moving day for the *Saturn* booster —the United State's biggest rocket— will involve a logistics problem of magnificent proportions. Too big for highway and railroad clearances, the huge clustered booster—22 ft. in diameter and 82 ft. long—will be moved from Huntsville to Cape Canaveral by a unique combination of trailer, barge, and ship carriers.

The 2200-mile trip will take from 18 to 25 days, depending on weather, availability of tugs, and other circumstances. (For comparison, the space vehicle boosted into space by the *Saturn* will take 2-3 days to travel the quarter-million miles or so to the moon.)

The assembled booster will be mounted on an eight-wheel transporter at the George C. Marshall Space Flight Center at Huntsville and towed by a tractor-tug to a nearby docking facility on the Tennessee River. Here the booster will be rolled aboard a special covered barge and towed down the Tennessee and Mississippi Rivers to the Gulf of Mexico.

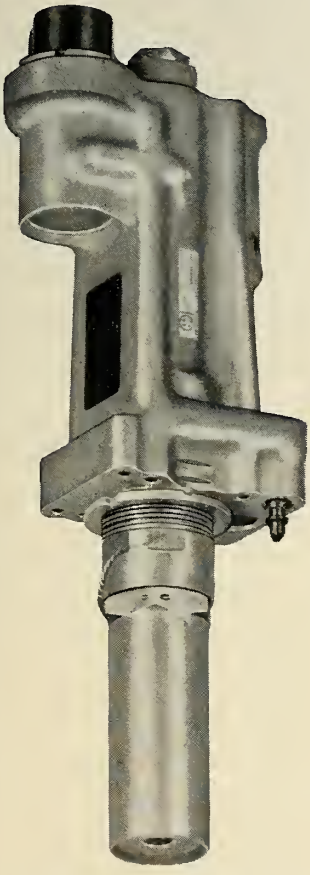
• **Off again—on again**—In the Gulf, the barge will be floated aboard an LSD (Landing Ship, Dock) which will carry it around the tip of Florida. Here it will be off-loaded and continue its journey once more under tug-tow up the inter-coastal waterway to Cape Canaveral. At the Cape, the booster will be rolled off the barge at a special docking facility and hauled to its launch area.

Both the transporter and barge are being specially built for the *Saturn*. The 180-ft. barge carries the booster in a sealed compartment that maintains closely controlled temperature and humidity. It also contains living quarters for the 10-man crew that accompanies the booster on its travels.

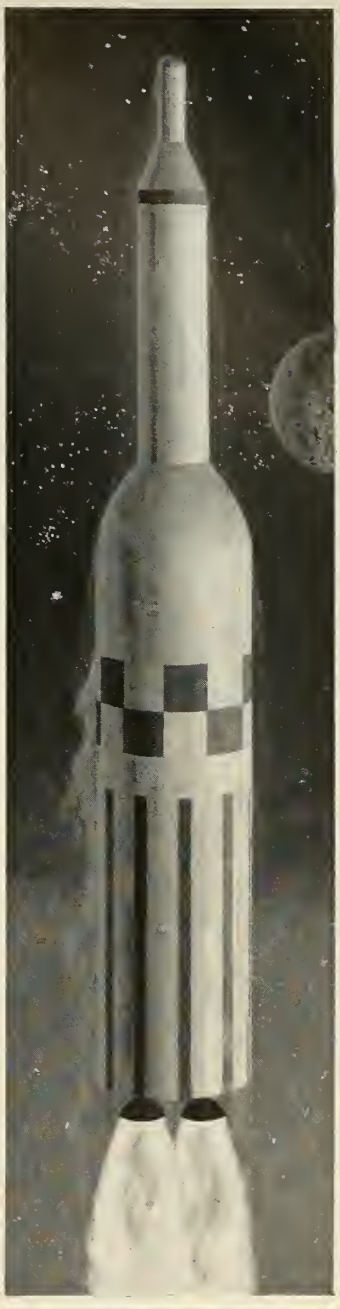
The barge is being built by Dodd Shipyards, Houston, Tex., under a $300,000 NASA contract. Delivery is scheduled for next October.

The land transporter has already been completed and used to haul the booster from the assembly area to the Huntsville static test area.

NEW VOUGHT SERVO ACTUATORS TOP-RATED FOR MINUTEMAN



give unequaled reliability under 7 stress conditions!



Unique design simplifications and quality control advancements are incorporated in this servo actuator.

These improvements enable the assembly to operate reliably under extreme conditions of force, shock, thermal shock, random vibration, sustained acceleration, and to withstand ICBM acoustical punishment. Under extended silo storage requirements, it still maintains close tolerance frequency response. The Air Force's ICBM, *Minuteman,* and other vehicles will use Vought servo actuators, now in quantity production at Vought Electronics, a division of Chance Vought.

Also available from Vought Electronics for missiles, space vehicles and aircraft:

Twin gyro controllers
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Malafon Now in Series Production

The French Navy's ASW missile, the *Malafon*, has gone into series production by Société Industrielle d'Aviation Latecoère, the system's prime contractor.

Extensive testing and evaluation was conducted last year by the Paris firm and the French Navy at Levant Island, a small Mediterranean rocky hogback a few miles off the Riviera coast. First official fleet deliveries are planned to coincide with the formal commissioning of the French Escort Ship "La Galissonniere" which will carry the *Malafon* weapon system as standard equipment.

Basically, *Malafon* is a rocket torpedo which blasts off from a short ramp and can kill enemy submarines submerged over 10 miles away, although its maximum range has not been released.

The torpedo is three-quarters recessed into the sleeve of the carrier shell, which has aerodynamic configurations. Two solid-fuel boosters propel the missile to a precalculated height established by its firing computer.

The boosters, dropped after burnout, are fastened on swivel joints; the nozzle orifices are under a horizontal stabilizer-deflector attached to the carrier shell. The carrier's configuration includes wings, ailerons, and an elevator and trirudder tail assembly.

• **Guidance**—The missile's launching ramp is positioned and adjusted automatically by sonar computing firing equipment. The initial one-third of the flight trajectory is programed at the same time, and aerodynamic controls keep the missile at the set altitude during boosted flight. Once free from the spent rockets and deflector, an autopilot maintains the set course.

At a point about two-thirds along its flight path the missile receives radio guidance from the sonar fire control aboard ship; aerodynamic flight corrections or adjustments are made during the last approach to the target area.

The torpedo and the carrier shell are separated by explosion of the security bolt which also releases a brake-parachute from the stub rear of the carrier vehicle just under the elevators. The torpedo falls free into the target area with its own motor working, then seeks the enemy submarine through acoustical homing.

While few details have been officially released on the *Malafon* system, its warhead is believed to be of the heavy explosive type with a proximity fuze.

British Merger Brings Shifts in Top Management

LONDON—Big changes in the lineup of top missile men in the English Electric Aviation Ltd. have followed the merger of the missile and aircraft interests of The English Electric Company, Vickers and Bristol Aeroplane Company by the formation of British Aircraft Corporation.

The following changes have been made on the Board of Directors of English Electric Aviation: Viscount Caldecote, formerly Deputy Managing Director, becomes Managing Director, in which capacity he will also act as Chief Executive, Guided Weapons Division; Sir Conrad Collier retires from the position of Chief Executive, Guided Weapons Division, and also from the Board; Lord Nelson of Stafford, Sir Archibald Forbes and Sir John Woods retire from the Board.

The following are appointed new Directors of the company: L. H. Bedford, Director of Engineering, Guided Weapons Division; R. F. Creasey, Director of Engineering, Aircraft Division; Air Commodore S. Graham, Commercial Director, Aircraft Division; G. R. Jefferson, Chief Engineer, Guided Weapons Division; A. T. Slator, Manager, Guided Weapons Division.

British Space Authority Pushed by Industrialist

LONDON—The formation of a U.K. Space Research Authority, to "overlord" Britain's space research efforts, is being strongly urged in Britain by Sir Robert Renwick, a prominent industrialist and president of the Radar and Electronics Association.

Sir Robert's view is that Britain should get into this field fast, if it wishes to retain its position in aerospace technologies. He put his plan forward at the recent annual dinner of the Radar and Electronics Association in London. He said such an Authority should consist mainly of scientists and technicians led by the best business brains in the country. Its work would include the examination of feasibility studies, study of vehicles, configurations and orbits, and an examination of power plants, both present and future.

"Navigation and guidance techniques should also be studied," he said, "and training of technical personnel should be undertaken. In addition, as a first requisite, the Authority should instigate and co-ordinate plans for sending British satellites into space, using *Blue Streak* and *Black Knight* as vehicles, utilising the existing facilities at Woomera for launching and obtaining the co-operation of Jodrell Bank for tracking, observation and control when required."

Sir Robert suggested that the initial phases of such a Space Research Authority, including, say, six satellite launchings over the next three to four years, commencing with the first launching two to three years from now, could probably be undertaken within a budget of about $42 million a year over a period of several years. By this time, he thinks, the commercial advantages are certain to be so compelling that further finance would be readily available.

AF May Do Final Minuteman Assembly

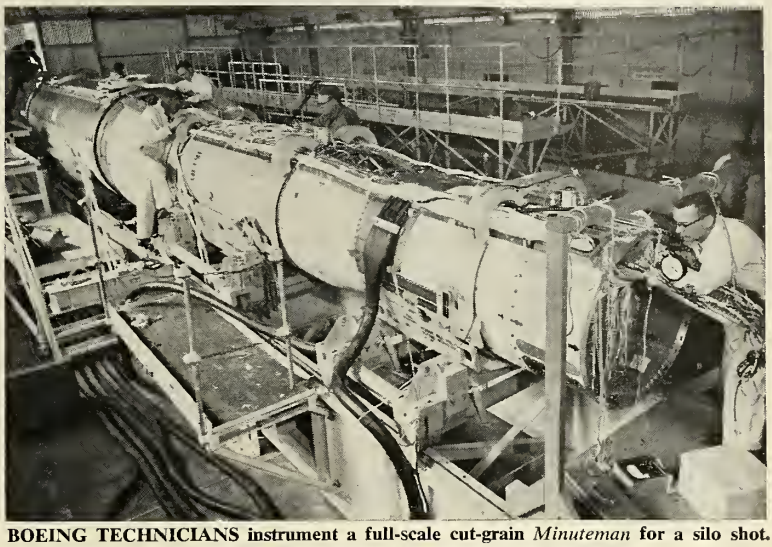
by William J. Coughlin

SEATTLE—The Air Force may take over from Boeing Airplane Co. the final assembly of the *Minuteman* missile at Hill AFB, Ogden, Utah.

Boeing at present holds the contract to operate the missile assembly facility, USAF Plant 77, where the *Minuteman* will be assembled and checked out. But sources here report Air Force has under consideration a plan to do its own final assembly on the missile.

At Air Force Ballistic Missile Division Headquarters in Inglewood, Calif., Col. S. C. Phillips, *Minuteman* Program Director, told M/R: "There is no plan at present for Air Force to take over Plant 77, although this will come up for consideration sometime later."

Final assembly, as the last production step, traditionally has been considered part of industry's job for the Air Force. Management of the *Minuteman* weapon system, however, has been considerably removed from traditional procurement policies.



BOEING TECHNICIANS instrument a full-scale cut-grain *Minuteman* for a silo shot. The success of the silo series made possible a speed-up of the program.

• **AF involvement**—The Air Force, for example, intends to carry out at Ogden its own depot maintenance and major modification program on the *Minuteman*, probably taking over for this the present Marquardt plant, which will become available due to *Bomarc* cutbacks.

Decision to use the Air Force-owned Marquardt plant is enabling a cut of some $2.9 million in construction funds for the *Minuteman* program, slated originally for a depot overhaul facility at Hill.

"This is a hazardous process in that the rocket engines have to be handled as a high fire hazard and get the same kind of treatment that is common in the munitions business," Col. Phillips said.

Under present plans, Boeing will assemble the missile at Plant 77 and put it through a very thorough final checkout for reliability and quality assurance. Major components will be shipped to Hill AFB by associate contractors—with the exception of the Avco re-entry vehicle, which will be shipped directly to operational sites in its own transporter.

Rocket engines are loaded into Boeing harnesses at the manufacturers and shipped by road in engine transporters. There is one transporter designed to carry either second- or third-stage engines while a larger transporter will carry the first-stage engine.

• **Assembly & shipment**—After arrival at the Ogden facility, the engines will be transferred to dollies, go through inspection, and then be transferred to fix storage rails.

At the in-plant missile assembly section, the engines will be mated with the guidance and control section from Autonetics, and with the skirt and two interstages built and shipped by Boeing.

The missile will be weighed and balanced, then transferred to a transporter erector at the transfer area ramp. Transportation to the operational site can be by air, road or rail, with the *Minuteman* remaining in its transporter-erector throughout. Present thinking indicates "piggyback" rail shipment is the most likely. Final step is emplacement in the silo.

• **Many hands**—Boeing's part in the *Minuteman* is a much smaller one than under traditional procurement. Air Force Ballistic Missile Division is managing the program with the Air Materiel Command's Ballistic Missile Center as a partner for procurement, logistics planning, maintenance and supply. Strategic Air Command is working out operational aspects. Systems engineering and technical direction of the program is under Space Technology Laboratories.

In addition to assembly and test of the missile, Boeing is developing the major portion of the ground support equipment, including the launch control system and ground-handling equipment. Boeing also will provide much of the test instrumentation and is responsible for the area security system.

Subcontract for the launch cars and command cars of the mobile system has been awarded to American Machine & Foundry and ACF Industries.

General Motors will provide the transporter-erector tractor and bogie-truck; Cessna Aircraft Co., the missile

Minuteman Contractors

Boeing—Assembly and testing, GSE development, test instrumentation, area security. *Space Technology Laboratories*—Systems engineering and technical direction. *Thiokol*—First-stage propulsion. *Aerojet*—Second-stage propulsion. *AMF/ACF Industries*—Launch cars and command cars. *General Motors*—Transporter-erector tractor and bogie-truck. *Cessna*—Missile container. *Bendix Corp.*—Erection system. *Avco*—Re-entry vehicle support equipment. *Autonetics Div., NAA*—GSE for integrated guidance and control system, and electromechanical activation for nozzles.

container, and Bendix Corp., the erection system.

Avco is under contract for re-entry vehicle support equipment and Autonetics will provide ground support equipment for the integrated guidance and control system, including the portion which will hold the guidance on alert. Autonetics also is developing the electromechanical activation for the nozzles on all three stages.

• **Electronics emphasized**—The *Minuteman* will be equipped with a completely transistorized all-inertial guidance system with a general purpose digital computer which will serve the dual purpose of guidance and control during flight and of assisting in monitoring the readiness status prior to launch.

Electronics, rather than propellant, will, in fact, be the governing factor in determining overhaul time of the missiles rather than propellant.

X-ray examination of the propellant will, however, be carried out during overhaul as a routine operation.

System simplicity and reliability will enable the *Minuteman* missiles to be left unattended for long periods of time in remote and isolated positions, thereby cutting maintenance costs. It is estimated that only one-tenth the number of personnel required for maintenance and support of an *Atlas* or *Titan* squadron will be needed for a *Minuteman* unit.

• **Security problems**—Boeing is at work on a mobile maintenance van which will be stationed at the squadron control center. This will be sent to the missile emplacement at regular intervals or whenever a red light in the control center lights up to indicate a malfunctioning missile.

The unusual isolation of the widely separated and unattended *Minuteman* silos raises a considerable security problem in the program; Boeing holds the contract for development of security systems. Several will be installed at each site.

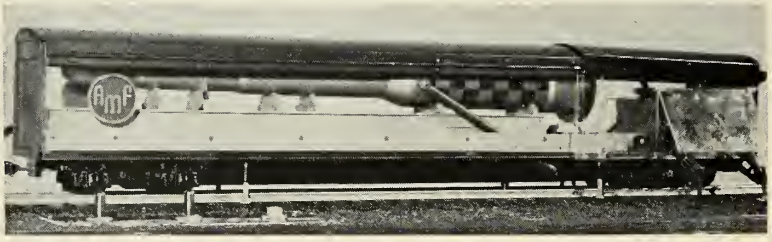
First Photo

What may be close to the operational method of transporting and launching the mobile *Minuteman* ICBM from railroad cars was demonstrated exclusively to M/R last week by American Machine & Foundry.

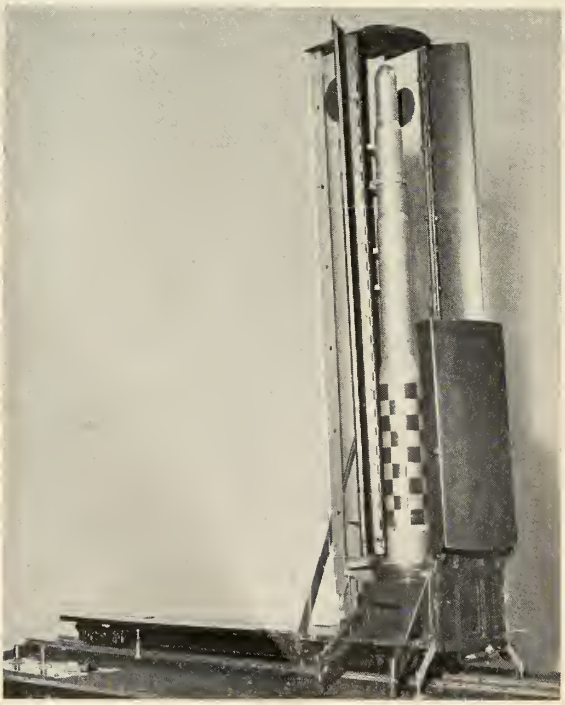
Using a model missile car, AMF engineers displayed a typical locating and erection sequence embodying most of the basic engineering considerations. Some modification is expected in the prototype.

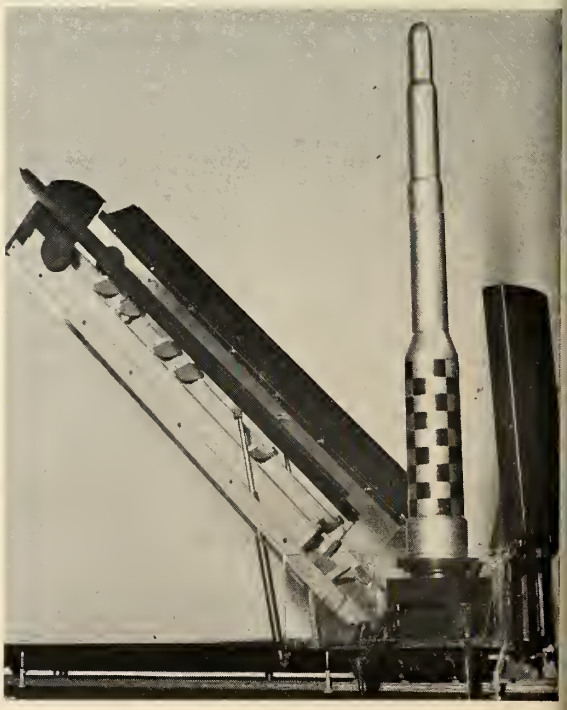
The series of four pictures demonstrates the operating sequence of setting up the mobile launch pad and erecting the missile for firing. (Metal sides of the car are represented in the model by clear plastic for demonstration.)

The first shows the car in the first stages of the launch procedure. Im-



RAIL LAUNCH sequence shows model car in transport position at left. Lower left, entire top of car is erected along with missile. Bottom photo shows erector being lowered, leaving missile on launcher. Big problem with system is to get *Minuteman* in launch position within 15-minute reaction time.





MF/ACF Rail Launch Car

mediately after stopping, stabilizing outriggers are swung out, anchored in the roadbed, and leveled to provide a stable launch pad.

The second photo shows the missile partially erected. Hydraulic rams elevate the carrying bed/erector to a vertical position, setting the missile base on the launch ring. (The erector bed will be made of lightweight aircraft-frame construction which adds only a small percentage to the total missile weight.)

After erection, the missile is unlatched from the erector which is lowered back to the car bed.

In firing position, the missile sits on its pad ready for firing from an adjacent control car (not shown). This car, which does not have to be uncoupled from the launcher, is the only other component needed for the system.

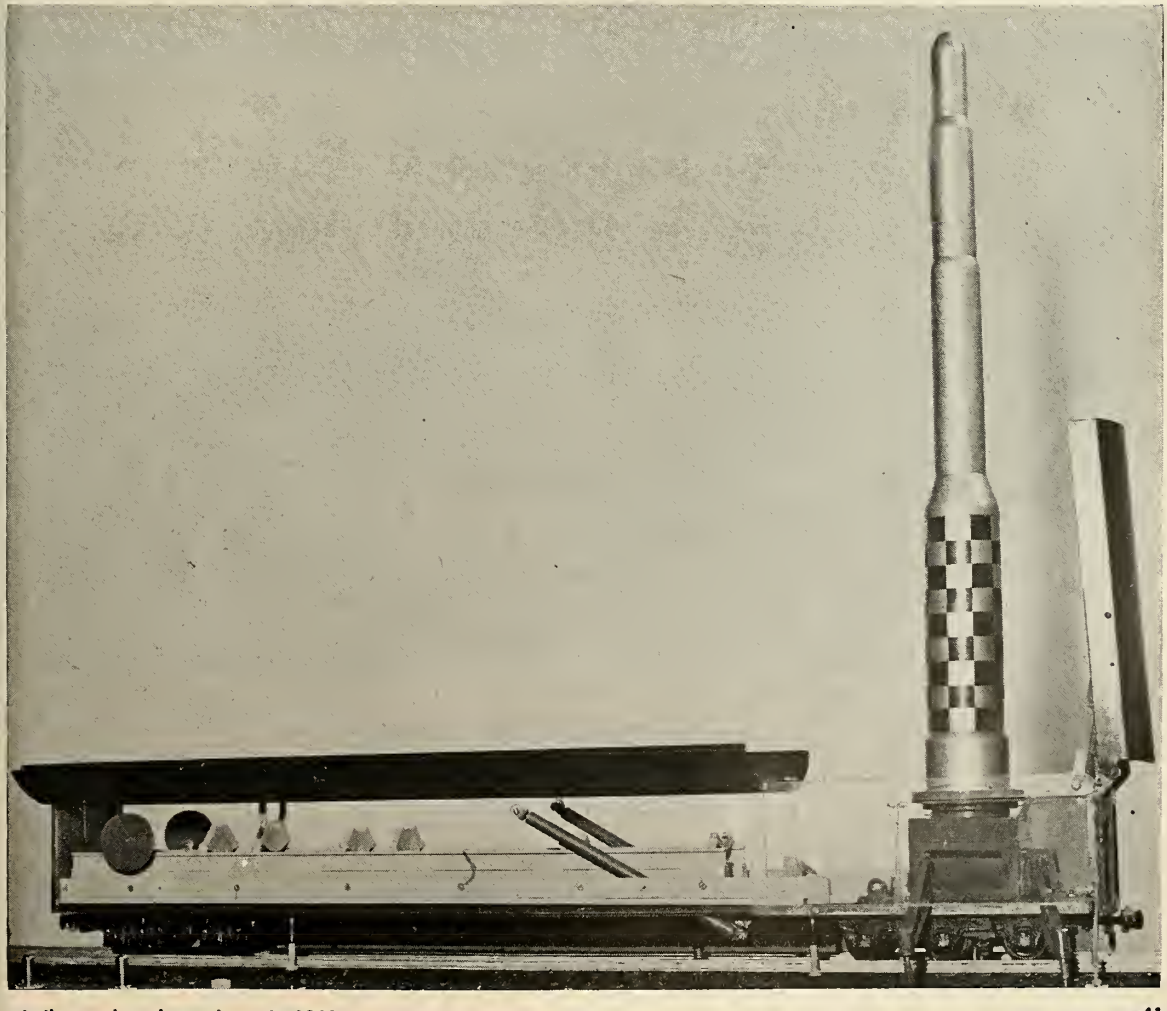
Flame deflectors at the base of the launcher deflect the booster flame to both sides of the car, equalizing the thrust forces on the car and shielding the roadbed from damage.

• **Answers due**—Major questions concerning the kind of treatment that the *Minuteman* ICBM will get as a railroad passenger will be decided within the next few weeks. Until these questions are resolved, the hardware concept of the transport and erector mechanisms must wait. Major decisions that must be made include the desired mobile operating ranges, time elements involved, and requirement for controlled environment.

Preliminary checkout of the railroad operations set up by the scheduled tests at Hill AFB is expected to shed some light on the problem. In any case, the green light for railroad hardware is not far away. Since the mobile system is scheduled to follow the hard-base system by only a few months, mid-1962 appears to be a likely target date.

Both AMF and Boeing stress the point that no radical concepts are involved in putting the *Minuteman* on the railroad. Its purely a matter of deciding the approach and building the hardware. Design and engineering are the guiding factors, with low cost and high reliability the goals.

Engineers feel that the only basic problem in the entire concept is in shielding the big bird from undue stress and strain in its travels over the nation's railroads. But this problem presents no formidable barrier. Current vibration and shock isolation techniques—applies on a bigger and different scale—will be sufficient, they feel, to protect the missile's delicate structure and instrumentation.



Last big competition . . .

Minuteman Third-Stage Award Nears

Both sides show confidence of winning; Aerojet spokesman claims development work has brought major improvements of technology

by Frank G. McGuire

SACRAMENTO, CALIF.—Award of the third-stage rocket motor contract for the *Minuteman* ICBM is expected to come very soon, resolving the last major competition being carried on in the program.

Two companies, Aerojet-General Corp. and Hercules Powder Co., are following different technical approaches to the system's design. The Hercules design has been described by the Air Force as promising "higher potential performance," but Aerojet exhibits great confidence that its design is "the obvious choice."

All three stages of the missile have now been successfully fired in full-scale tests a number of times, and flight tests are due to begin at the Atlantic Missile Range late this year. Thiokol is producing first-stage motors at its facilities near Brigham City, Utah, and Aerojet is producing the second-stage motors at its Sacramento plant.

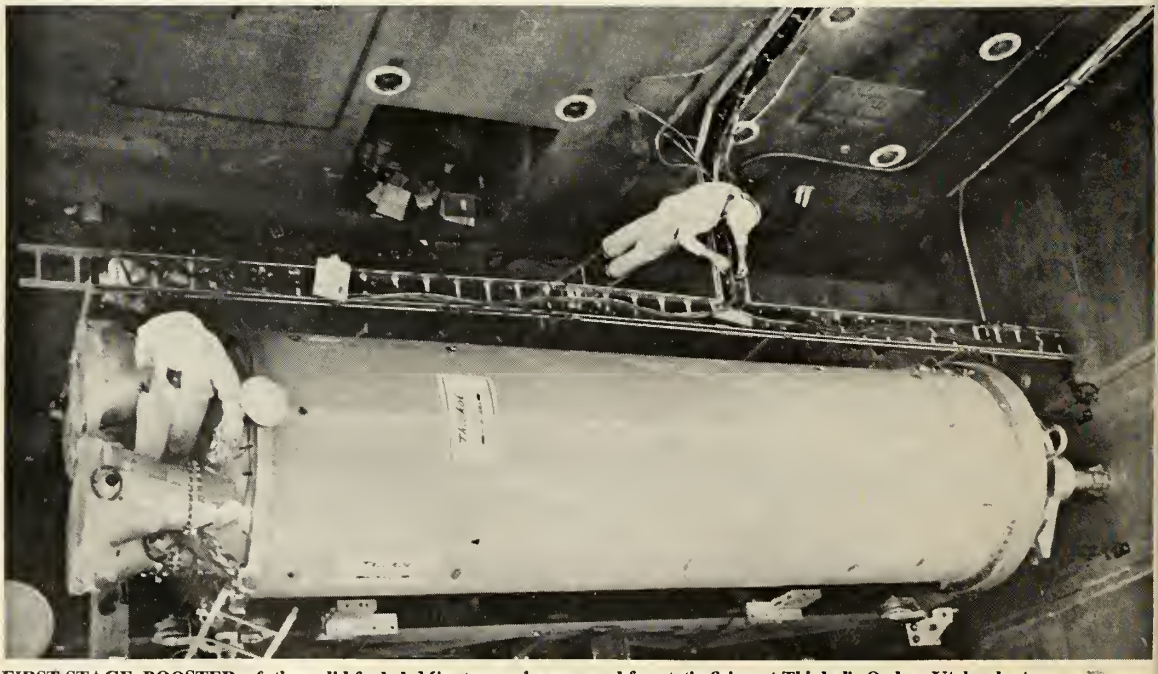
Thiokol's first stage, which burned for about 60 seconds in full-scale tests at the Utah site, uses a propellant composed of polybutadiene and acrylic acid fuel, an ammonium perchlorate oxidizer, and an aluminum additive to stifle unstable combustion. All these ingredients contribute to specific impulse.

Aerojet's second- and third-stage designs, also using an aluminum additive, are powered by a polyurethane propellant. Second-stage burning time is believed to be about 60 seconds. Aerojet says it has fired many consecutive successful tests of both stages, using flightweight hardware and thrust vector control. None of these second- and third-stage tests have experienced malfunctions. The third-stage motor casing, after static firing, can be recharged with propellant and fired again.

Col. S. C. Phillips, *Minuteman* program director for the Air Force Ballistic Missile Division, said: "Propellant problems were actually solved fairly early and we have a good solid determination of the propellant formulation. It has been fixed and proven."

Ignition of the first stage is achieved through use of a Thiokol-produced pyrogen unit, mounted in the forward end of the motor. The company points out that a high shock effect might be produced by a pyrotechnic device; hence it chose the solid-propellant pyrogen.

Second- and third-stage ignition is



FIRST-STAGE BOOSTER of the solid-fueled *Minuteman* is prepared for static firing at Thiokol's Ogden, Utah, plant.

achieved by Aerojet through use of a solid-propellant igniter containing Al-clo, a composition long standard for such applications.

• **Nozzle solved**—Major feature of the *Minuteman* propulsion control system is the use of movable nozzles for thrust vector control. All stages have now been successfully fired with the improved nozzles.

Phillips told M/R: "We're on top of the nozzle problem—we have the solution. There is no doubt that the biggest problem facing the propulsion program was the movable nozzle, particularly on the large first stage. There have now been successful firings on all three stages."

Phillips added that while some work still needed to be done to reduce nozzle weight, the high-temperature, high-gas-flow problems now are solved. He said it is a question of refinement of design and that basically the nozzle materials are "pretty well established."

The use of the movable nozzles instead of *Polaris*-type jetavators for thrust vector control results in a higher efficiency, since there is no obstacle at all in the exhaust stream. The swiveling nozzles are also somewhat lighter.

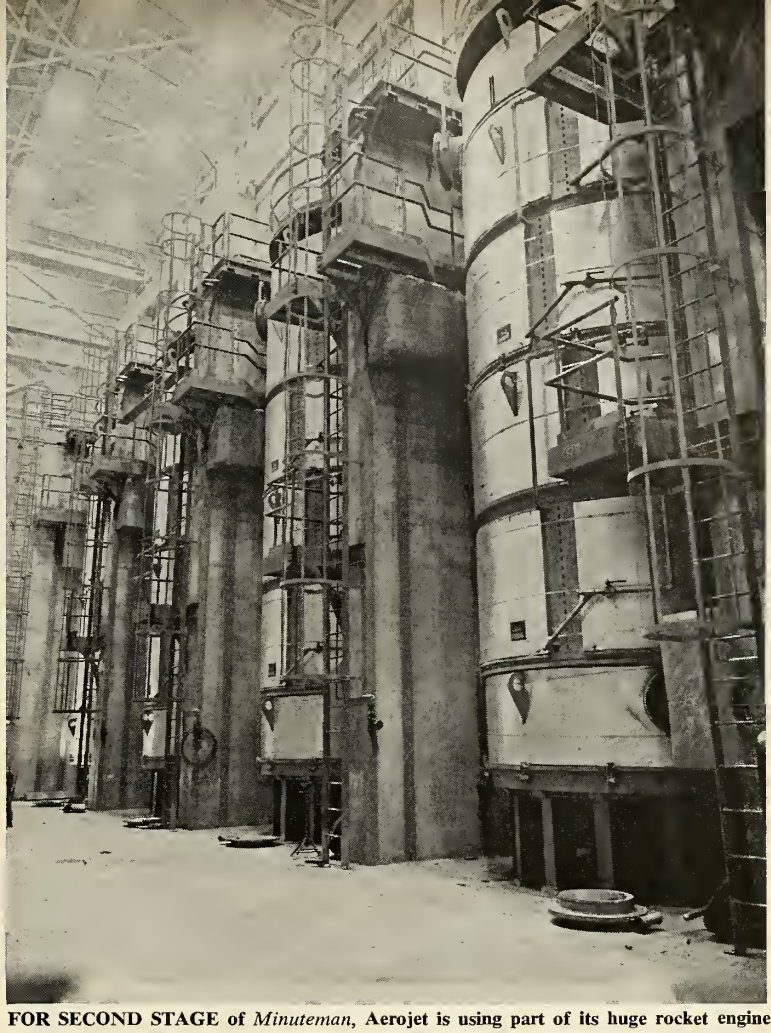
In action, two of the diagonally-opposed nozzles move in only one parallel axis, while the other two diagonally-opposed nozzles move in either of two perpendicular axes.

Erosion by unconsumed aluminum particles in the propellant was another problem, amounting to a high-temperature sandblasting of the nozzle throats and the aft bulkhead. This has also been alleviated, partly through grain re-design and partly through increased insulation. All three stages use an aluminum additive in the propellant.

• **Big advances claimed**—Two companies in the program, Boeing and Thiokol, have stated that the *Minuteman* does not constitute any spectacular leap forward in the state of current technology, (they characterized the program as "a grand exercise in reliability"), but Aerojet's D. F. Sprenger, *Minuteman* Program Manager, strongly disagrees.

"The *Minuteman* may not be as great a leap forward as *Polaris* was," he said, "but it is certainly an improvement in all three aspects of performance: specific impulse, mass fraction, and thrust vector control. In each of these areas, *Minuteman* is considerably improved over *Polaris*." Sprenger could not, however, give specific details on the improvements.

His remarks were echoed by Thiokol's Charles Hodges, who described *Minuteman* as having a better mass fraction than virtually any other solid-propellant vehicle ever built. The greatest breakthrough in *Minuteman*, however, stems from the economic advantages of the system, according to Hodges. Cost reduction through manufacturing techniques and the inherent features of the system contribute greatly to the "cost effectiveness" of the missile.



FOR SECOND STAGE of *Minuteman*, **Aerojet is using part of its huge rocket engine cast and cure plant at Sacramento. Firm is competing for the third stage.**

One aspect of the *Minuteman* concept, that of being able to use any of the upper stages in short-range missions independently of the first stage, has quietly passed into limbo. This idea, widely publicized at the outset of the program, has apparently slid into a grave as deep as the *Minuteman* silo itself. Whether or not it will be revived is not known.

• **Longer range coming?**—The three-stage missile now is nominally rated at a 6300-statute mile range, but there's a strong possibility that it will someday greatly exceed this.

Thrust termination, achieved in a manner similar to that of *Polaris* with its blowout ports in the forward bulkhead of the final stage, is accomplished in milliseconds, thus reducing residual thrust to an insignificant amount.

Cases for the solid-propellant motors are produced by a number of companies, including General Electric, Allison, Solar, Curtiss-Wright, Aerojet/Rheem, Avco-Lycoming and Pratt & Whitney. Nozzles are being produced by Arde Associates, Allison, Thompson Products, Bendix, and others.

Reliability of the *Minuteman* motors is extremely high, and the missile is compared to a loaded shotgun in readiness and dependability. Aerojet points out that it alone has fired well over 500 large solid-propellant motors without a failure. This includes *Polaris*, *Minuteman* and *Scout* propulsion units. In the case testing program for *Minuteman*, Aerojet says there has never been a failure of a second or third stage casing during hydrotest. These cases are fabricated by a number of methods, and a final method will be determined before full production status is achieved.

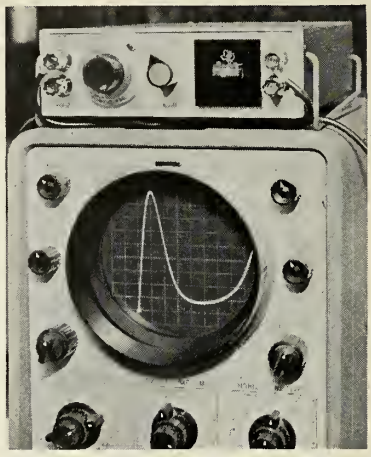
Curve Tracer for Tunnel Diodes

A Tunnel Diode Curve Tracer has been introduced by Texas Instruments, Inc.

The instrument permits the study of forward characteristics of tunnel diodes made by various manufacturers, including gallium arsenide tunnel diodes recently introduced by TI. A plug-in adapter can be changed to accommodate different package configurations. One adapter is included with original equipment; others may be purchased as required.

Any sensitive oscilloscope may be used with the Tunnel Diode Curve Tracer to create current and voltage wave forms. The TI instrument creates a sharp representation of the entire critical region of the forward characteristics curve of the tunnel diode under test rather than just a portion of that curve.

Through the use of an external decade bus shunted across the horizontal terminals, it is practical to read the



actual negative resistance of the tunnel diode at any point on the curve. This shunt can be provided as an optional feature at additional cost.

Circle No. 225 on Subscriber Service Card.

Encapsulated Rectifiers

Radio Receptor Company (Selenium Division) is manufacturing subminiature encapsulated rectifiers in center tap, bridge and doubler assemblies. All units are designed for operation in ambient temperatures from −50°C to +100°C without derating and are protected against atmospheric conditions by the plastic encapsulation. They will withstand peak surge currents up to 250 mils for 1 sec. duration and can be operated in circuits at frequencies up to 25 kc. All types are color-coded for simple identification and polarity indication. Maximum case length is .480 in. for all types, widths ranging to .480 in. max.

Circle No. 226 on Subscriber Service Card.

Versatile High Vacuums

Two high-vacuum systems, now being manufactured by Consolidated Vacuum Corp., can produce a low ultimate pressure of 2×10^{-6} mm Hg, and are ideal for use in electronics, optics, and research and development, where functional vapor deposition or general high-vacuum processes permit the use of an evacuated chamber with 14- or 18-in. diameter.

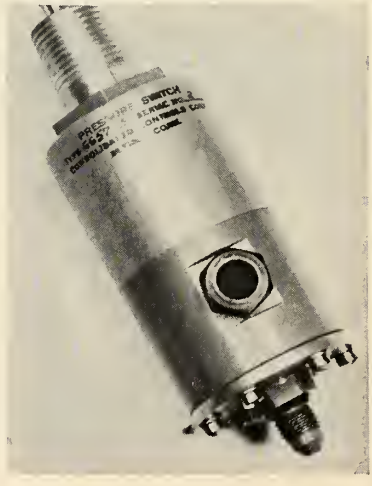
The LC1-14B system (14-in. chamber) reaches a working pressure of 5×10^{-4} mm Hg in 3 minutes with a 4-in. PMC diffusion pump and a 13-cfm mechanical roughing pump. The LC1-18B system reaches a working pressure of 1×10^{-4} mm Hg in 5 minutes with a 6-in. PMC diffusion pump and a 13-cfm mechanical roughing pump.

Circle No. 227 on Subscriber Service Card.

Precision Pressure Switches

A series of externally adjustable precision pressure switches has been introduced by Consolidated Controls Corp.

Used to convert fluid pressures into electrical "on-off" signals, the switches



are available in nine models covering the range from 2 to 3000 pounds per square-inch gauge pressures. Adjustable ranges of the various units are from 2 to 12 psig, 6 to 25 psig, 20 to 75 psig, 50 to 125 psig, 75 to 250 psig, 100 to 500 psig, 250 to 1000 psig, 500 to 2000 psig, and 750 to 3000 psig.

Changes in the actuation points are made in the field by removal of a plug and adjustment of a splined screw.

Circle No. 228 on Subscriber Service Card.

High Temp Spring Wire

A precipitation-hardening austenitic alloy, known as NS-A286, has been introduced for spring wire for 600° to 1000°F service by National-Standard Company. Costing about one-tenth as much as other, more highly alloyed exotic materials, NS-A286 experiences as little as half the percent-relaxation loss at 1000°F as comparable alloys at 850°F.

Sixteen hours at 1350°F precipitation-hardening is recommended for springs after they are coiled to increase the physical properties and to improve stability at 600 to 1000°F. Typical tensile properties for annealed 0.080-in. NS-A286 are 103,500 psi as drawn and 176,000 psi after 16 hours at 1350°F; for 15% reduction are 122,500 psi as drawn and 190,000 psi after 166 hours at 1350°F. Tensile properties for 30% reduction are 150,000 psi as drawn and 198,000 psi after 16 hours at 1350°F.

Circle No. 229 on Subscriber Service Card.

Gage Measures Height

A patented height gage is being manufactured by United States Chemical Milling Corp.

The Height Master gives accurate measurements to .0001 in. and eliminates the need for expensive gage blocks and transfer gages. Speed and ease of operation reduce inspection costs as much as 70%.

Standard and oversize gages, from 17 in. to 108 in., with a wide variety of accessories are available. Each gage is individually calibrated electronically at 70°F under controlled conditions.

Circle No. 230 on Subscriber Service Card.

Control Servo Valves

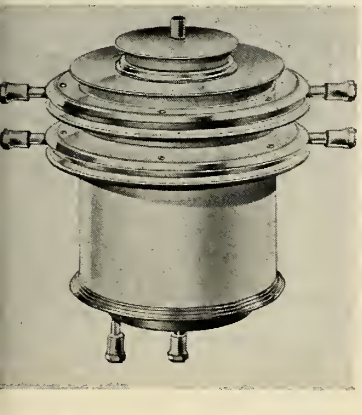
Flight Control Tandem Servo Valves and Actuators having one-piece sleeve and one-piece spool machined to reproduce identical flow characteristics in two separate hydraulic systems are

being manufactured by Hydra-power Corp. The one-piece construction guarantees that factory set synchronization will be retained unaltered during service use. The Servo Valves with low dynamic plunger forces have true linear flow, made possible by use of rectangular orifices. These units are designed for use in 4000 psi, 275°F Systems.

Circle No. 231 on Subscriber Service Card.

Giant Switch Tube

The Central Electronic Manufacturers Division of Nuclear Corporation of America is developing a high-vacuum tetrode capable of switching approximately 44 megawatts.



The XD-32 is completely water-cooled and approximately 15 x 12 in. overall. Typical operation as a Class B modulator, .01 duty requires 7 kilowatts average power grid drive, 65 kilovolts at the anode and a heater current of 233 amperes at 6 volts. At these figures, the SC-32 has a pulse width of 25 micro-seconds.

Circle No. 232 on Subscriber Service Card.

Precision Force Gages

A series of precision mechanical force gages for measuring tension in permanent test set-up is announced by Hunter Spring Company, a division of American Machine & Metals, Inc. The Force Indicator's free-floating transmission rod, which transmits the tension load to a dial indicator, is threaded (5/16-18) at its end for mounting in test apparatus of fixtures.

The DT Series Force Indicator does not have the compression head for measuring compression forces, or the removable end attachments for measuring tension, nor the means for hand holding with detachable handles which are part of Hunter's standard DM Series designed for manual measuring. Thus simplified, the Series DT Force Gage is available at a lower price.

Circle No. 233 on Subscriber Service Card.

Water-based Solder Flux

Non-resinous water-based fluxes featuring instantly soluble and non-charring residues are available from London Chemicals Co., Inc.

Known as Lonco Organo-Fluxes, they are available in four grades to provide sufficient activity for any job, while holding residues to an absolute minimum for the soldering speed required. The grade descriptions are #3355 Red for fast action and medium residue, #2133 Pink for rapid action and moderate residue, #3133 Pink for medium action and minimum residue, and #735 Blue for medium action and light residue.

Circle No. 234 on Subscriber Service Card.

Shock Overload Indicator

A device for detecting excessive shocks to delicate instruments, equipment, etc., during shipment or handling is announced by Arizona Gear and Manufacturing Co. Known as a Shock Overload Indicator, it can be mounted directly on or with fragile equipment in the same container during shipment. If the indicator is subjected to a shock exceeding its setting, a sleeve is tripped on a rod under the plastic dome, exposing a red indicator band. The action is completely mechanical—no batteries or magnets.

Circle No. 235 on Subscriber Service Card.

new literature

PHOTOMICROGRAPHY OF METALS—A 46-page data book may serve as a short course in photomicrography for metallurgists interested in reviewing the latest techniques in this field. It is illustrated with photographs, charts and graphs. Written in layman's language, the booklet contains six major sections which include detailed information on the metallographic microscope, illumination, filters in metallography, photographic materials, exposure determination, and processing and printing.

Circle No. 200 on Subscriber Service Card.

PRODUCTION CHILLING EQUIPMENT — Large-capacity production chilling equipment for stabilization of metals, stress relief of castings, dehydration of gases, expansion assembly, and many other production chilling applications is described and illustrated in a new bulletin offered by Cincinnati Sub Zero Products. Standard R, T, and V Model low-temperature chambers are designed for accurate, economical and continuous performance in large-capacity production chilling operations. The standard models are each modified to meet individual user specifications of size, type of operation, floor space, temperature range, and thermal capacity.

Circle No. 201 on Subscriber Service Card.

PREPARING FOR PATENT-HOOD —Trak Electronics Co., Div. of CGS Laboratories, Inc., announces a booklet about patents for inventors and engineers. The brochure tells what to do with your invention idea; when to talk with a patent attorney; importance of dates and a verifier; about the patent office; application handling; revising claims; claims and patents; economic importance of patents; and foreign patents.

Circle No. 202 on Subscriber Service Card.

EXPLOSIVE FORMING—A new bulletin on the Explosiform process, a method of shaping metal parts by means of explosive energy, has been issued by Propellex Chemical Division, Chromalloy Corp. The statement, Technical Bulletin No. 4, includes a list of advantages of this fabricating technique, which can shape certain materials which are difficult to fabricate by conventional means.

Circle No. 203 on Subscriber Service Card.

ELECTRONIC COMPONENTS—Standard, split bushing and precision rotary trimmer capacitors are described in a new data sheet published by the Electronic Components Department of Corning Glass Works. It says the trimmers are especially applicable to high-frequency tuned circuits. Their temperature coefficient of capacitance is 50 ± 50 ppm/°C. Operating temperature is —55°C to 125°C. Capacitances range from .3 to 12 micro-microfarads.

Circle No. 204 on Subscriber Service Card.

CLIMELT MOLYBDENUM—A non-technical, descriptive booklet on molybdenum products has been published by Climax Molybdenum Company for those executives, purchasing agents and others with a general interest in the unique combination of properties found in these materials. The 24-page booklet gives full details on the various sizes, forms, conditions of use, tolerances, weights, and methods of identification of Climelt products available for commercial use.

Circle No. 205 on Subscriber Service Card.

MOLDING CHART—A new comparative chart for compression molders and transfer molders shows the mechanical, electrical and thermal properties of all general-purpose thermoset materials comparatively. It indicates the relative position of Epoxy Molding Compounds for flexural strength, impact strength, heat distortion, dielectric strength, etc. under controlled tests.

Circle No. 206 on Subscriber Service Card.

names in the news

Presson S. Shane: Elected Vice President of Atlantic Research Corp. Responsibilities presently include the Company's Solid Propellant Division and Desomatic Products, Inc. He joined Atlantic Research in 1958 as Director of the Solid Propellant Division. Before joining AR, was employed by the McGean Chemical Company of Cleveland and E. I. DuPont Co. in various capacities.


SHANE

Robert O. Vaughan: Named Vice President of Southwestern Industrial Electronics Co. Formerly western regional manager of government operations for Dresser Industries, Inc. Prior to joining SIE was affiliated with RCA, The National Aircraft Corp., and Hoffman Laboratories.

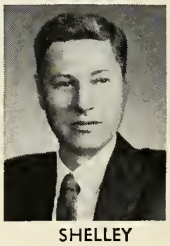

VAUGHAN

Dr. Richard W. Soshea: Appointed to technical staff research and development department, Rheem Semiconductor Corp., where he will do research on new semiconductor devices.

Harland A. Bass: Named Chief Engineer, Data Handling, Electronics and Controls Operation, Avco Corp. Previously served as Assistant Chief Engineer, Data Handling. Joined Crosley in 1940 as an engineer on military products.

Arthur Marquis: Appointed Manager-Specialty Resistor Project, Magnetic Materials Section, Metallurgical Products Department, General Electric Company. Joined GE on Engineering Test Program in 1950. Later appointed Magnet Laboratory Engineer.

Edwin F. Shelley: President of USI Robodyne, has been appointed a Group Officer and Vice-President of U.S. Industries, Inc., the parent company. He will have executive supervision over the USI Technical Center at Pompano Beach, Fla.; the USI Western Design Division at Santa Barbara, Calif.; and the USI Office of Government Programs, New York, N.Y., in addition to the USI Robodyne Division, which he has headed since 1958.


SHELLEY

Homer F. Lewis: Appointed vice president and treasurer, Transval Electronics Corp. Formerly associated with Hughes Aircraft Co.

Harry L. Wolbers: Named chief, equipment and safety research section, El Segundo Division, Douglas Aircraft Co. Succeeds **A. M. Mayo,** now assistant director, life sciences program for bioengineering, NASA.

Dr. Saul Feldman: Joined Electro-Optical Systems, Inc. as Principal Scientist, Fluid Physics Div. Prior to joining Electro-Optical Systems, was Principal Research Scientist at AVCO-Everett Research Lab., where he contributed to ICBM nose cone research.


FELDMAN

Jules Kravetz: Former director of the U.S. Army Signal Corps West Coast Research and Development Office, named Director of Government Relations, Aerolab Development Co.

Ben W. Badenoch: General Manager, Aero Hydraulics Division of Vickers Inc., elected a Vice President. Joined Vickers in 1949. Appointed Division General Manager in 1957.

John H. Richardson: Appointed vice president - marketing of Hughes Aircraft Co. He has been with the company for 12 years, and served as director of marketing since last July. Has held Hughes posts as director of military sales, assistant director of sales, manager of the Dayton, Ohio office, contracts supervisor and staff planner.


RICHARDSON

T. Phillips Morgan: Appointed director of operations, Consolidated Systems Corp. Was formerly controller of Consolidated Electrodynamics.

Murray W. Lindenthal: Formerly with The Martin Company since 1956, has been appointed to the staff of Hoover Electronics Co. He will be one of Hoover's senior electronics engineers.

Carl A. Hultberg: Formerly an engineering group leader, Bell Aircraft Corp., has joined the staff of Hoover Electronics Company as Senior Project Engineer.

Dr. Howard S. Seifert: Recently joined technical staff, United Technology Corp., named Director, Professional Development Staff.

Pacific Semiconductors, Inc. has announced three new vice presidents: **Lawrence T. Lindgren,** vice president, manufacturing; **Dr. John W. Peterson,** vice president, research and development; and **Sidney L. Spiegel,** vice president, marketing.

Joseph B. Elliott has been appointed president and general manager of the York Division of Borg-Warner Corporation. Was formerly executive vice president in charge of all engineering, manufacturing, and distribution of consumer products for Radio Corporation of America, and president of Schick, Inc. Has also been president of Teledynamics, Inc., and executive vice president of Raymond Rosen, Inc., RCA distributer.

Gustave A. Bleyle, Jr., has been named vice president in charge of engineering activities at the Santa Monica, Calif., office of Arthur D. Little, Inc. He joined the firm in 1947 and has been active in the design development and construction of liquefied gas equipment for use in missile projects and related applications.

contracts

NAVY

$9,100,000—North American Aviation, Columbus Div., for construction of a radio telescope reflector at Sugar Grove, W. Va.

$4,000,000—Stromberg-Carlson Div. of General Dynamics Corp., for special transistorized airborne radio equipment.

$2,114,886—Del Mar Engineering Laboratories, Los Angeles, for weapons training systems for Navy fighter aircraft.

$500,000—Babcock Radio Engineering, Inc., for remote guidance and control equipment.

ARMY

$20,075,000—H. B. Zachry Co., San Antonio, and Brown and Root, Inc., Houston, for construction of *Atlas* launch complexes near Dyess AFB, Abilene, Tex.

$6,642,496—Chrysler Corp., for *Jupiter* repair parts and modification services (three contracts).

$4,114,000—Johnson, Drake & Piper, Inc., Downey, Calif., for construction of two *Atlas* missile launching silos at Vandenberg AFB.

$2,070,000—The Martin Co., for R&D on the *Pershing* system.

$1,869,998—Sperry Rand Corp., for production engineering on the *Sergeant* program.

$583,339—Sperry Utah Engineering Laboratory, Salt Lake City, for *Sergeant* missile repair parts.

$495,247—Hayes Aircraft Corp., Birmingham, Ala., for engineering, design, fabrication, modification, and re-work, ground services equipment (*Saturn* program).

$470,981—Brown Engineering Co., Huntsville, Ala., for engineering and manufacturing services (*Saturn* program).

$300,000—Sperry Utah Engineering Laboratory, for technical publications.

$159,789—Electro-Optical Systems, Inc., Pasadena, for R&D work in areas of exploding wires, space heat rejection systems, and stressed plate optical shutter fabrication.

$66,909—Hayes Aircraft Corp., Birmingham, Ala., for design, engineering, fabrication installation and maintenance services.

$46,200—Brown Engineering Co., Huntsville, Ala., for engineering and fabrication services.

AIR FORCE

$130,000—Space Electronics Corp., Glendale, Calif., for research, experimentation and development in long range communications using earth currents.

$85,331—Rocketdyne Div., North American Aviation, Inc., Canoga Park, Calif., for classified work on target missile flight service program.

$74,975—Hughes Aircraft Co., Culver City, Calif., for radar research.

$73,420—Consolidated Electrodynamics Corp., Pasadena, for study program aimed at increasing the percentage of useful data telemetered from satellites and space vehicles during extended flights.

$53,418—The Firestone Tire and Rubber Co., Los Angeles, for *Corporal* missile repair parts.

$44,986—Vickers Inc., Aero Hydraulics Div., Torrance, Calif., for *Nike* missile spare parts.

$39,185—Resdel Engineering Corp., Pasadena, for research and development.

$37,829—Rocket Power/Talco, Div. of Gabriel Co., Pasadena, for basic research on thermodynamics of reactions involving light metal oxides and propellant combustion gases.

$33,800—Cooper Development, Div. of Marquardt Corp., Monrovia, Calif., for loading, clustering and testing *Loki* motors.

$26,711—Motorola Inc., Scottsdale, Ariz., for destruct command receivers.

NASA

$1,758,440—Chance Vought Aircraft, Inc., Vought Astronautics Div., Dallas, for design, development, fabrication, acceptance tests for 8 vehicle launchers and ground support equipment.

$548,000—Hoffman Electronic Semiconductor Div., Los Angeles, for lunar study program to fabricate solar power panels.

$325,000—California Institute of Technology's Jet Propulsion Laboratory, for design, packaging and fabrication of a digital data handling system for transmission of information from deep space.

$303,821—Hermes Electronics Co., Cambridge, Mass., for services and materials for range programing and timing systems.

$118,000—California Institute of Technology's Jet Propulsion Laboratory, for fabrication and test of flight decoder units, ground equipment and system test consoles related to a spacecraft radio command system.

$44,800—Horne Brothers, Inc., Newport News, Va., for services and materials for new turning vanes and wind screen.

MISCELLANEOUS

$250,000—The Twin Coach Co., for production of consoles for electronic equipment used in missiles.

Lear, Inc., for design and production of a digital servo system, from Lockheed Missile and Space Division, amount undisclosed.

Rucker Co., Oakland, Calif., for structural test fixture for simulation of stresses encountered during the initial launching period of *Polaris* missiles, from Aerojet-General Corp., amount undisclosed.

Navy's RUM

(Continued from page 35)

with orange filters to achieve a stable pattern.

• **Vertical lift appendage**—The Hughes design for the vertical lift appendage has a large three-bladed fixed-pitch 30-inch width rotor mounted on the vertical axis to the hub of a toroidal-shaped float and is attached to the vehicle through a ring mechanism interconnected by cables.

Three individual, pod-mounted, oil-immersed electric motors mounted directly on the rotor blades would provide propulsion for the rotor. Each motor, which generates 25 hp per blade, would power a 12-in., three-blade, standard marine propeller to drive the rotor blade. This combination would permit the vehicle not only to rise and descend while under water but also impart lateral movement in any direction. The normal rate of descent for the vehicle would be approximately one foot per second. During forward speed and climbing, the unit would have a speed slightly in excess of two feet per second. Guidance and operational control could be by narrow band-width radio frequency carried over the main vehicle cable.

when and where

JUNE

Machinability Seminar, Pennsylvania State University, University Park, June 6-10.

National Society of Professional Engineers, Annual Meeting, Statler Hotel, Boston, June 8-11.

American Nuclear Society, National Meeting, Palmer House, Chicago, June 12-14.

Seminar in Design Engineering, Pennsylvania State University, University Park, June 12-17.

1960 Radio Frequency Interference Symposium, sponsored by the IRE, Shoreham Hotel, Washington, D.C., June 13-14.

American Institute of Mining, Metallurgical and Petroleum Engineers, International Powder Metallurgy Conference, Biltmore Hotel, New York City, June 12-15.

Symposium on Molecular Structure and Spectroscopy, Dept. of Physics and Astronomy, Ohio University, Columbus, June 13-17.

1960 Cornell University Industrial Engineering Seminars, Ithaca, N.Y., June 14-17.

Special Summer Program on Fluid Power Control, Massachusetts Institute of Technology, Cambridge, June 14-24.

American Institute of Chemical Engineers, Del Prado Hotel, Mexico City, Mexico, June 19-22.

University of Connecticut, Institute for Practical Research on Operations, Storrs, June 19-25.

Atomic and Molecular Gas Beams Symposium, University of Denver, Denver, June 20-22.

ASME Applied Mechanics Conference, Pennsylvania State University, University Park, June 20-22.

Gordon Research Conference, Colby Junior College, New London, N.H., June 20-24.

Institute of Navigation, 16th Annual Meeting, Air Force Academy, Colorado Springs, June 23-25.

International Machine Tool Trades Exhibition, Brettenham House, Lancaster Place, London, W. C. 2, June 24-July 8.

Fourth National Convention on Military Electronics, sponsored by IRE PGMIL Sheraton Park, Washington, D.C., June 27-29.

JULY

Metallurgical Society of AIME Conference on The Response of Materials to High-Velocity Deformation, Estes Park, Colo., July 11 and 12.

Third International Conference on Medical Electronics, sponsored by Institution of Electrical Engineers, Olympia, London, July 21-27.

Pennsylvania State University, R&D Management Development Seminar, University Park, July 24-29.

Denver Research Institute, Seventh Annual Symposium on Computers and Data Processing, Stanley Hotel, Estes Park, Colo., July 28-29.

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editorial . . .

The Case of Mr. Hagerty and the U-2

Looking back upon some notable contradictions in the information given the public after the U-2 affair, it is very difficult to isolate the part played by the one man most responsible—James C. Hagerty, the White House press officer.

If Jim Hagerty occupied his post in the reasonably anonymous style of previous incumbents under previous Presidents, it would be possible to assume that the press officials of the other government agencies concerned were operating under the best guidance of their own official knowledge and judgment.

In this case it is a little difficult to assume that. While Hagerty doesn't make it a constant practice, he has never when he felt the occasion demanded, been reluctant to dictate policy to press officers of the State Department, the Defense Department or the National Aeronautics and Space Administration.

The question in the case of the U-2 is how much policy did Hagerty dictate? Or, conversely, how much did he fail to dictate? Can he evade the responsibility for the worst public relations fiasco the administration and the nation has suffered since—since when?

We suggest that while Congress is investigating it might like to hear from Jim Hagerty what his responsibility was in the following welter of statements given the press and the public:

The original announcement by the Air Force that the U-2 was missing on a weather flight after the pilot had radioed an oxygen failure; denial that the flight had been a military reconnaissance flight over Russia; admission that it had been; denial that such a flight had been authorized; admission that it had been; a declaration that such flights would continue; a denial of this declaration and—finally—a declaration that they would *not* continue.

In issuing the above rather remarkable sequence of statements, the press officials of the State Department and of NASA were caught in the attitude of being either fools or liars. So was the Vice President of the United States.

We do not credit Hagerty with dictating our foreign relations or in deciding when confession is good for the national soul, but we do credit him with dictating the public relations policy of the government down to small details when he thinks the occasion warrants.

In the case of the U-2, a cover plan had been devised which wouldn't hold water—yet NASA was left in the position of upholding it even while it was being abandoned; the President was placed in the position of confessing he didn't know who was running the country—a position from which he had to be extricated; the Secretary of State made the statement about the flights continuing—a statement so obviously untenable that it had to be denied; someone forgot to so inform the Vice President and he continued affirming the statement after it had been denied.

All of these events were directly or indirectly press and public relations matters and they were handled with a minimum of competence and a maximum of hysteria.

Because of the position the White House press officer has created for himself, it is difficult to separate him from the handling of the all-important public relations details of the U-2 affair. We feel that his part in the fiasco is a matter of considerable importance to the public. It would be very interesting to learn his reaction to an invitation from Congress to tell that story.

Clarke Newlon

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