SEPTEMBER 5, 1960

missiles and rockets

THE MISSILE/SPACE WEEKLY

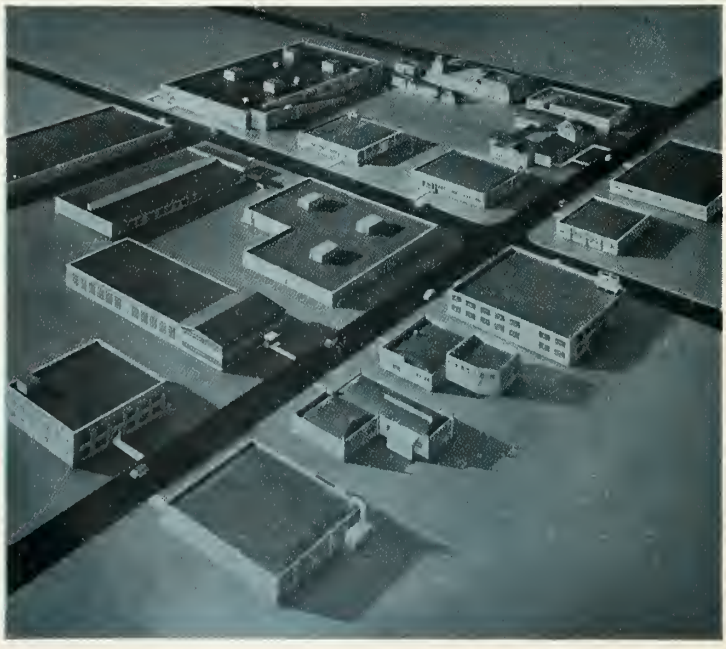
Linde's New Liquid Hydrogen Plant

AN AMERICAN AVIATION PUBLICATION

LIBRASCOPE COMPUTER FACILITIES

Shown below is a composite view of Librascope's facilities where a variety of computer systems are currently in different stages of design and production. Some are strategically involved with national defense...others deal with business and industrial process control. Each is uniquely designed to answer a particular need. The success of these systems illustrates the value of Librascope's engineering philosophy: A decentralized organization of specialized project teams responsible for assignments from concept to delivery...and backed up by excellent research, service, and production facilities. For your computer requirements, call on the company whose breadth of diversification in computer technology is unsurpassed. ■ Librascope Division, General Precision, Inc., 808 Western Avenue, Glendale, Calif. For career opportunities write to John Schmidt, Engineering Employment. ■

computers that pace man's expanding mind



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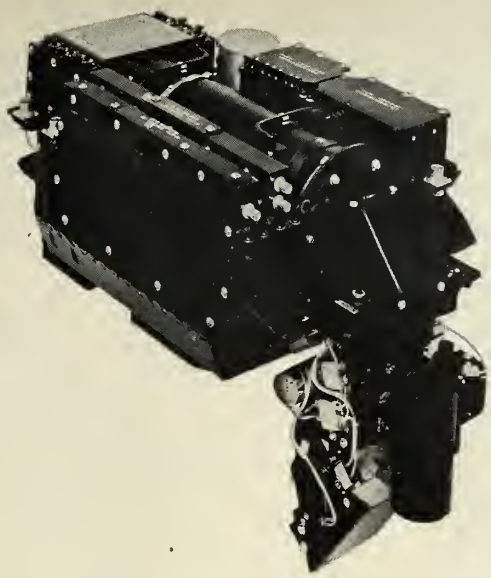

TV SYSTEMS SKY-HIGH

TELEVISION-DRONE RECONNAISSANCE SYSTEM ONE STEP FROM SPACE...

One of many Hallamore "firsts" in television and space communications, this airborne TV system, operational for one year, is the forerunner of those soon to be reporting from space. Its ground controlled, Hallamore image orthicon television camera scans vast areas from its winged platform far above potential target areas. Eye of the complete air-to-ground system, the camera reports with unusual clarity under the most difficult circumstances of distance, platform speed, and light. Unit affords 600 line resolution and electronic-pulse shuttering that can stop pictures at Mach 4 with automatic scene brightness compensation. Integral in the Hallamore mobile receiving and control station are an instrumentation camera that provides a permanent photographic record at the rate of one television frame 6 times per second and a film processor that develops the film, ready for viewing in projection viewer or stereoscopic binoculars in 60 seconds. Let our experienced engineers attack your requirement for "TV Systems Sky-High." Write Hallamore Airborne TV Systems, 714 No. Brookhurst St., Anaheim, California.

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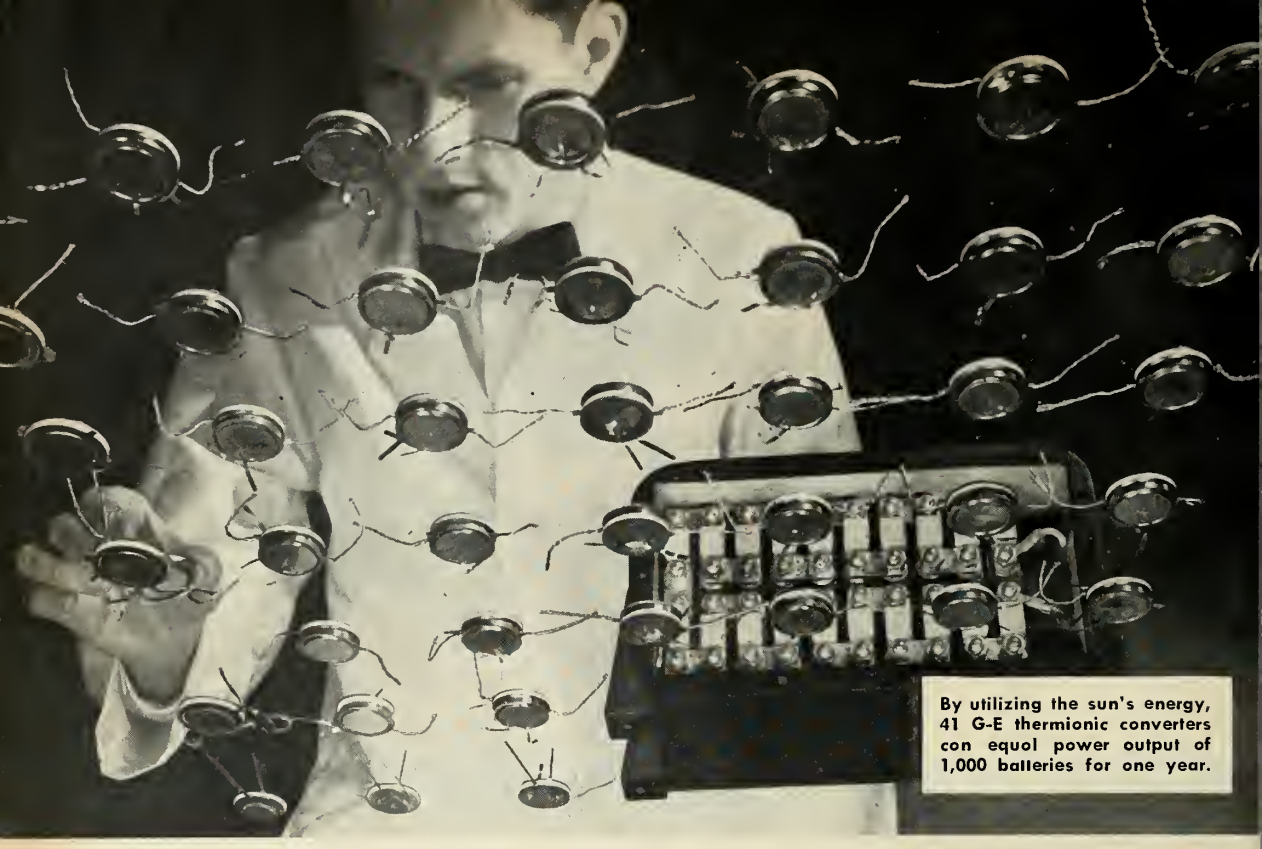

By utilizing the sun's energy, 41 G-E thermionic converters con equol power output of 1,000 batteries for one year.

MISSILE AND SPACE VEHICLE DEPARTMENT

...center for missile and space technology research and development at General Electric

Progress in power for space

Manned space flights, as well as other U.S. space projects, will require new, light-weight, long-life sources of electrical energy. Conventional batteries, now being used in missiles and satellites, are far too heavy for most future space applications.

For example, during a year's operation, one thousand 15 amp/hr batteries, similar to the one shown above, would be required to equal the 41 watts which the thermionic converters in the photo can generate from the heat of the sun. These batteries would weigh 15,000 lbs—a complete thermionic system, including the converters developed in General Electric's Research Laboratory plus a collector and orientation equipment, only about 20 lbs.

To provide such new, light-weight systems, engineers at General Electric's Missile and Space Vehicle Department are investigating a wide variety of promising space power sources, utilizing the specialized capabilities of other Company research operations. For instance, under U.S. Air Force contract, G.E. is conducting extensive research in thermionics, and is developing an experimental thermionic system consisting of a solar collector, converters, and storage and control components. Intensive work in photovoltaics includes the development of an advanced unit to provide more than 500 watts of continuous power for the Advent communications satellite.

For the U.S. Army Signal Research and Development Laboratory, a regenerative fuel cell is under development, as are magnetohydrodynamic electrical converters for the Air Force Office of Scientific Research, WADD and BMD. In addition, MSVD is investigating nuclear thermionics and nuclear turbines.

To learn more about these MSVD space power developments, write to Section 160-76, General Electric Co., Missile and Space Vehicle Department, Philadelphia 1, Penna. 160-76

GENERAL ELECTRIC

MISSILE AND SPACE VEHICLE DEPARTMENT

A Department of the Defense Electronics Division

Scientists and Engineers interested in career opportunities in Space Technology, contact Mr. T. H. Sebring, Dept. 160, MSVD

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THE MISSILE / SPACE WEEKLY

missiles and rockets

September 5, 1960 Volume 7, No. 10

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THE COVER

Linde Co.'s new liquid hydrogen plant in Torrance, Calif., is the first privately owned and operated facility to supply the fluid on a commercial basis. *See p. 14.*

SEPTEMBER 5 HEADLINES

SPECIAL REPORT ON TITAN

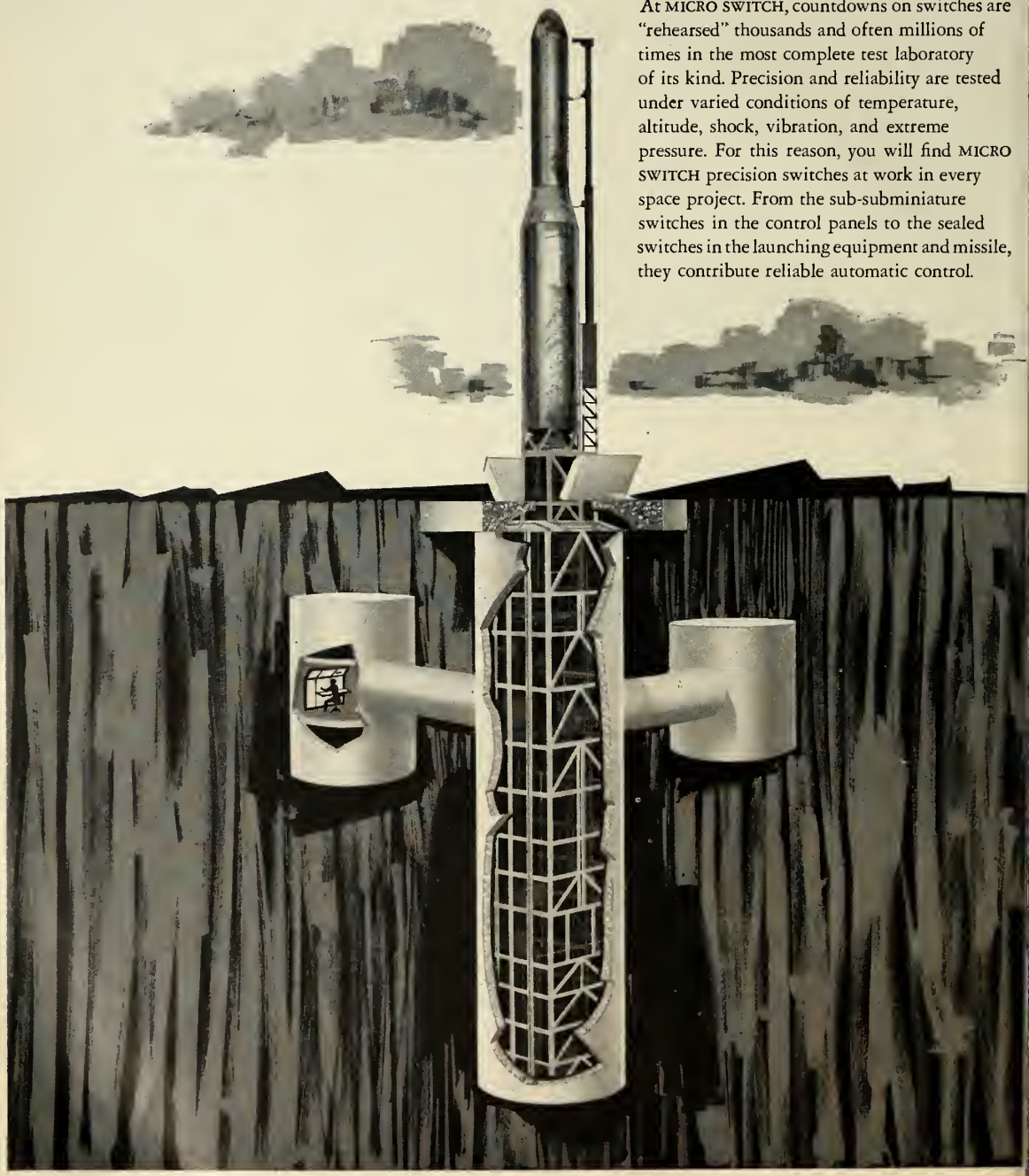
INTERNATIONAL

DEPARTMENTS

30,911 copies this issue

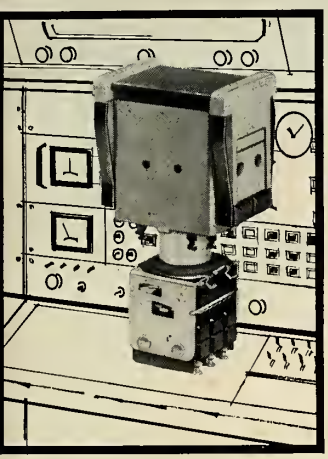
MICRO SWITCH Precision and Reliability Are Thoroughly Proved When

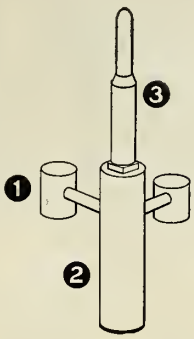
Switches go to work



At MICRO SWITCH, countdowns on switches are "rehearsed" thousands and often millions of times in the most complete test laboratory of its kind. Precision and reliability are tested under varied conditions of temperature, altitude, shock, vibration, and extreme pressure. For this reason, you will find MICRO SWITCH precision switches at work in every space project. From the sub-subminiature switches in the control panels to the sealed switches in the launching equipment and missile, they contribute reliable automatic control.

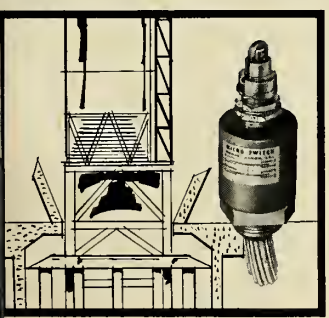
at Countdown!





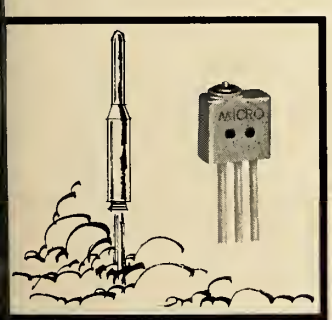
1 GROUND SUPPORT CONTROL

MICRO SWITCH "Series 2" Lighted Push-Button Switches meet the very latest requirements in the field of Human Engineering. Their modular design permits complete flexibility in the arrangement of visual indicators on the control panel. Behind the panel they can be connected to an infinite number of switch combinations. "Series 2" switch modules simply snap together to fit your design requirements, then snap into slots in the mounting panel—all without tools. Write for Catalog 67.



2 LAUNCHING

MICRO SWITCH "EN" Series and "HR" Series switches perform automatic control and signal functions during launching. They are sealed against the elements, making them completely reliable on outside gantry locations. Their shock-resistant design makes them suitable for use in explosion areas. They can be adapted to many different applications through their wide selection of actuators. Write for Catalog 77.



3 MISSILES

The new Sub-subminiature "XE" Switch is an environment-sealed switch, yet is smaller than a dime. It was developed by MICRO SWITCH to make possible a 30% savings in size and a 20% savings in weight over any previous environment-sealed snap-action switch, while still maintaining the same electrical rating. The "XE" is typical of new switches for missiles and advanced aircraft applications that give MICRO SWITCH unmatched experience. Write for Data Sheet 169 on the "XE" or Catalog 78 which describes many other sealed switches for these applications.

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The nearby MICRO SWITCH Branch Office can make engineering help promptly available for particular switch problems. See the Yellow Pages for the address.

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With its third consecutive satellite success, RCA Astro-Electronics Division has made "reliability" meaningful in space systems engineering and development. Read the "Reliability Record" for yourself.

December, 1958: Project SCORE. AED developed the communications and control systems for the U.S. Army Signal Corps' "Talking Atlas", part of a program under ARPA, Dept. of Defense. Transmitters, receivers and control units in the satellite and at the ground stations all operated perfectly as the "Talking Atlas" broadcast the President's Christmas message and proved the feasibility of active communications satellites.

April, 1960: TIROS I. The sophisticated satellite, including its structural design as well as the electronic systems, and its ground stations were developed and built for NASA by AED under the technical direction of the U.S. Army Signal Corps. It accomplished its mission in meteorological observation, sending down over 20,000 TV pictures of earth and its cloud cover.

August, 1960: Project ECHO. The only electronic equipment on this 100-foot balloon, launched by NASA to prove the feasibility of passive communications satellites, are two "dinner plate" beacon transmitters 10 inches across by ⅜ inch thick, including storage batteries and solar cells. These units, designed to permit beacon tracking of the satellite, weigh only 11 ounces apiece and were developed and built by AED.

As more and more sophisticated space systems are developed, AED will continue to design for reliability in this most demanding of all environments. To find out how you can draw on this dependable R&D capability, contact the Manager, Marketing, RCA Astro-Electronics Division. If you are interested in participating in this challenging team effort, contact the Employment Manager, Astro-Electronics Division, Defense Electronics Products, at RCA's "Space Center" in Princeton, N. J.

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RADIO CORPORATION OF AMERICA

The Countdown

WASHINGTON

Red Missile Photographed

Extremely clear color photos of a Russian missile warhead which blazed into the Pacific July 7 are in the possession of the U.S. COUNTDOWN has learned the pictures—taken from U.S. aircraft—are so plain they have enabled intelligence experts to identify the type of ablating material used on the re-entry vehicle. Just what type has been classified by the Pentagon, along with the pictures. The missile was the second in a test series of two rockets fired by the Russians more than 8000 miles, presumably from a base near Murmansk.

TBX is Killed

The Air Force top command, COUNTDOWN is told, has flatly rejected Tactical Air Command proposals for developing the so-called TBX—a tactical-range ballistic missile. The weapon—suggested as a 1000-mile-range missile for NATO—is considered unnecessary. This leaves TAC without a successor to the fighter-bomber in the late '60's.

Norstad Leaving Soon?

Talk persists that Gen. Lauris Norstad will step down fairly soon as commander of NATO and retire from the Air Force. The reason: there appears to be no job for him to go to. Gen. Thomas White, AF chief of staff, continues to be considered the top condidate to succeed Norstad.

Atlas Base Increase

A possible increase in the present 13 *Atlas* squadrons is understood to be up for decision at the Secretary of Defense level. The Air Force wants two more 12-missile squadrons (dispersed in silos in a 12-by-1 configuration) and is gaining some support for the idea.

Picking Last Titan Site

The site for the last of the planned 14 *Titan* squadrons is all but set. The location is expected to be announced by the AF within two months.

Another Courier Try Coming Up

Next attempt at launching the first *Courier* Signal Corps communications satellite may come within a few weeks. The first try failed Aug. 18 when the *Thor-Able-Star* booster blew up.

On the Pad

NASA's *Atlas-Able* Moon orbiter is on the pad for launching late this month, probably between Sept. 25 and Sept. 29 when the moon is at perigee . . . But the first flight of the polar-orbiting second-generation *Nimbus* weather satellite now has slipped to the first half of 1962. It was to go in late '61.

INDUSTRY

Demand Drops for Engineers, Scientists

An index based upon recruitment advertising shows that the demand for engineers and scientists throughout industry fell 13% in July. Deutsch & Shea Inc., which developed the index, says the drop-off continues a downward trend established in the second quarter of 1960 and is partly explained by a seasonal slack in recruiting.

Army Spending $1.3 Billion on Rockets

FY 1961 spending on missiles by the Army is now computed at $1.3 billion. The Army says 10% of this figure is being spent in-house and the remainder is going to industry.

New Saturn Static Tests

A new series of *Saturn* static tests using the prototype SAT booster (modified as the result of tests this spring) will begin late this month or early next at Huntsville. Construction is continuing meantime on *Saturn-1*, which will be launched in its first flight test from the Cape next year.

Name Changes

The Crosley Division of Avco Corp. is being renamed the Avco Electronics and Ordnance Division (reflecting the company's switch from consumer production) . . . International Telephone and Telegraph Corp. is shortening the name of its communications division—Kellogg Switchboard and Supply Co.—to simply ITT Kellogg . . .

INTERNATIONAL

Italy Starts IRBM Project

SISPRE is prime for a mobile 900-mile missile being started by Italy's Ministero Difensa Aeronautica. The weapon could be used to cover targets from the Balkans to Warsaw.

French A-bomb Testing

France is reported preparing to explode an atomic weapon underground in north Africa north of Tamanrasset in the Hogar Mountains. The shot could come as early as Oct. 15.

British Firm Expanding

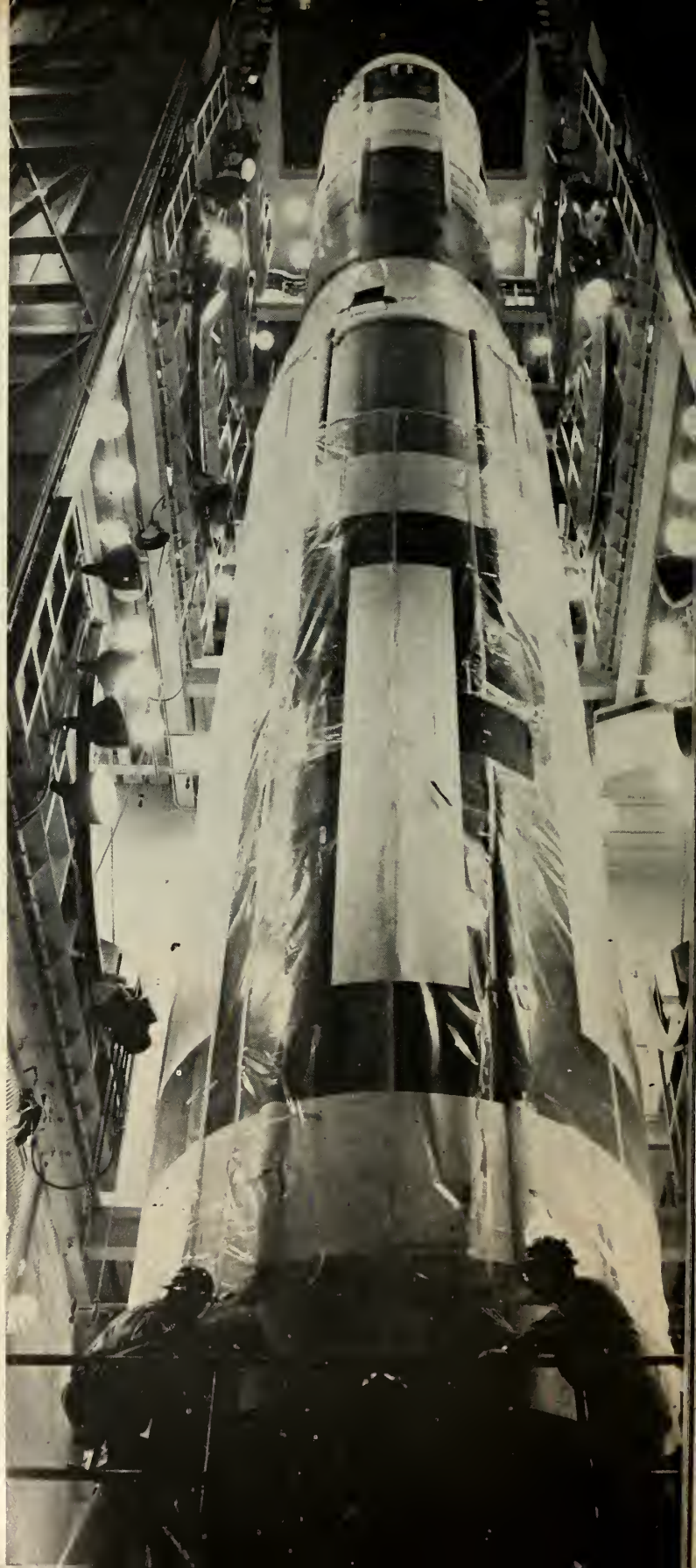
COUNTDOWN hears Cossor Communications Co. Ltd. is branching out into the missile guidance and GSE field. Well known in radar, Cossor has hired top missilemen from the guided weapons department of the R.A.E. and from Ferranti Ltd.

Big Red Missile Buy

Word from under the Iron Curtain has Khrushchev ordering into production 100,000 of Russia's new *M-55* tactical missile. The missiles reportedly require the diversion of 2 billion rubles.

TITAN

SPECIAL REPORT



PRIOR TO static firing, Titan is tested in Martin-Denver's Vertical Test Lab.

SAC Getting ICBM 'Crusher'

Massive $4.9-billion program will provide vehicles for multi-megaton nuclear warheads—and powerful boosters for Air Force space projects; more than 230 will be built

by James Baar

CRUSHING nuclear power and military space work are clearly emerging as the *Titan* program's top goals as it drives toward its first technically operational launching by Jan. 1.

Titan II will provide SAC with a missile capable of delivering the largest nuclear warhead in the nation's ICBM arsenal—possibly well over 10 megatons.

The huge Martin ICBM, powered by fast-reaction storable fuel, will be SAC's main assault missile for obliterating the enemy's hardened targets.

Titan I and, later, *Titan II* will provide the Air Force with boosters capable of hurling *Dyna-Soars* and other space vehicles and satellites into orbits around the earth and into lunar space.

They will be, in the language of their manufacturer, military "space trucks" of the future.

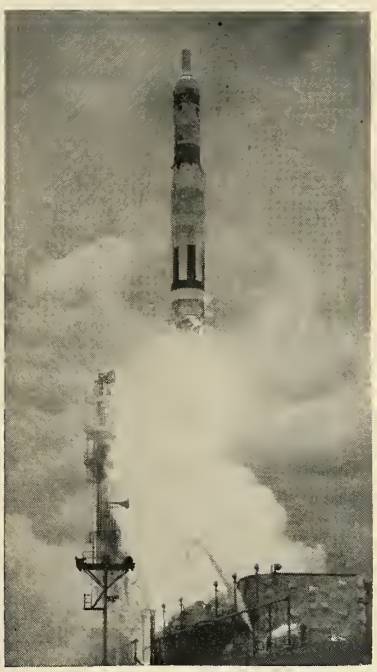
• **SAC crew shot**—The *Titan* program's timetable now looks approximately like this:

–The first V series *Titan* is scheduled to be launched from a test silo at Vandenberg AFB, Calif., within the next eight weeks. The "V birds" are similar to the instrumented all-but-operational J series *Titans* that have been launched from surface pads at Cape Canaveral.

–The first technically operational *Titan I* is scheduled to be launched by a SAC crew 30 to 60 days later from the three-silo *Titan* training site at Vandenberg. The SAC crew later will be part of the cadre of *Titan* instructors.

–The first full nine-missile *Titan I* squadron is scheduled to be operational at the sites surrounding Lowry AFB, Colo., in the fall of next year. Six are slated to be operational by early 1963.

–The first *Titan II* R&D missile is scheduled to be launched from Cape Canaveral in late 1961. The first of eight *Titan II* squadrons is scheduled to be operational by early 1963.



A TITAN I ICBM takes off from launch pad at AFMTC, Cape Canaveral.

The Air Force says the *Titan* program has recovered time lost last year and this year when R&D difficulties resulted in three blow-ups and other snags at Cape Canaveral.

Moreover, Col. Albert J. Wetzel, *Titan* program director at the Air Force's Ballistic Missile Division, has said: "There are no major basic technical problems outstanding in the *Titan I* program."

• **To build 230 birds**—The present official Air Force score on *Titan* R&D shots, including the successful launching of a "J" series bird from Cape Canaveral Aug. 30, is: 14 successes, two partials, and five failures.

Some 50 more R&D shots are scheduled—about evenly divided between *Titan I's* and *Titan II's*. That would bring the total R&D launchings to about 70.

The total *Titan I* and *Titan II* production run now planned is about 230, exclusive of *Titan* production for space work.

The main R&D effort in the *Titan* program is rapidly swinging to *Titan II*.

The division of the program into two distinct missiles is a sharp break with the step-by-step manner in which *Atlas* was developed.

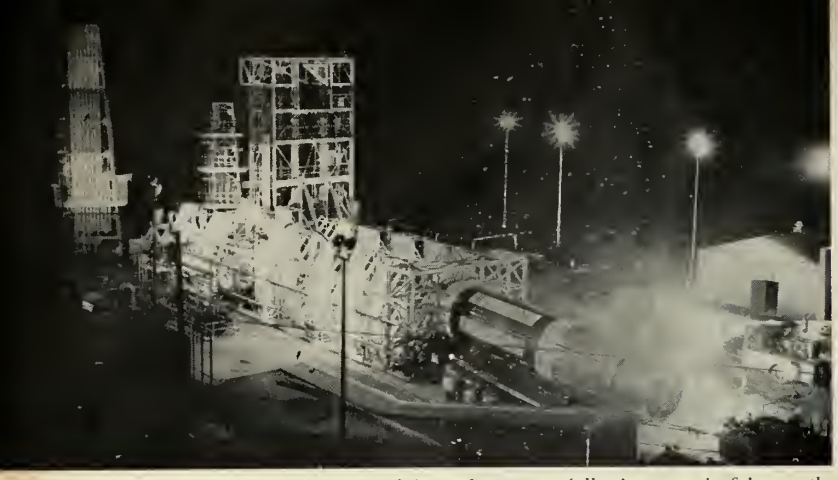
Because of the pressure on the *Atlas* program, improvements generally were introduced into the production line as quickly as possible. This was not done with *Titan*. Instead, a cut-off point was established for the introduction of further modifications into *Titan I*, and these were collected for introduction into *Titan II*.

The result is that *Titan II* is for all practical purposes a second-generation missile.

Like the solid-propelled *Minuteman*, the Air Force's main second-generation ICBM, it will have a reaction time of one minute rather than the 15 minutes of *Atlas* and *Titan I*. Like *Minuteman*, it will have higher reliability because of its relative simplicity. Like *Minuteman* and the *Atlas* "E" series, it will have all-inertial guidance.

Titan II will not have *Minuteman's* mobility or relatively low cost. But it will provide a means of delivering a far greater warhead.

• **$4.9 billion program**—The first *Atlas* squadrons are manning each



TITAN'S FIRST STAGE is removed from the erector following a static firing at the Denver Division of The Martin Co.

complex of three missiles with 16-man crews. The first *Titan I* squadrons are expected to man each complex of three missiles with 10-man crews.

Each dispersed *Titan II* is expected to be manned by a two- or three-man crew. Each group of 10 dispersed and unmanned *Minutemen* is expected to be launched remotely by a two-man crew.

Air Force figures on the cost of *Titan* bases vary, depending on whether development costs are included.

Official Air Force estimates put the total cost of the *Titan* program at $4.9 billion—about $2.7 billion of which is to be spent by the end of FY 1961. On the basis of the presently planned 14 squadrons, the average cost per squadron of nine ready-to-launch missiles is $350 million.

However, excluding the development costs, the Air Force puts the cost of each *Titan I* squadron at $166.5 million and each *Titan II* squadron at $138 million.

Comparatively, the Air Force has estimated the cost of the early soft *Atlas* squadrons at $133 million and the improved, hardened *Atlas* squadrons at $152 million. The *Atlas* figures also do not include development costs.

One of the principal reasons for the decrease in the cost of the *Titan II* squadrons and the increase in the cost of the later *Atlas* squadrons is that one can be stripped of much support equipment while the other calls for more such equipment.

• **No strategic overlap**—*Minuteman* is expected to be far cheaper than either *Atlas* or *Titan*.

Estimates of *Minuteman* costs also vary considerably. However, many Air Force officials expect the total *Minuteman* program to cost not more than $2 billion, including development. This would pay for some 450 *Minutemen* scattered in silos across the country and some 150 *Minutemen* deployed on 50 missile trains.

The first fixed *Minuteman* squadrons are scheduled to become operational in the second half of 1962; the first train squadrons in 1963. Thus the *Minuteman* and *Titan II* programs overlap—but not strategically.

Only *Titan II* among the nation's big strategic missiles will have the striking power to knock out a hardened target without expending large numbers to ensure success.

For example, assume the target is a Soviet missile site hardened to withstand pressures of 100 lbs. per square inch. Also assume the missile to be launched against it has a one-megaton warhead and a CEP of about two miles.

In order to have a 90% chance of destroying the missile site, about 19 missiles would have to be launched against it.

On the other hand, a 10-megaton ICBM with the same CEP greatly reduces the number needed. About six missiles could do the job of the 19.

• **Super destruction**—If accuracy improves and the CEP can be reduced to 1.5 miles, about 14 one-megaton missiles would be needed—still a large number. But two 10-megaton missiles could do the job—and more.

The reason for this, of course, is the immensity of a 10-megaton blast. Such a warhead detonated on the surface could dig a crater 250 feet deep and a half-mile across. The fireball would be more than two miles wide.

Both *Atlas* and *Titan I* are considered to be capable of carrying multi-megaton warheads. But *Titan II* alone is considered to be in the super warhead class.

Titan's space role is equally formidable.

At present, all Air Force plans for the use of *Titan* as a space booster are officially centered on the *Dyna-Soar* R&D program. However, the potentialities of both *Titan I* and *Titan II* for space work are considered to range far beyond *Dyna-Soar*.

Martin officials have said that *Titan I* in its present form is capable of launching a 2.5-ton satellite into orbit around the earth, and that a modified *Titan I* would be capable of launching more than a five-ton satellite.

• **Booster for space ships**—Dr. Albert C. Hall, Martin vice president for engineering, has said that *Titan I* without new development could launch a major space vehicle around the moon or place a small instrumented payload on the moon.

Titan II is considered capable of launching manned spacecraft on missions in lunar space.

Initially, Air Force plans call for using only *Titan I* in the *Dyna-Soar* program. However, *Titan II* is expected to be brought into the program as it advances toward development of operational military spacecraft.

At the same time, some experts close to the *Titan* program foresee the use of *Titans* to launch military missile defense satellites and other types of military space stations.

This is *Titan*—in war and space.

Planned Deployment of Titan ICBM's

Base Location	Number of Squadrons*	Base Configuration
Lowry AFB, Denver	2	3 missiles at each of six sites
Ellsworth AFB, S.D.	1	3 missiles at each of three sites
Beale AFB, Calif.	1	3 missiles at each of three sites
Larson AFB, Wash.	1	3 missiles at each of three sites
Mountain Home AFB, Idaho	1	3 missiles at each of three sites
Davis-Monthan AFB, Ariz.	2	18 missiles at 18 sites
McConnell AFB, Kans.	2	18 missiles at 18 sites
Little Rock AFB, Ark.	2	18 missiles at 18 sites
Undesignated	2	18 missiles at 18 sites

Total Bases: 9; Total squadrons: 14; Total launchers: 126.

**Each squadron has 9 Titans and launchers plus one spare Titan.*

As Red manned shot looms . . .

Administration Acts to Speed Apollo

by Jay Holmes

Under pressure of a possible pre-election man-in-space shot by Russia, the Eisenhower Administration is prodding into life NASA's Project *Apollo* —the plan for a three-man space ship.

Until last week what one congressman called merely a "designers dream," *Apollo* now has been raised to full study status, with plans to move it swiftly into the R&D stage.

NASA has set up a timetable to complete study contracts by the middle of next May. It also plans to ask for R&D money in the FY 1962 budget.

The timetable was given to industry at an Aug. 30. conference in Washington by Robert R. Gilruth, director of NASA's Space Task Group. He set Sept. 6 as the deadline for expression of interest by prospective bidders, with a bidders conference to be held Sept. 12 at the Langley, Va., NASA Research Center. Proposals are due Oct. 10, with contracts (probably more than two) to be awarded Nov. 14.

Tentative plans call for design, development and manufacture of the space ship, which would be boosted by a *Saturn* launching vehicle, in 1962-65. Active flight testing and mission flights are projected for 1965-70.

Apollo will carry provisions and atmosphere for flights lasting several weeks. It is to come down on dry land, but must be designed for emergency landings on land or water, and able to sustain the crew for several days after landing.

• **Space station step**—Command of the mission will be on board the space ship, with almost continuous contact with the earth. The crew will be expected to fulfill a role comparable with that of a transcontinental jet airliner.

Gilruth listed some of the major technological problems as:

–Coping with or avoiding excessive solar radiation.

–Safe crew recovery in case of space ship or booster malfunction.

–Managing heat and other loads resulting from re-entry into the atmosphere at speeds near 36,000 ft./sec.

Apollo's multimission capability, Gilruth said, will include a variety of scientific, technological and civilian services as an earth-orbiting vehicle. It will serve also as an intermediate step toward the establishment of manned space stations.

When later versions of the *Saturn* vehicle are available, *Apollo* will be capable of manned reconnaissance flights to the vicinity of the moon.

• **Launch program**—John W. Townsend Jr., assistant director of the Goddard center, gave details of satellites to be launched soon.

The *Juno II* satellites—following Explorer VII, S-15 and S-45, both built by the Marshall Space Flight Center, will be launched in the next six to eight months. S-15 will study gamma rays and S-45 will be a multifrequency ionosphere beacon.

Typical missions of the Goddard center, Townsend said, are the ionospheric topside sounders, S-48 and S-27. American industry is building S-48 while Canada is producing S-27 as part of the international cooperation program. Other Goddard satellites include S-30, an ionosphere direct measurements satellite; S-51, the United Kingdom satellite; S-16, the orbiting solar observatory; S-6, the atmospheric structures satellite; P-14, the magnetometer probe; and P-26, the nuclear emulsion recovery vehicle (NERV).

Robert J. Mackey, head of the Communications branch, reported that NASA is interested in active communications satellites. Although NASA has no active program in this area, he said, Department of Defense activities are being monitored and studied to determine their implication to civilian communication studies.

The Orbiting Geophysical Observatory, project manager Wilfred E. Scull said, will be used on two separate missions. The Polar Orbiting Geophysical Observatory (POGO) will be used on low-altitude polar orbits for study of the atmosphere and ionosphere. The Elliptical Geophysical Observatory (EGO) will follow highly elliptical, low-altitude orbits to study energetic particles and magnetic fields.

Building semi-hard Atlas Pads

FIRST 'HOLLYWOOD HARD' Atlas pads are taking shape at Sheppard Air Force Base near Wichita Falls, Tex. Being constructed flush with the surface of the surrounding ground, the pads are an intermediate step toward fully hardened silo launchers.

The Missile/Space Week

Reds May Have Dyna-Soar Type Vehicle

Information obtained by U.S. scientists is reported to indicate that the Soviet "space menagerie" satellite may have been a winged *Dyna-Soar* type spacecraft. Until now it has been generally assumed that the Russians brought their two dogs back to earth from orbit Aug. 20 in a *Mercury*-type capsule rather than a more advanced vehicle.

Use of a winged spacecraft, if it could be controlled from the ground, would explain how the Russians were able to obtain a high degree of accuracy in returning the life capsule. European military sources have reported previously that the Russians were working on the *Dyna-Soar* type T-4A, reported to weigh about 3000 lbs. The Soviets said the space menagerie weighed nearly 5 tons.

NASA Wins Rover Control

The National Aeronautics and Space Administration has won a five-month struggle with the Atomic Energy Commission for control of the project *Rover* nuclear rocket. Harold B. Finger, NASA chief of nuclear propulsion, was chosen to head a joint NASA-AEC Nuclear Propulsion Office (NPO), set up at AEC headquarters in Germantown, Md. Milton Klein, assistant manager for technical operations in the AEC's Chicago Operations Office, will be Finger's deputy.

The joint NASA-AEC announcement said the new offices will be staffed by employees drawn from both agencies. However, it will not include Col. Jack E. Armstrong, who has headed the AEC effort as deputy chief of the Aircraft Nuclear Propulsion Office. Finger said he would have a staff of about 10 or possibly a few more, planned to set up operations in Germantown late last week. He said he will be in charge of Project *Rover,* with authority to make decisions that formerly had to be made by agreement between NASA and AEC.

Echo's Reflectivity Holds Up

So far, radio reflections from the *Echo I* balloon satellite have suffered no permanent ill effect from passing through the earth's shadow. A slight distortion of signals was observed on passes through the shadow during the first eight days beginning Aug. 23, but the quality returned when *Echo* reentered sunlight. This would indicate that sufficient gas remains in the balloon to reinflate it each time it returns. By Aug. 30, *Echo* was spending 27 minutes of each 118-minute orbit in darkness. This is expected to increase to about 37 minutes by late November and then gradually decrease to zero in another three months.

SBA 'Dictator' Bill Fought

Congressional leaders are expected to block a rider which could give the Small Business Administrator virtual dictatorial power on DOD procurement contracts. The controversial measure, S3903, is an amendment to the Small Business Act proposed by Sen. William Proxmire (D-Wis.) Legislative authorities, including House Armed Services Committee Chairman Carl Vinson (D-Ga.), say it would hand the SBA Administrator power to make defense contracts conform to his judgement in small business subcontract setasides. It would also enable him to obtain contractors' records from government procurement agencies—a "search warrant" as some have termed it.

ICBM Base Catch-up Seen by February

Industry officials in the *Atlas* base contruction program are optimistic about the new AF management set-up (M/R, Aug. 22, p. 8) to end slippage. Some are hopeful of getting back on the original schedule by January or February. Last week, the AF handed over to SAC the remaining three pads of the 564th Strategic Missile Squadron at Warren AFB, Cheyenne, Wyo. The 6-pad squadron is now the nation's first fully operational combat ICBM unit.

Linde's Liquid Hydrogen Plant on Regular Delivery

Linde Co. reports distribution is now on a regular delivery schedule from its new liquid hydrogen plant in Torrance, Calif., which has a capacity of 13,000 lbs. a day. (See cover)

The plant, which went on stream June 27, has shipped more than 300,000 lbs. of the supercold liquid to West Coast missile/space development projects. It is the first privately owned and operated facility to supply liquid hydrogen on a commercial basis. Linde designed and constructed the plant after winning a contract in April, 1959, to sell up to 3,300,000 lbs. a year to the National Aeronautics and Space Administration.

The NASA contract was awarded on the basis of an estimated maximum requirement of 10,000 lbs. a day. However, this need will grow rapidly.

Correction

Several inaccuracies in an article titled "FBM Accuracy Starts with SINS," published in Missiles and Rockets, July 25, 1960, pp. 8-9, have been corrected by Sperry Gyroscope Div. of Sperry-Rand Corp., subject of the story.

The following comments plus statements extracted from a Sperry letter recently received by M/R will clarify the situation.

The M/R story said, in effect, that 12 Sperry Mark III SINS had been delivered to the Navy and that starting in July 19 more would be delivered. This statement, based on a Sperry-Navy press release, is incorrect.

Sperry's recent letter stated: "The article attributes us with the delivery of 12 Mark III Inertial Navigation Systems. Sperry has delivered 12—as a matter of fact, by now we have delivered 16—inertial systems, but technically speaking these are Mark I, not Mark III systems. The major difference between the Mark I and the Mark III is a changeover from an analog to a digital system."

The article further stated that Sperry's Mark III SINS would be installed on the third and fourth *Polaris* subs. This was drawn from the same source and is also incorrect. Actually, Mark III SINS will be installed on the third and fourth subs of the second series.

North American's Autonetics will provide its Mark II SINS for all five of the 598 Class submarines.

Sperry's clarification said: "Our new type SINS, the Mark III, is scheduled to go aboard the four 608 Class submarines and, beginning with this series, Sperry has thus far delivered one."

GE Noise Communications System Promises Top Security

A new noise communications system being developed by General Electric's Heavy Military Electronics Department may prove to be the most secure system ever designed.

The company says signals transmitted by this system will be "as difficult to detect as a needle in a haystack."

Called "Phantom," the broad-band communication system receives and transmits intelligent noise or static. It is a radical departure from conventional narrow-band military communications technique where each radio link is allocated a specific narrow bandwidth to avoid interference and to crowd as many channels as possible into the electromagnetic spectrum. In broad-band communications the transmission bandwidth is many times larger than the intelligence bandwidth.

For military communications, broad-band techniques provide three types of security: security against jamming because of the tremendous amounts of power required to interfere with the transmitted signal; transmission security since the average power is spread over a wide bandwidth making the signal extremely difficult to detect; and message security in that even if the signal is detected, it can be made very difficult for an unauthorized listener to understand what is being transmitted.

• **Special bandwidths**—The system uses a special form of double side-band transmission, resulting in bandwidths much greater than those in conventional practice. The prototype Phantom equipment is designed for use in long-haul, high frequency circuits where multipath conditions are encountered; however, it can be operated at frequencies much lower or higher than HF (3-30 mc) without any major design changes. Its operation is not restricted to any particular frequency, GE says.

Since the system's average power is spread over such a large bandwidth, conventional narrow-band circuits operating within the Phantom channel are unaware of its presence. In normal operation, the Phantom signal appears as random noise, or ordinary static, to conventional receiving equipment.

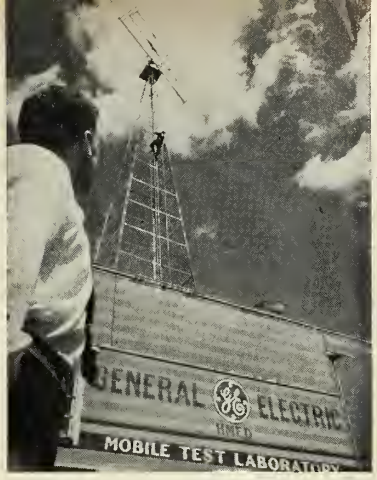
The data rate of the system is purposely kept low in relation to transmission bandwidth. This provides excellent jamming immunity and allows Phantom to be operated in heavily congested portions of the r-f spectrum. The system can tolerate the interference caused by other signals, and at the same time these other signals provide "cover," which enhances the transmission security of Phantom.

In order to receive the Phantom transmissions, an authorized receiving station must not only have the proper equipment, but also knowledge of the operating frequency and the specific signalling wave form being used. Present Phantom equipment has many hundreds of thousands of signalling waveform selections available which can be changed as often as necessary. Two Phantom systems operating in the same frequency band—but using different waveform selections—will appear essentially as random noise to one another. Conventional radio transmissions falling in the Phantom channel also appear as random noise to the system.

Comparable to a combination lock, Phantom is designed so that it can still perform its military communications function even though an enemy knows its frequencies and how it operates.

• **Over 2000 miles**—According to GE, feasibility of the system was conclusively proved during recent field tests when signals were beamed successfully more than 2000 miles.

General Electric engineers working at the receiving site during the field tests with conventional equipment—



THIS 100-ft. antenna at General Electric's Heavy Military Electronics Department, Syracuse, N.Y., was used to receive signals during recent field tests of the Phantom broad-band communication system.

even though they knew what to look for—were unable to locate with any certainty the signal being received by the Phantom equipment nearby. Many different frequencies in the HF band were used during the tests.

High frequency was selected for the field tests because of the severe multipath and interference conditions normally encountered in this frequency range. Besides point-to-point communications, GE foresees application of Phantom in aircraft and satellite communciation systems.

Thermionic Converters Near Market

Practical thermionic converters are now being produced in quantity by General Electric and are expected to be on the market next month. Present output of the pilot-line operation in Schenectady, N.Y., is 60 per week. According to the company, capacity could be stepped up to 100 per week.

These first devices—type Z-5386 vacuum thermionic converters—produce one watt with a minimum thermal efficiency of 2.5%. Each is the size of a silver dollar and weighs three ounces. Cathode temperature is approximately 1100°C.

GE is also pushing research and development in vapor thermionic conversion. Plans are to produce and market the vapor type at a later date. The company believes that outputs up to 20 watts per square centimeter of cathode surface and thermal efficiencies as high as 30% can be attained.

Thermionic converters transform heat from any source—the sun, nuclear reactors, isotopes, chemical and fossil fuels—directly into electricity. They can operate on waste heat from other power-generating methods.

Such devices are particularly attractive as power sources for space applications. Commercial possibilities exist for remote areas on earth.

ONE-WATT vacuum thermionic converter produced by General Electric's Power Tube Department will be commercially available next month. The close-spaced sealed-off unit has minimum power density of 0.2 watts per square centimeter of cathode surface and thermal efficiency of at least 2.5%.

At record WESCON show . . .

Packard Reminds Industry of Its Duty

LOS ANGELES—Hewlett-Packard president David Packard gave his fellow electronic industry managers a talking-to on responsibility last week—spearing at those who would like to pull out of defense work.

Opening up the sixth annual Western Electronic Show and Convention, Packard said the ever-mounting dependence upon electronics by the military had thrust the burden of leadership upon the industry. "We are the heart and nerve center of America's defense effort," he said, adding pointedly:

"The hope . . . that our industry can and should become less dependent on military work is sheer wishful thinking that borders on irresponsibility.

"It will be the continuing task of the electronics industry to add to our military strength for many years . . ."

WESCON, sponsored by the Western Electronic Manufacturers Association and the Seventh Region of the Institute of Radio Engineers, this year drew a record attendance of 40,000 to the Los Angeles Sports Arena. The show was permeated with serious technical presentations, rather than headline-hunting predictions that usually crop up in meetings of this type.

On this note, Dr. William V. Wright said microelectronics pioneered in the U.S. has done much to keep this country abreast of Russia in space.

• **'We launch brains'**—Dr. Wright, who is manager of Electro-Optical Systems Inc.'s Solid State Division, remarked that "Russia launches weight, we launch brains." He said the United States certainly leads Russia in collecting space data.

As an example of microelectronic technology, Dr. Wright demonstrated a silicon disc device that reports the position of a spot of light focused on the disc's surface. He said the radiation tracking transducer could be applied to space navigation systems, satellite tracking, antenna orientation and advanced communications systems. With some modification, the same unit can detect infrared radiation.

Much comment was stimulated by a paper presented by Bernard Baldridge of General Electric's Light Military Electronics Department. He pointed out the danger of pollution of electronic environments by inadequate systems planning.

Denigrating the current emphasis on experts and specialists, Baldridge cited the need for more "generalists" who understand overall system problems, causes and effects. He said the experts must understand that the interactions of our society preclude working in anything like a vacuum.

The ultimate systems interaction, he said, might be a runaway satellite transmitter powered with solar batteries which would require intercept and destruction to permit the frequency to be used again.

Dr. Eberhardt Rechtin, telecommunication division chief at Cal Tech's Jet Propulsion Laboratories, received the 1960 Achievement Award of the IRE Seventh Region. Dr. Rechtin was cited for "research in communications systems and leadership in setting up deep space communications stations."

TECHNICAL

LOS ANGELES—A new approach to semiconductor micro-component packaging was reported at WESCON by Thomas C. Hall of Pacific Semiconductors, Inc.

This was one of a number of advances in the rapidly-expanding technology of microelectronics described at the meeting's technical sessions.

The Pacific Semiconductor technique employs surface passivation, which Hall defined to mean the generation on the semiconductor surface of a chemical film layer which does not adversely affect electronic properties of the surface leading to good device characteristics.

In addition, it provides electrical stability of the surface as well as isolation from electrical and chemical influences which might lead to deterioration.

Hall said that in addition to improved performance and reliability, significant and critical advantages in micro-miniaturization and fabrication are achieved.

He said an order of stability exceeding that obtainable with the best hermetic packaging has been obtained by generating oxidic layers of altered composition and structure on silicon surfaces. These films are attached by strong covalent chemical bonds to the crystal substrate.

Substitution of various organic groupings into the structure of the oxide film renders the film water repellent.

Hall listed these advantages of surface passivation packaging over hermetic packaging of semiconductor devices: improvement in reliability, reduction in size, superior performance, simplification of manufacture and extension of state-of-the-art limits.

• **Layer deposits**—D. J. Shombert and J. Allegretti of Merck, Sharp & Dohme told of a method of depositing layers of single crystal silicon on single crystal silicon substrates. This alternation of layers of controlled resistivity and type was said to permit the introduction of many functional elements directly into a structure. They said elements deposited experimentally in five and seven layer structures include capacitors, resistors, rectifiers, voltage limiting Zener diodes, pnpn transistors and solar cells.

A number of speakers dealt with micromodules, in which interest has been increasing during the year. Radio Corporation of America, in fact, offered what it termed a Basic Micromodule Laboratory specifically intended for electronic equipment manufacturers interested in the conversion of existing systems to the micromodule form. It was described by D. T. Levy.

He said the simple laboratory permits equipment design engineers to design, assemble, and evaluate experimental micromodules in a minimum of time. Taking up 10 ft. of lab bench, the equipment includes not only an airabrader and process control unit, a stereoscopic microscope, solder-coating equipment and a curing oven, but also all necessary small tools, chemicals, jigs and fixtures. It includes a small but adaptable stock of microelements and even an instruction booklet describing the principles of micromodule construction and the methods by which complete electronic circuits may be divided into individual micromodule units.

The laboratory is intended for design engineers as a research tool for building and testing experimental micromodules, not as a production unit, RCA emphasized.

Robert G. Rockwell, Varian Associates, reported on development of a new klystron tube weighting eight oz.

Defense

EQUIPMENT

LOS ANGELES—Outstanding missile and space electronic equipment on display at the recent WESCON show ranged from a large high-performance tape recorder which cost $2-million to develop to an infrared detection device smaller than a lipstick.

The tape recorder was an all solid-state advanced recorder selected by Boeing Airplane Co. for testing of the *Minuteman* missile. It is being used as the primary recorder/reproducer of a telemetry ground station.

The FR-600 recorder developed by Ampex Corp., Redwood City, Calif., also took one of five outstanding design awards at the show. The Ampex recorder is the primary unit of a test system to record telemetry signals during pre-flight, launch and flight.

First production models of the recorder were shipped recently to the Boeing Seattle plant. Seventeen of them will be used in the test program. A normal two and one-half year product development period was compressed into 18 months to meet requirements of the *Minuteman* program, Ampex says.

First nine recorders shipped to Boeing have a frequency range of 300 cycles to 250 kilocycles per second with a 60 ips tape speed. Although this is more than double the bandwidth previously available, Ampex reports that circuitry and magnetic head improvements now are being engineered to extend the bandwidth of the remaining eight Boeing recorders to provide for recording up to 500 kilocycles at a tape speed of 120 ips.

• **Early application**—Boeing's use of the recorders was one of the first major applications of serially recorded data for missile programing. At a tape speed of 60 ips, information is transmitted to the recorder at up to 350,000 bits per second.

Boeing selected a 7-track configuration for the *Minuteman* testing, although the recorder is capable of handling up to 14 tracks on inch-wide tape.

The tape-recorded data in the telemetry system is the primary information source to a tape format convertor. The information is pulse-code-modulated and frequency-modulated telemetry data. Ampex reports that the output of frequency-modulated receivers, containing serial coded PCM information, is redundantly recorded for reliability on three separate tracks.

Remaining four tracks are used for recording conventional FM/FM telemetry signals and other information.

Some of the recorders sent to Seattle will be re-shipped to Edwards Air Force Base, Calif., and Patrick AFB, Fla., after checkout by Boeing system engineers.

Ampex says an all solid-state modular electronic system was chosen to assure minimum down-time and high reliability. Modular packaging permits quick replacement of individual electronic units and the solid-state devices do not require the 30-min. warmup time associated with vacuum tubes. The recorder is applicable to other advanced missile systems.

The lipstick size infrared detector was developed by Raytheon Co.'s Microwave & Power Tube Infrared Devices Laboratory at Waltham, Mass.

The device is for use in detection units pinpointing missiles, launching pads or rocket motor test areas.

The passive beamless unit is said by Raytheon to be the smallest known metal-encased unit in the field of infrared detectors, less than two inches long.

The company says the new detector's long-range operation, its small size and metal casing make it particularly applicable to missiles.

• **Some highlights**—In other developments at the WESCON show:

Mincom Division of Minnesota Mining and Manufacturing Co. introduced a new video band recorder/reproducer which it said could simulate an actual missile flight by feeding original data back to the receiver in the missile.

General Electric's Receiving Tube Department displayed application of ceramic tubes as part of an ultra-high frequency transmitter built by Space Technology Laboratories. The ceramic tubes in Resdel Engineering Corp.'s identified by GE as a 7486 radio-frequency oscillator triode and a 7296 VHF-UHF power amplifier. The STL communication unit was designed to transmit two watts of CW power from a space vehicle 10-million miles from earth. GE also showed use of ceramic tubes, currently in production, were "UDOP" UHF Doppler velocity, acceleration and position systems, which have successfully flown in all *Pershing* missiles, as well as ceramic tubes in a miss-distance indicator built by the Ralph M. Parsons Co.

Leach Corp. displayed a 24-oz. tape recorder carried by Air Force Capt. Joseph Kittinger to record medical data on 14 separate magnetic channels during his 19½-mile leap from a balloon. It was learned that Leach has under development one half as small, 10½-oz.

Corning Electronic Components, Corning, N.Y., announced plans to market one-watt and half-watt high quality film resistors in direct competition with composition resistors. The one-watt resistors will sell for 6.1 cents, the half-watt for 5.9 cents.

Collins Radio Co.'s Western Division, Burbank, Calif., unveiled mechanical filters with ferrite transducers for the first time. Improved performance was said to result from replacing of former nickel-alloy material with the ferrite transducers.

Nike-Hercules Goes Mobile

THE ARMY shows the mobile Nike-Hercules for the first time. The Western Electric air defense missile—now packing an antimissile punch—is mobilized with a Douglas M-94 field installation kit including jacks, outriggers and blast deflector.

BMD beefs up . . .

Air Force Satellite Program Gets New Boss

Greer will bring sharp eye to job of expediting Midas, Samos and Discoverer

by Clarke Newlon

The man the Air Force has selected to boost USAF satellites higher—and to do it faster—is a tall, lean West Pointer, class of '39, a command jet pilot and an electronics engineer who catches errors in computers.

He is Brig. Gen. Robert E. Greer, who will assume his duties as Vice Commander of the Air Force Ballistic Missile Division for Satellite Programs on October 1. Actually, he is already spending more time in the BMD offices at Englewood, Calif., than his own at the Pentagon where he was Assistant Chief of Staff for Guided Missiles.

General Greer's assignment as satellite boss and expediter comes coincidentally with word from California that BMD will hike its personnel from a present 2000 to nearly 7000 in the next two years and to 12,000 in the coming 4-5 year period. Eventual payroll: $100 million annually.

In Bob Greer's Pentagon office he kept an old-fashioned s c h o o l - room blackboard hanging by his desk. In the course of a normal conversation he would cover it with mathematical equations, sometimes to satisfy his own thinking, sometimes to clarify a point. The mistake the computer had made was not really the computer's fault. It had been fed one bit of wrong data. Neither the computer nor Greer knew this but only Greer knew the answer was wrong.

One of the general's main jobs at BMD will be to push the *Midas* and *Samos* programs, but it will be more to keep a critical eye on the entire Air Force satellite schedule, as his job title indicates.

Under his sharp scrutiny will come, in time, the *Discoverer* satellites, one of the next two of which will probably put a monkey in space and, hopefully, recover it.

General Greer was not, he says, too impressed with the latest feat of the Russians in putting their menagerie in orbit and recovering it. But the reason he was not impressed was, he said, that it had been apparent for some time they had such a capability.

• **On Soviet ability**—Will the Russians put a man in space?

"No doubt of it," he said. "Not the slightest doubt."

"When?"

"Within the next six months," he thought and then qualified that. "Make it the near future."

"Like October?"

"It's possible," he said. "Mostly it depends on their program, on how flexible it is. They may have programed more than one shot carrying animals and if their program is rigid, they'll do that again. If they are flexible they could wipe out animal shots and go right on to man. Or, they may have planned only one animal shot.

"Actually," he continued, "now that they have proved they can land a capsule where they want it and land it safely, the feat of putting up a manned vehicle is simpler than an unmanned.

"In the unmanned operation you have to depend on servo-mechanisms and pre-programing. They have definite limitations. A man in the satellite, though, makes things much simpler. He can think and react. He can look up or down and figure out his position for stabilization. He can focus a camera, fire a retro rocket, handle controls and guidance. He's about the best servo-mechanism ever built."

General Greer felt that some of the long Pacific Ocean shots made by the Russians were tests for the menagerie shot and for the manned capsule which will follow it.

The Soviet feat of landing their capsule with an accuracy of six or seven miles he thought showed high technical skill and high confidence in that skill. He also explained how he thought they had accomplished such precision.

The Russians, he said, have sufficient thrust in their booster to carry aloft an inertial guidance system, regardless of weight. They can guide their satellite into exactly the orbit they wish. Knowing the exact orbit they can also predict where it will be at any given second, kick it out of orbit with a retro-rocket and land it with great accuracy.

Because our *Thor-Agena* has not sufficient thrust to lift the *Thor's* inertial guidance system as well as a payload, guidance is forfeited. The *Discoverer* satellites are guided into orbit by an auto pilot which is preprogramed and which cannot correct for wind drift or gyro error, for instance.

Hence, without precise knowledge of the orbit the U.S. satellite recoveries have to account for a much greater margin of error—a margin figured in 200 or more miles instead of 10.

This is also the reason the U.S. recoveries are scheduled over water instead of land—to prevent the possibility of a satellite landing on, say, Los Angeles.

Navy & Air Force Bullpup

Air Force Mace

Army Lacrosse

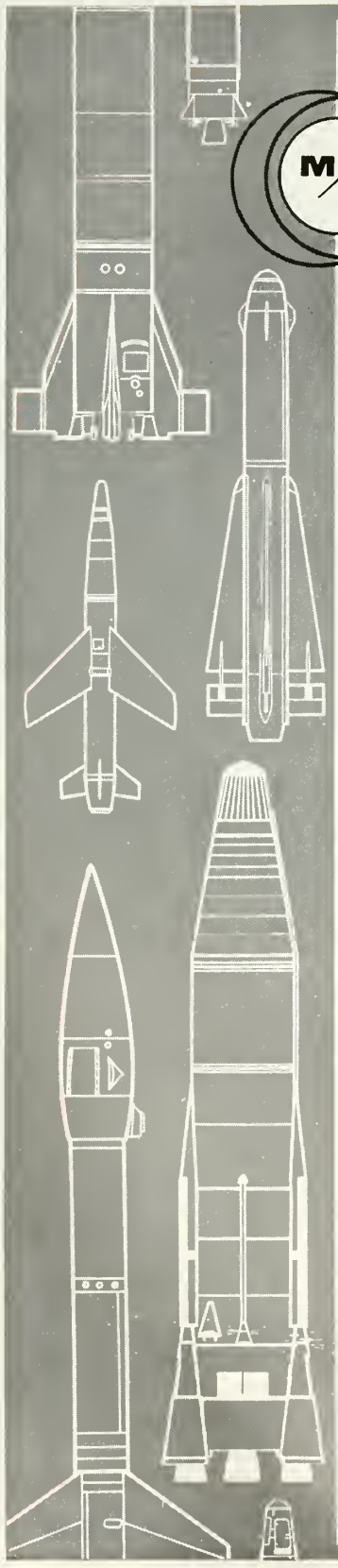
Army Pershing

At 00h00m01s GMT, September 1, 1960, Martin logged its 658,008,000th mile of space flight

Air Force Titan

Five major U.S. missiles developed and built by Martin

MARTIN



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THE MISSILE/SPACE WEEKLY

missiles and rockets

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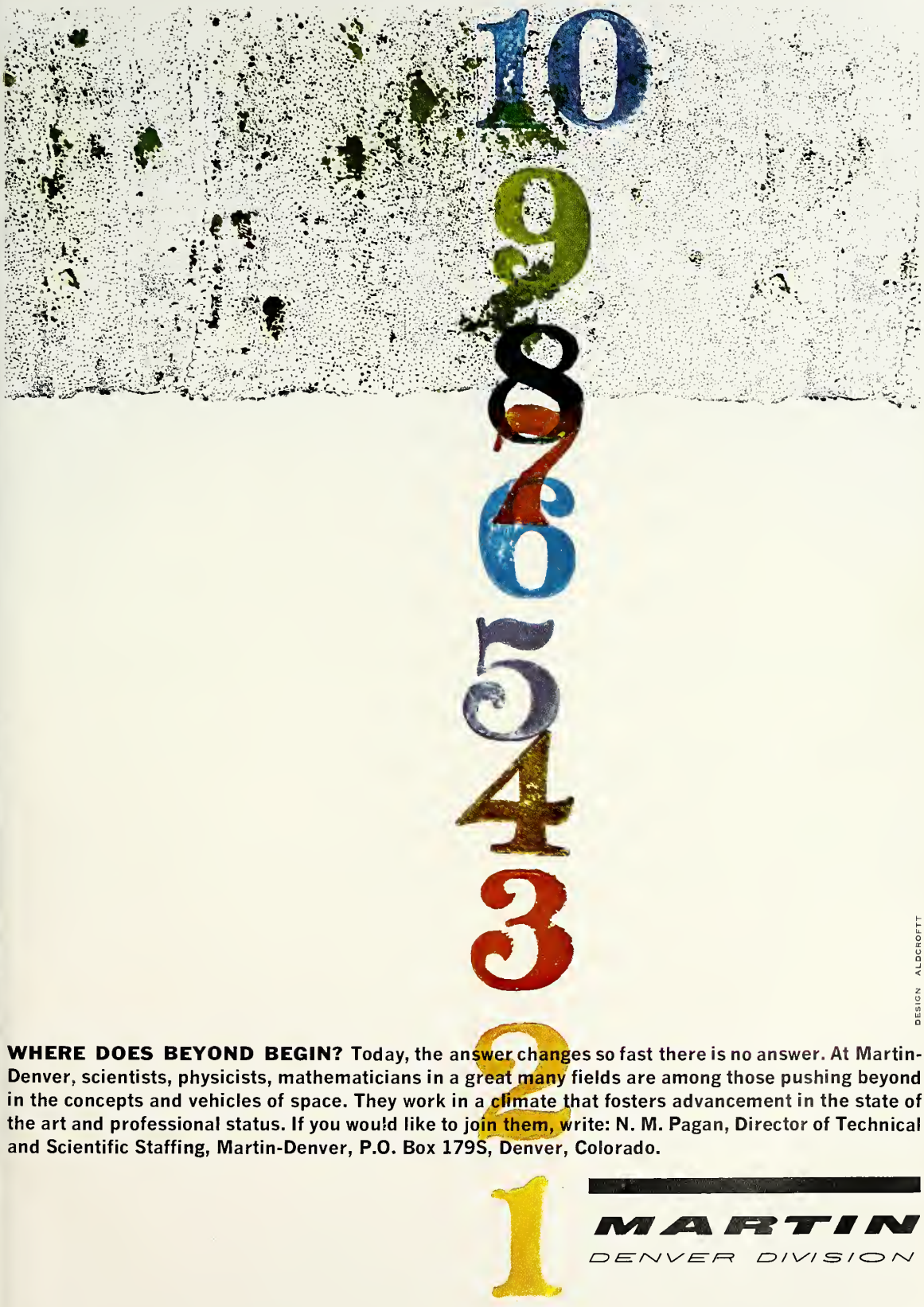

DESIGN ALDCROFTT

WHERE DOES BEYOND BEGIN? Today, the answer changes so fast there is no answer. At Martin-Denver, scientists, physicists, mathematicians in a great many fields are among those pushing beyond in the concepts and vehicles of space. They work in a climate that fosters advancement in the state of the art and professional status. If you would like to join them, write: N. M. Pagan, Director of Technical and Scientific Staffing, Martin-Denver, P.O. Box 179S, Denver, Colorado.

MARTIN
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NIKE-ZEUS

Repeated successful R & D launchings of the U. S. Army anti-missile missile have demonstrated the capability of its Thiokol booster to start the missile on its way to reach high altitudes in seconds. The Zeus' Thiokol motor boasts highest thrust of any single solid rocket in the free world... 450,000 pounds. Thiokol means reliability!

Prime Contractor: Western Electric. Missile: Douglas.
Booster Motors Propulsion Contractor: Thiokol.

THIOKOL

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Rocket Operations Center: Ogden, Utah
Nike-Zeus Motors produced at the Redstone Division

Technical Countdown

ELECTRONICS

Titan II Guidance To Fly Next Spring

First flight test of AC Spark Plug's all-inertial guidance system reportedly will be in the spring of 1961. Touted as extremely accurate, the system also features small volume (1.1/3-cu.-ft.) and weight (below 200 lbs.).

Cosmic Deluge Upsets Theory

MIT physicists believe they have recorded the heaviest cosmic-ray shower ever observed. Because of its unusually high energy level, scientists believe that the source was beyond our galaxy (which conflicts with present theory of cosmic ray origin). Detected in Albuquerque, N.M., last Dec. 3, the shower rained down 10^{10} atomic particles during a period of only 10 microseconds. The primary cosmic ray causing the shower had energy from 20 to 40 billion bev, scientists said after a three-month analysis.

Thermionic Converters Available Soon

One-watt vacuum thermionic converters are now in pilot production at General Electric's Schenectady plant. The 3-oz., 2-in.-dia. miniature power sources will be commercially available by October, says GE. For the near future, the company is developing vacuum-type converters with 5-w output and cesium vapor-type converters with up to 20w/sq.cm. output. Until now, all of GE's production has been for its own missile/space use.

No Shadow Operation For Echo

The *Echo I* radio beacon is now operating solely on its solar cells. The beacon goes off each time the balloon satellite moves into the earth's shadow. The balloon remained almost fully inflated during the first few shadow crossings.

Self-Cooled Accelerometer Developed

An integral self-cooling system for accelerometers, patented by Dr. Leslie Gulton, will allow the sensing units to endure temperatures of more than 2000°F. An expansible gas under ultrahigh pressure—released at prespecified temperatures into an expansion chamber surrounding the accelerometer—absorbs heat and cools the wall enclosing the instrument.

Thermoelectric Units Both Heat and Cool

Temperatures of crystal filters in an IR detection system were controlled within 0.5°C by Westinghouse thermoelectric cooling devices in a recent *Aerobee-Hi* rocket shot. The NRL probe was reported to be the first use of such devices for both heating and cooling.

GROUND SUPPORT EQUIPMENT

Titan Base Wiring Prefabricated

Wiring and cabling for an entire *Titan* base is prefabricated in the factory in a new technique developed by Martin. The prefab harness—widely used in mass-production of electronic chassis but never before extended to such heavy cable and long runs—is said to be quicker, cheaper and more reliable than conventional methods.

Contract Awarded for HIPAR Radars

General Electric HMED has been awarded a $14.5-million production contract for high-power acquisition radars (HIPAR) for Army's improved *Nike-Hercules*. This radar—reported to triple the effectiveness of the weapons system—was credited with the recent successful kill of one *Hercules* by another.

PROPULSION

Hydrazine by Neutron Bombardment?

Fissio-chemical production of hydrazine from ammonia—by bombardment with neutrons from a nuclear reactor—is under investigation by Aerojet-General Nucleonics as a possible means of cutting cost. A-GN is making the study under an Air Materiel Command contract.

Secret Test Lab Revealed

Full-scale component testing with liquid hydrogen is conducted at a hitherto secret AiResearch facility near Boron, Calif. The test center, built in 1957 for the Air Force, is capable of evaluating liquid hydrogen pumps and heat exchangers.

ARC Broadens Scope

Atlantic Research has moved into the ramjet fuel business. Wright Air Development Division last week awarded ARC a contract for development work on high-volumetric-heating value slurry fuels. Combustion testing will be subcontracted to Marquardt Corp.

ASW ENGINEERING

Environments Differ, Techniques Same

Convair is using flight-test data techniques to record temperatures of underwater waves under a one-year, $130,000 Office of Naval Research contract. Data recording and processing methods are acquiring and handling information five times as fast as those now in use for oceanography.

No Hams; It's Fish or Fowl Operators

American Electronics Laboratories, Inc., Phil., has developed for the Office of Naval Research a tiny radio transmitter to be carried by pigeons. It has a 2-week life and a 22-mile range. A later model for attachment to an albatross will have an 800-mile range and a five-month lifetime. Marine biologists are looking at the transmitters for possible attachment to sharks, porpoises and whales to send back internal and external data.

ADVANCED MATERIALS

High-Temperature Alloy for Pluto

Vital components for the Project *Pluto* nuclear ramjet engine will be fabricated from Sierra Alloy, a high-temperature, radiation-resistant material from American-Marietta Co. *Pluto* is slated to be the propulsion source for *Slam*, a low-level supersonic weapon.

Titan II Will Get More Payload in

DENVER—*Titan II* will be developed with tooling, testing and electronic facilities based on those designed for *Titan I*, but with greatly improved performance, reliability and reaction time, Martin-Denver says.

The company expects to phase its facilities here from the original version of the two-stage ICBM to the follow-on version with a minimum of effort and complication.

The biggest single change from a tooling point of view is the expanded diameter of the second stage from eight to ten feet, equalling the first stage size. Materials used in the two systems will be identical in most cases, jigs and fixtures will apply to both, and fabrication techniques will be equally applicable.

Testing, to be conducted here with the exception of actual flight, will all be handled in *Titan I* facilities. Test stands D-1 and D-2 are now being retrofitted for the 108-ft.-long *Titan II*. Static tests of the complete missile are expected here next year.

Tests of components and subsystems are already being carried out and Aerojet-General Corp., the propulsion system contractor, has been testing the storable engines for several months.

• **Accent on simplicity**—The prime interest in the *Titan II* system is reliability, not optimum theoretical performance. As one program executive remarked: "The first engineer who suggests a design modification in the interests of sophistication will promptly be shot."

Range of the storable-fuel missile will be in excess of 12,000 miles, according to Martin. This figure is based on a payload weight equal to that of *Titan I*. Despite its heavier payload, *Titan II* is expected to surpass the range capability of any other ICBM system.

Some structural "beefing up" will be provided for two major reasons: the requirement for an in-silo launch, and the denser nature of the storable fuels. The former beef-up results from studies

Range and Production Line Modification

by Frank G. McGuire

First stage of Titan I is shown on production line at The Martin Co.'s Denver Division.

of acoustical and vibration factors present in an in-silo launch.

The Aerojet engines will provide the *Titan II* with slightly greater thrust than its predecessor, through a series of modifications to the powerplant. The engine will have a space-start capability, making it useful as an upper stage for future extremely large boosters.

Most of the additional ten feet in length will be accounted for by tankage in the first stage. A slight increase in second-stage length will be used for the payload compartment, making possible a larger warhead. The second-stage tankage increase will result from the enlarged diameter, not lengthening.

• **New sequence**—Additional changes are planned in subsystems, such as the stage separation sequence. In the *Titan II* sequence, the second stage will ignite while still connected to the first stage, and the engine blast will insure separation. An interstage connector will have a number of slots located about its periphery to allow initial escape of engine gas and flame until separation is positively achieved. Velocity at this point is about 6000 to 7000 feet per second. The *Titan I* system called for a delay in second-stage ignition until the two stages were about 15 ft. apart.

The 15-ft. distance was supplied by two solid rockets mounted on the second stage. These performed the dual function of aiding separation while supplying a positive force to feed fuel to the second-stage turbopumps. Without this force, Martin said, there was danger of the liquid forming globules and floating around the tank in weightless condition.

Accuracy of the engine cutoff is believed to be such that verniers will not be required for final velocity and course correction. *Titan II* will, if this is true, have an extremely clean configuration and simple operation sequence.

Mass ratio of *Titan II* is believed to be roughly equal to that of its predecessor, about .94. (The German *V-2* had a mass ratio of about .57).

An all-inertial guidance system by AC Spark Plug will replace the present radio-inertial system supplied by Bell Telephone Laboratories. The re-entry vehicle will be made by General Electric.

The scheduled launch in October of a *Titan I* from its silo at Vandenberg AFB is designed to test certain *Titan II* design features. These will consist mostly of structural changes, including the modification of chemical milling areas to reflect the altered requirements of strength vs. weight.

• **Production**—Martin plans no production lots for the *Titan II,* primarily because it is being designed from the start as an operational configuration and will undergo as few engineering changes as possible, consistent with system reliability and simplicity.

The entire *Titan I* vehicle is estimated by Martin to have "fewer parts than the nose section alone of some modern combat aircraft." Spares will be selected from the approximately 23,000 line items in the missile and kept on hand at maintenance and overhaul depots, such as the San Bernardino Air Materiel Area. Parts in *Titan II* will probably number significantly less.

The company estimates that chemical milling applied to the fabrication process has reduced weight of the vehicle by 900 to 1000 lbs. Although the exact areas to be chemically milled on *Titan II* are not yet determined, a comparable weight saving is expected.

Basic airframe material on *Titan* is 2014 aluminum alloy, supplied by Dow Metal Products Co., Harvey Aluminum, and Alcoa. Martin devised special welding methods for the alloy, due to its undesirable characteristics. The excellent strength-to-weight ratio of 2014 led to its choice.

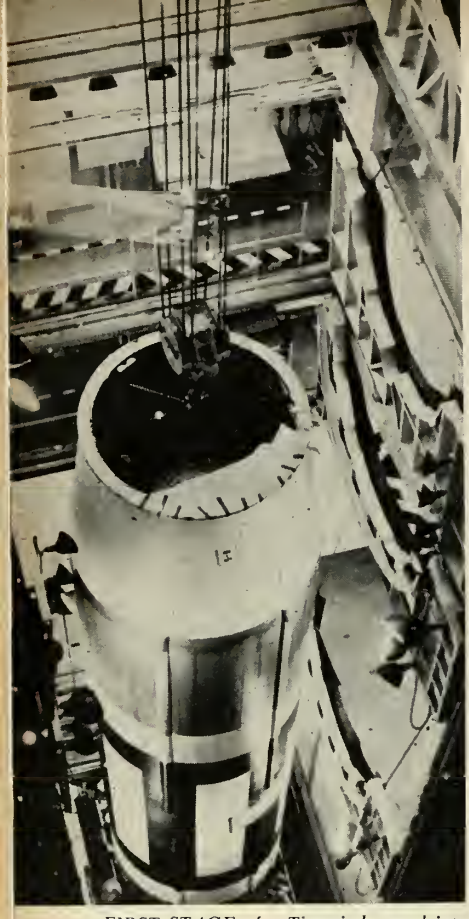
• **Welding**—Manufacturing development engineers at Martin established a process using an inert-gas shielded tungsten arc with an aluminum filler wire. It was found that this also kept the heat-affected zone in the parent material to a minimum.

Tensile strength in the welded joint is maintained through use of an aluminum backup chill bar which dissipates heat. A steel plate located under the butt joint prevents the parent material from adhering to the fixture during welding.

The overall welding technique is roughly similar to that used in welding magnesium-thorium alloys on the *Polaris* FBM.

• **Panel treatment**—Extruded panels are received from suppliers in a semi-hardened condition, and are subsequently machined in order to maintain a tolerance of 0.050 in. thickness.

One supplier of skin panels, Dow, extrudes them in a 13,200-ton press at its Madison, Ill., plant, one of the three largest such presses in the world. Panels are extruded in "U" and "V" shapes to



FIRST STAGE of a Titan is lowered into place in a cell of the Vertical Test Fixture. Here, for first time in production sequence, both stages are mated.

achieve a required 34-inch width. They are then straightened and flattened to close tolerances. Flatness tolerance in bend areas on the stiffener side is 0.030-in.-convex, and the side 0.030-in.-convex-or-concave.

Panels are extruded in 37.-ft. lengths —the "U" shape being used for panels with three stiffeners, and the "V" shape for panels with two stiffeners. After the flattening process in Dow's contour-correction equipment, panels are sent to the stretcher for desired percentage of stretching.

Machining at Martin-Denver is done on the flush surface of the panel, using a tape-controlled Giddings and Lewis Mill, then on the reverse side between the "T" shaped stringers.

Following machining, panels are mounted on a Kirksite contour block, placed in another stretch press and formed to the proper radius. The Hufford press used in this operation is reputedly the first of its size and capacity to be used in the industry. It has a 1400-ton capacity and measures 43 ft. long, 11 ft. wide and 20 ft. high.

Chemical Milling follows the stretch press operation. Neoprene base materials prevent the etching solution from attacking portions of the panel to be kept constant. The neoprene is scribed, after being cured, and by peeling off selected sections Martin has in effect a template which determines where the alloy will be affected by the etchant.

• **Assembly**—The *Titan* is composed of twelve of these panels, which are assembled in a locating fixture in groups of three and automatically welded together longitudinally. The locating fixture, custom-built for the *Titan* program, consists of a bed assembly, locating and clamping paddles, a welding bridge and the automatic welding head with its control system.

The "T"-shaped stringers running the length of each panel are used by the pneumatic clamps to hold the panel in position on the weld fixture. Three panels at a time are welded into a quarter-barrel assembly.

After four of these quarter-barrel assemblies are complete, they are clamped to the locater paddles and welded together to form the complete barrel which constitutes the *Titan* airframe. Upon completion of this operation two electrical cutting heads trim the ends of the barrel.

Domes to form the ends of tanks for the vehicle were fabricated in "orange peel" fashion until the development of equipment which could fabricate them of fewer segments, including a specially-formed dome cap with formed-in outlets for liquid flow.

After completion of welding on the dome itself, two of the finished domes are placed in chucks on a welding fixture, while a completed barrel assembly is placed between them on a rolling base. All fixture segments are synchronized so that they roll together, resulting in butt joints being formed by component edges. The weld is performed by a fixed welding head, which remains in one position while the workpiece rotates before it, thus accomplishing the job in one pass.

Both visual inspection and the use of a dye penetrant are utilized to verify the integrity of welds. All welds of tank panels, domes and finished barrels are checked by X-ray techniques as well.

Following X-ray tests, tanks are subjected to hydrostatic operations, which accomplish testing, cleaning and finishing of metal surfaces. Hot air and nitrogen are then introduced into the tank, one after the other, to dry it and reduce the dew point to 10°F. Finished and tested tanks are then sealed.

Tankage assemblies, engine fairings, inter-tank structures and transition assemblies are then positioned in fixtures for joining.

• **Testing**—Because of the extreme reliability required of *Titan*, Martin-Denver has adopted a building-block approach to testing. Components, then subsystems, then complete systems are checked out thoroughly. Electrical components and harnesses are bench-tested, and relays are subjected to simulated missile electrical loads.

Hydraulic and pneumatic subsystems are tested against specifications in facilities with up to 15,000 psi hydrostatic pressure available.

Upon completion of the vehicle, the missile is taken to the vertical test facility, a 13-story structure with isolated test cells.

This vertical test facility (VTF) has provisions for completely isolating the missile from outside interference while electrical and electronic checks are performed in one of the nine test cells.

"Marriage system checks" are performed on guidance, control systems, telemetry, pressure lines, and correct sequencing. A complete countdown is carried out, and electronic simulation of engine firing and flight sequences is included.

How Titans Compare

	Titan I	Titan II
Height	98 ft.	approx. 110 ft.
Diameter (1st stage)	10 ft.	10 ft.
Diameter (2nd stage)	8 ft.	10 ft.
Weight	220,000 lbs.	approx. 250,000
Range	7000 stat. mi.	10,000 stat. mi.
Guidance	radio inertial	all inertial
Propellant	liquid	storable liquid
Thrust (1st stage)	300,000 lbs.	400,000 lbs.
Thrust (2nd stage)	80,000 lbs.	100,000 lbs.
Operational	1961	1963

Parts Reduced in Titan II Engine

Switch to storable fuels eliminates ignition system and provides space start capability for big vehicles

SACRAMENTO, CALIF.—The *Titan II* engine is expected to have only about half as many control components and moving parts as the original *Titan* design, according to Aerojet-General Corp., associate contractor for propulsion on both versions of the two-stage ICBM.

The company is relying on simplicity to provide high reliability in the storable-fuel version of the Martin missile.

The estimate of parts reduction includes ground support equipment and reflects elimination of the helium and nitrogen start systems, the ignition systems, and many valves and regulators. Instead of the start systems, solid-propellant gas generators will be used to spin the turbines at launch to feed propellants to the engine.

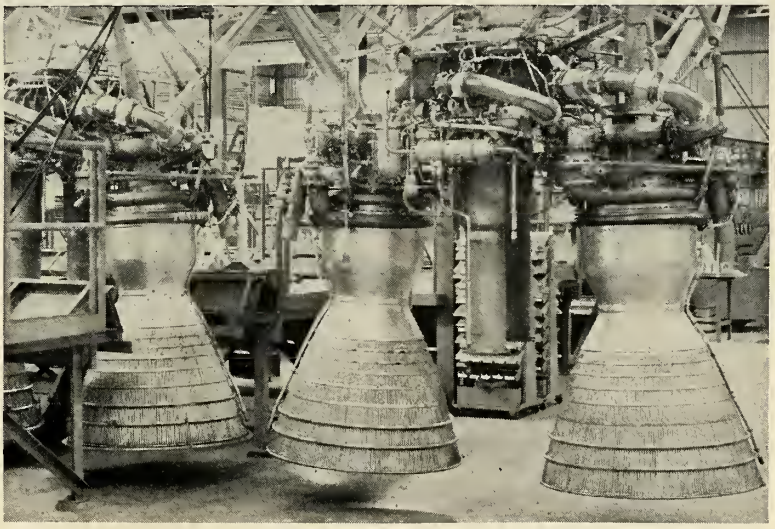
Adoption of storable hypergolic fuels has enabled the company to eliminate the ignition system.

Aerojet has dubbed the storable fuel mixture for *Titan II* "Aerozine-50"; it is a composition of 50% hydrazine and 50% unsymmetrical dimethylhydrazine. Aerozine-50 will team up with nitrogen tetroxide to power the two-stage ICBM with more than 400,000 lbs. thrust in the double-barrelled first-stage engine.

As it did with *Titan I*, Aerojet will follow the now-in-vogue concurrency concept—simultaneous development and production of engines. The phase-in of the *Titan II* on the heels of the *Titan I* model is expected to be relatively smooth.

• **Eligible for space**—An additional feature of the first-stage engine which will have no direct application to the weapon system, but will make *Titan II* a front-runner for any upper-stage job in huge space systems, is the capability of a space start. The hypergolic nature of the storable propellants greatly simplified the problem of starting the big engines in space, and the already proven second *Titan* stage will be a natural companion for third-stage honors atop any new super-booster.

Aside from the great reduction in parts, modifications of the engine for its *Titan II* role will include changing the seals on fuel and oxidizer lines and valves, altering mixing ratios, and re-working injector plates.



FIRST-STAGE ENGINES for Titan I at the Sacramento Liquid Rocket Plant of the Aerojet-General Corp. Titan II first stage will have similar specifications.

Aerojet has been testing a storable-fuel version of the *Titan* engine for several months.

The particular storable fuel mixture chosen for *Titan II* has the following general characteristics: weight mixture ratio of 2.00; volume mixture ratio of 1.24; combustion temperature about 5590°F; characteristic velocity about 5725 fps; and specific impulse approximately 288. These are calculated at 1000 psia, shifting equilibrium and optimum expansion at sea level.

Aerojet is reported to have made some increases in specific impulse performance and other properties. Specific impulse figures for the *Titan II* propellants, for example, have been estimated to be equal to the LOX-RP 1 combination of *Titan I*.

• **Similar specs**—First-stage engine dimensions and specifications for the *Titan II* will undoubtedly follow the *Titan I* design closely. Designated the LR-87-AJ-3, *Titan I's* booster has an overall length of 10 ft., a maximum width of 9 ft., and a gross weight of 3700 lbs. It is a bell-nozzle configuration using regenerative cooling and having an area ratio of 8:1.

Fabricated of stainless steel, the double barrels use common missile tankage for propellant supply. About 250 stainless steel tubes are welded side by side to conform to the properly shaped mandrel and shape the thrust chamber. Burning time is 120 seconds.

The second stage generates about 80,000 lbs. thrust at altitude (equivalent to about 60,000 at sea level) and is billed as the free world's largest space-started rocket engine. It consumes about 25 tons of propellant during its 150-second burning time.

Designated LR-91-AJ-3, the engine's bell nozzle thrust chamber is partly regeneratively cooled and has an area ratio of 25:1. Entire engine unit is about seven feet long, four feet wide and weighs about 1300 lbs.

When modified for the *Titan II* vehicle, the first and second stage engines will be re-designated LR-87-AJ-5 and LR-91-AJ-5, respectively.

Safety Stressed in A-G's Storable

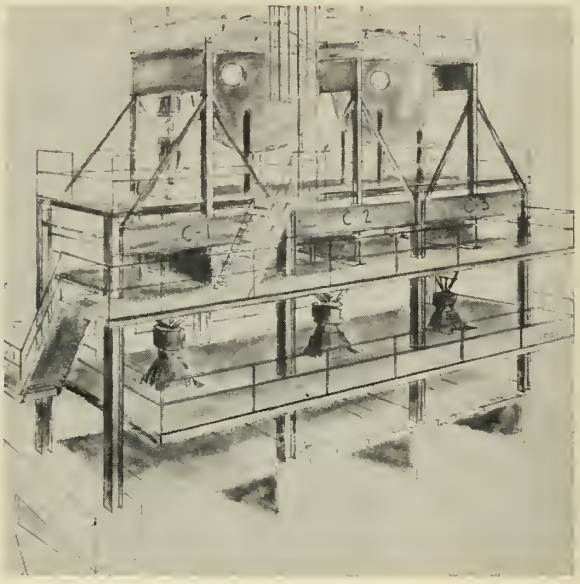
by Dan M. Tenenbaum
Manager, Test Divisions
Aerojet-General Corp.

SACRAMENTO, CALIF.—Development of engines for *Titan II* has required some major changes in test facilities at Aerojet-General's Liquid Rocket plant here to accommodate the storable propellants nitrogen tetroxide and Aerozine-50 (a 50-50 mixture of UDMH and hydrazine).

Important modifications include: conversion of engine test stands and a new central storage and pumping facility for propellants; a new remotely controlled continuous mix station for Aerozine-50, so that the constituents can be mixed as they are unloaded from tank cars; a 5½-mile railroad spur for direct transportation of propellants to the storage area, and a number of new safety devices to protect personnel from the possible hazard of toxic vapors.

The present facilities, built for developing *Titan I* engines, were designed to accommodate liquid oxygen and RP-1, a hydrocarbon type fuel. Interim modifications to existing facilities are being utilized for *Titan II* engine tests until construction and conversion of the new facilities is completed late this year.

In the new design and modification work, the most important considerations were the toxic nature of the storable propellants and, hence, the need for extra safety measures for the personnel who handle them. Aerojet's extensive experience with storable-type propellants, posing the same or similar handling problems, has helped greatly in the present rapid changeover. Our experience with storables includes developing rocket engines for assisted take-off of the Air Force B-29, B-45, B-47, and F-84 aircraft; inflight thrust augmentation on the Air Force F-86 airplane; and propulsion systems for the *Aerobee, Bomarc, Nike, Vanguard* second stage and *Able* second stage.



← *THRUST Chamb test Stand C-1-2-3 ce version depicted in artist's drawing.*

COMPLEX of th test stands on each s of control room un bunker in center.

Work on *Titan* engine testing is an around-the-clock operation for 1150 members of the Liquid Rocket Plant Test Division.

• **Test area**—The liquid rocket test area is composed of 24 high-thrust test stands ranging in thrust capability from 150,000 to 1,500,000 lbs. The high-thrust test stands are constructed in groups of three on a common concrete structure referred to as a complex. The basic test stand structure consists of a reinforced concrete base with steel superstructure to accommodate the propellant run tanks and rocket engine thrust mounts.

The 24 test stands are separated into four test zones. Each zone consists of two complexes, operated from a reinforced concrete, revetment-protected control building housing two control rooms, one for each complex. Each test zone also contains a test shop for the maintenance of test stand equipment and instrumentation for checkout of rocket engines and components prior to test.

Each zone has its own gaseous nitrogen, fuel, oxidizer, and water supply and distribution systems. Two of the test stands are capable of simulating altitudes up to 250,000 ft.

A vibration facility is provided for dynamic vibration and shock testing of components and complete engine assemblies.

The high-thrust test facilities are augmented by a fifth test zone which is used for component testing. This facility includes five control buildings—each operating up to four test set ups and a time-versus-volume flowmeter calibration facility.

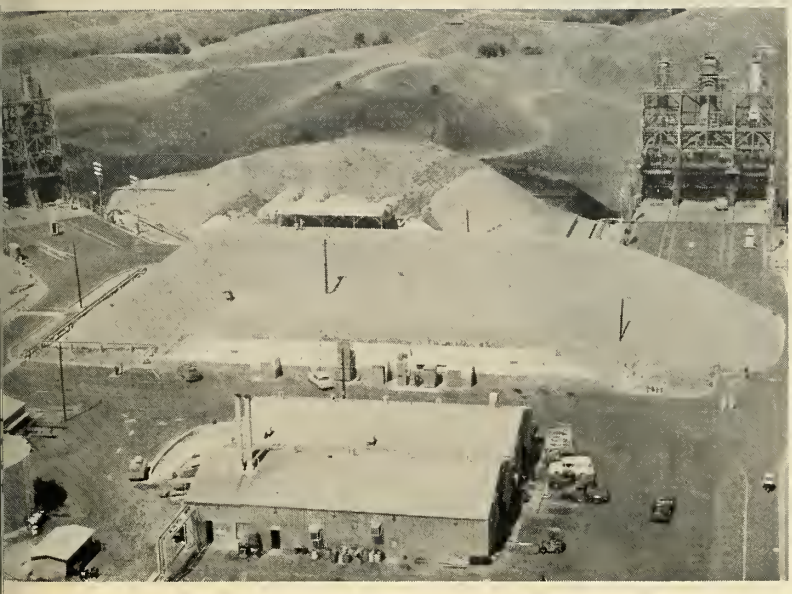
• **Propellant storage and distribution**—The bulk storage and distribution control system is centrally located. The selection of this area was influenced by two factors; it was minimum distance for a single bulk storage facility, and it most nearly complied with quantity-distance regulations established by for the propellants hydrazine, UDMH, and nitrogen tetroxide.

Fuel and oxidizer unloading stations are provided for truck and rail-

About the Author

D. M. (Dan) Tenenbaum directs testing operations for both the Liquid Rocket Plant and the Solid Rocket Plant of Aerojet-General Corporation near Sacramento. An Aerojet employee since 1948, he was responsible for testing of numerous rockets for aircraft programs. He now directs rocket engine testing for the Titan, Polaris, Minuteman and other Aerojet projects.

est Facilities



car deliveries. The unloading operation, as well as the fuel mixing and coordination of transfer to the various test locations, will be controlled from the central control building located within the storage area. Propellant spillage and scrubber effluent are directed to the large concrete-lined water sump equipped with a pH meter to detect excessive concentrations of fuel or oxidizer. Chemicals are added to provide neutralization if the concentration exceeds the normal limit.

The unloading of the tankers, which are pressurized by nitrogen, and the transfer from the storage facility to the test stand tanks, is an operation remotely controlled from the station located in the storage area. It is conducted from a process-type display panel with an override control at the receiving point for use in the event of an abnormality.

• **Fuel mix facility**—Since Aerozine-50 fuel is not supplied in the blended condition, a fuel mixing facility had to be constructed. This facility is located between the fuel unloading station and the fuel storage.

Two stainless steel tanks having capacities of 11,300 gallons (UDMH) and 8800 gallons (hydrazine) are mounted on strain gage load cells. The fuel components are pumped separately but simultaneously from each outlet into an impeller mixer, the output of which is directed to the fuel storage tanks.

Continuous recording of the percent mix is presented at the control station on a potentiometer-type strip chart recorder. In addition, a continuous record is made of the specific gravity of the mix. The percent mix display includes visual limits of mix, as well as off-mix alarm devices. The tank load cell system provides a backup with these system refinements:

a. A check on the overall ratio of the mixed fuels.

b. A record of the delivered propellant weight.

c. A backup in the event of a failure of the conductivity system.

• **Scrubbers**—Scrubbers are provided to minimize the toxicity of the propellant vapors expelled from the test stand run, catch, or storage tanks during any venting operations. Interim scrubbers of the water spray or chemical type have been used.

The operational facility has venturi throat scrubbers typical of those manufactured by the Schutte and Koerting Co. The gases are scrubbed by the action of the liquid spray—a 20% sodium hydroxide solution for oxidizer gases, and water for fuel gases—which creates sufficient suction to entrain the gas and enter the throat of the venturi where the gas and spray are mixed and the gas thoroughly scrubbed.

• **Test stand systems**—For the storable propellants, all bleed and drain systems are closed-loop (i.e., propellants are never intentionally exposed to the atmosphere) or routed into scrubbers. In addition, downward slopes are maintained in all propellant lines to provide for ease of draining and bleeding; propellant outflow from the bleeds and drains is routed into a catch tank for each propellant. All propellant vapors are routed through the scrubbers for each propellant.

Catch or dump tanks are provided for each propellant in each test zone. They have enough capacity to contain the full run tank volume in the event of an emergency that requires rapid evacuation of the propellant run tanks. These tanks are also used as catch tanks for all closed-loop bleeding or draining effluent.

Provisions have also been made to transfer contaminated propellant from these tanks into tank trucks for disposal or refining.

Propellants which have been inadvertently spilled are immediately washed down with copious amounts of water. Concrete drains route the spilled mixture into a large concrete sump equipped with a pH monitoring device. When excessive buildup of a propellant is noted, the sump is chemically treated to neutralize its contents. The deflector residue is also routed into this sump.

Ground water outflow from the plant perimeter is continuously monitored to detect the presence of excessive propellant residue. If excessive buildup is detected, the outflow is directed into retention ponds for chemical treatment.

• **Safety**—Safety of personnel has been a major part of this program from its inception.

Design of the system for safety has naturally been stressed. We have also added emphasis on pre-planning to insure that all employees completely understand the work to be performed, installed a buddy system so that no employee is allowed to work alone on storables, and thoroughly instructed employees on comprehension of safety clothing and the plan for unexpected emergencies.

The current medical history record of a representative group of personnel has shown no adverse effects as a result of their daily work with storables.

FROM LABORATORY CURIOSITY TO MISSILE TRAJECTORY...

MICROELECTRONIC GRAY MATTER FOR

TOMORROW'S air and sea launched ballistic missiles will fulfill a pivotal role in the nation's retaliatory arsenal. Directing their flight will be revolutionary guidance computers, miniaturized to a point far beyond the limit of conventional design techniques.

But before this degree of miniaturization can be achieved in a computer *that must be more than a laboratory curiosity* a radically new design philosophy must be applied.

Engineers at G.E.'s Light Military Electronics Department are meeting the challenges of size and sophistication by pursuing a predominantly *functional* approach to micro-electronics... exploiting the versatility of tunnel diodes and other semiconductors in conjunction with thin film circuit wafers.

And by designing *for* microminiaturization from the start, not only is it feasible to achieve far greater component densities — the development of standardized circuits and functional modules also reduces the numbers of components and connection interfaces, significantly enhancing predicted reliability.

MISSILE GUIDANCE

Electronics engineers with experience and interest in this burgeoning field are invited to write informally for additional technical data or information on specific professional opportunities.

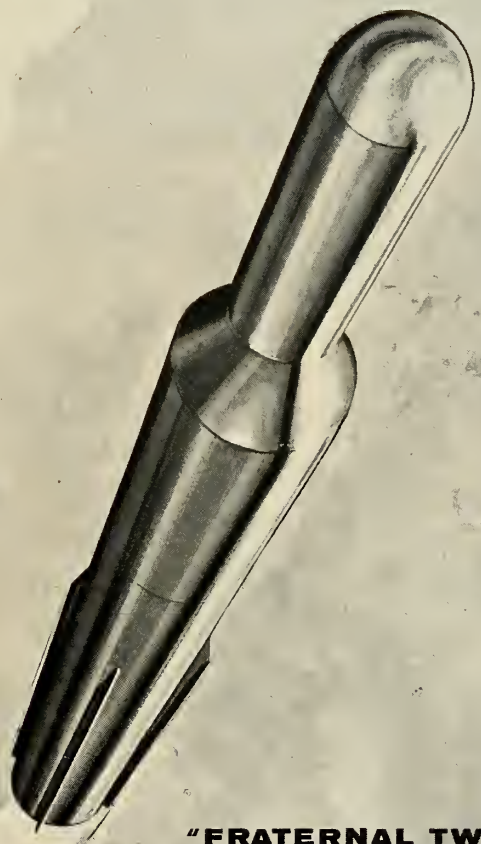
Address inquiries to Mr. R. Bach, Department 73-WJ.

LMED

LIGHT MILITARY ELECTRONICS DEPARTMENT

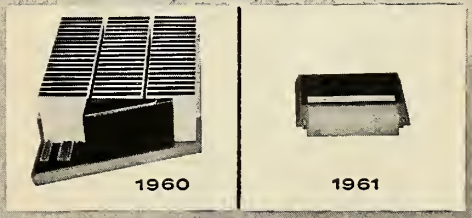
GENERAL ELECTRIC

FRENCH ROAD, UTICA, NEW YORK



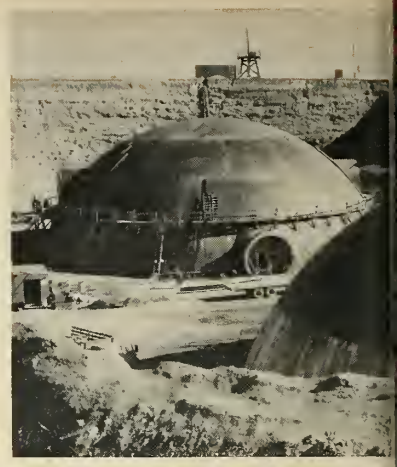
"FRATERNAL TWINS"

The unit at left represents a missile-borne computer developed by Light Military and miniaturized by conventional techniques to near the limit of 1960's state of the art. The 1961 experimental model along side (providing equivalent function) will be designed for microelectronics employing LMED's thin film wafers in modular construction. It is about 1/20th the size of its "fraternal twin."



TITAN
SPECIAL REPORT

First Hard Site For Titan I Takes Form



Complex at Lowry due to be operational by mid-1961; designed reaction time less than 15 minutes

FIRST TITAN delivered to Vandenberg AFB, Calif., is used for check-out.

LOWRY AFB, COLO.—A "concrete machine" rapidly taking shape here—the first hard site for *Titan I*—is expected to be ready for operation by a squadron by mid-1961.

Construction on the complex is now at its peak, the Air Force says, and final brick-and-mortar work will take another six months. The remaining site (minus equipment) will house the 703rd Strategic Missile Wing; it is built to withstand a near miss, but not a direct hit.

The Air Force declined to specify what size weapons these estimates were based on, but the structures are designed to withstand a 100 psi overpressure.

Tolerances required of the concrete work in this first site gave rise to the "concrete machine" description. These require a 1/32-in. silo tolerance, in addition to shock-mountings for all other equipment, including stairways, toilets, doors, light fixtures, floors and operational equipment.

The overwhelming size, weight, and depth of the complex make it apparent the Air Force expects to be hit first, but is intent on maintaining the ability to hit back. Everything is designed to maintain a reaction time of less than 15 minutes.

Maintenance will be on a remove-and-replace basis, with no attempt to make any repairs at the site. The Air Force says it is producing birds at a rate which will allow for replacement. Crews will travel periodically to one of the established missile ranges to get experience in actual launches, rather than merely static tests.

Each squadron will have nine missiles, with one extra as a spare. Three missiles will be at each of the three launch complexes in the *Titan I* system, and the *Titan II* system will have only one storable, fueled missile at each site.

• **Direct command**—If war comes, a command to launch the missiles will come directly from the White House to the launch control center without travelling through any of the routine command channels. In event the President and other government leaders are casualties, ". . . an alternate plan will be followed," said a SAC officer.

There will be about five 12-man crews at each complex—about half as many as are considered necessary at a hardened *Atlas* site, the Air Force said. Living quarters are provided underground for crew members. The *Titan* sites are expected to be ready for operation before the hardened *Atlas* sites.

The second floor of the control center in the power house is not attached in any way to the external domes of these units, but is mounted on independent pillars which are attached to spring-beams in the main floor. Under a load, these steel beams flex like an automobile leaf spring. There is a 12-in. "rattle space" between the edges of the second floor and the internal wall of the dome.

Dispersal between sites is about six miles here, although the Air Force says the optimum is 18 miles.

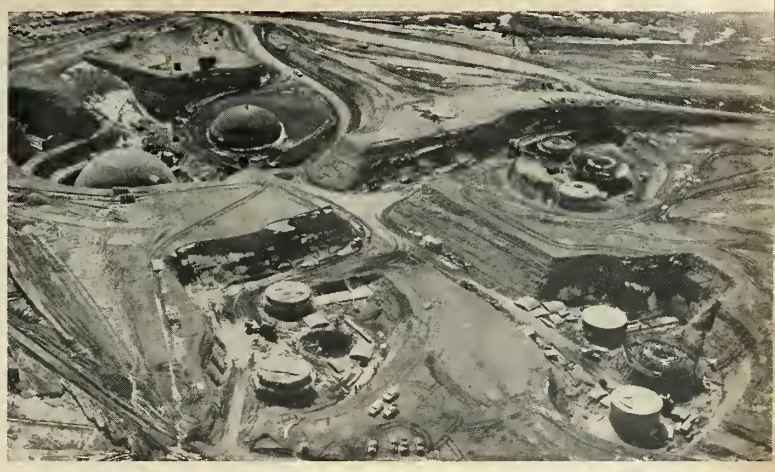
The initial explanation for the discrepancy was that the Air Force reduced the distance in the interest of economy, considering the cost of additional land acquisition. It was later explained that the Lowry complex was planned and begun before the 18-mile figure was established.

This in turn was attributed to increased Soviet nuclear capability.

• **Vulnerability**—Despite the tremendous emphasis on hardened sites and short reaction time, there is an unescapable period of vulnerability which the Air Force hopes to eliminate with all-inertial guidance.

The radio-inertial guidance now used in early models of *Atlas* and *Titan* requires that final velocity and trajec-

LEFT: Underground Powerhouse Dome of typical "hard site" at Lowry (at left) and the Control Center Dome (at right).



RIGHT: In the foreground are three of the launch silos; at top left, the Control Center Dome, nerve center.

tory corrections be radioed to the missile during flight. This will be true of the *Titan I* squadrons.

Two characteristics of the problem are that the correction for *Titan I* does not begin until after second-stage ignition and continues until final vernier burnout, and that radio antennas must be out of silos and above ground.

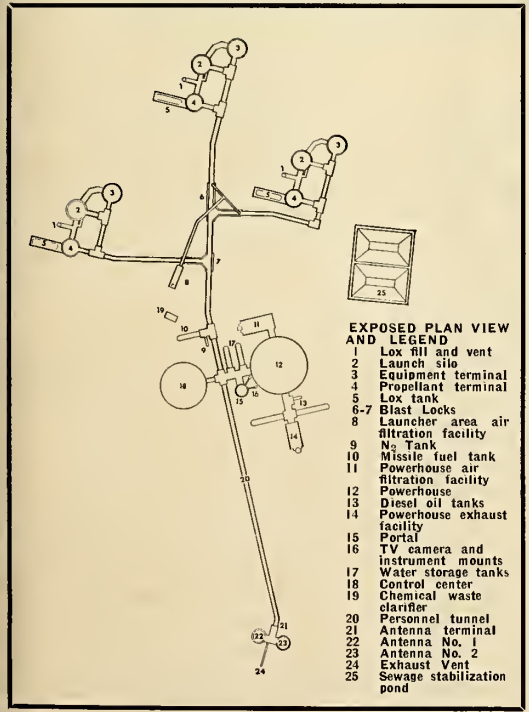
So, despite the short reaction time, *Titan I* is vulnerable for several minutes after launch—a condition which the switch over to all-inertial guidance is expected to correct.

The open-cut excavation containing the concrete and steel domes is about 40 ft. deep; it required removal of 600,000 cubic yards of earth for each of the three sites. Seventeen feet of earth will cover the apex of each dome, and contractors have already begun filling in the excavation, since all external concrete work has been finished.

Each half of the silo doors will weigh 116 tons, comprised of steel reinforced concrete about 36 in. thick.

Total material used in the site construction for the squadron include 200,000 cubic yards of concrete (405,000 tons), 200 tons of six-inch steel beams and 45,000 tons of other steel and metals. The 40-ft.-diameter, 157-foot-deep silo will have hydraulically-operated doors. After these open, an elevator (rate of ascent classified) will raise the missile and its 18-foot-square crib to ground level, with the aid of 240 tons of counterweights.

Simultaneously, the guidance antennas will emerge from 65-ft.-deep silos ready for action. Power for all electronic and electrical equipment in the complex will be supplied by four diesel generators, each producing 1000 kw with overload capacity of 163 kw. The 24 generators used by the two Lowry squadrons will consume 1,589,790 gallons of diesel fuel per month.



TYPICAL TITAN I BASE, with three missiles, shown in a schematic and an artist's conception.

Guidance Designed to be Fail-proof

A look at the radio command system being developed for Titan I and the all-inertial plans for Titan II

by Charles D. LaFond

Without the accurate and reliable guidance being built for the *Titan* ICBM, it would never be more than a simple, 90-ft., 100-ton monster incapable of discrimination.

The *Titan* ICBM is designed for but one task: To deliver a nuclear warhead a distance of 6000 statute miles and impact on a designated target.

If it fails to do this within the statistical accuracy demanded by the Air Force, it will have failed as a deterrent to war and will be ineffectual in retaliation.

Titan guidance is being designed *not* to fail.

To assure early capability, *Titan I* squadrons will employ radio command guidance; *Titan II* squadrons will follow with all-inertial guidance systems.

Radio command has certain weaknesses—such as the need for close grouping to fire in salvo, the need for exposed antennas, and the possibility of jamming. But it does offer early development, high reliability (because of the simplified missileborne equipment), and relative low cost and weight.

With operational squadrons in hand, the time and money to develop the more desirable all-inertial guidance systems can be more wisely spent.

Radio-Inertial Guidance

Employment of radio-inertial guidance in the early *Titan I* squadrons was recommended to the Air Force's Western Development Div., ARDC, by the Guided Missile Research Div. or Ramo-Wooldridge Corp., responsible for systems engineering and technical direction of the *Titan* program. (WDD is now the AF Ballistic Missile Div.; the Ramo division later became Space Technology Laboratories, a nonprofit corporation, and more recently this same functional group became Aerospace Corp.)

Bell Laboratories and Western Electric Co. (WECO) formed the team chosen in 1955 to develop *Titan I* guidance. System development has been directed by Bell Labs at Whippany, N. J. The guidance system is produced by WECO at its North Carolina Works.

TITAN I COMMAND GUIDANCE instrumentation, in upper section of 2nd stage, just aft of warhead, includes radar beacon, autopilot, command receiver and decoder.

The system basically consists of the following:

–In the missile are the autopilot (developed by The Martin Co.) and a command receiver, decoder, and radar beacon or transmitter (all developed by WECO). The missileborne system is located in the second stage just aft of the warhead.

–On the ground are the guidance computer complex (Remington Rand-Univac Div. of Sperry-Rand) and the radar and associated electronics for tracking and command signal transmission (all by WECO). The radar system employs a single antenna for tracking and for transmitting guidance command signals.

Titan guidance radar is based on the *Nike-Hercules* target tracking radar system. Completely redesigned for *Titan* use, the system was made more automatic and maintenance requirements were reduced.

• **Operation**—The ground-based radar continuously determines missile position during powered flight. A digital computer (Remington Rand Athena) accepts this data and refers to previously stored trajectory data for comparison. Correction commands following computation are then transmitted to the missile. These are applied to the missile autopilot and control system.

Six parameters must be controlled during the powered flight: the positions and the velocities along each of three space coordinate axes. To assure correct impact, these parameters must be accurate at the precise moment of thrust termination (forward velocity at this instant is approx. 24,000 ft./sec.).

Radar provides the required position measurements. The three instantaneous-velocity components must be predicted by the ground computer from radar observations. The autopilot system in the bird provides gyro stabilization during the absence of radio guidance control. Highly accurate velocity predictions can be provided within several seconds.

• **Athena is the boss**—The brain behind any of today's command guidance systems is the ground computer center. For *Titan I*, this is the Athena solid-state digital computer. (The original Remington system was built in May, 1951.)

The primary task of the system is to compare actual missile position, furnished by the tracking radar, with the desired position and to issue corrective commands. An equally important control function of the computer is to shut down the second stage engine at precisely the right time.

From the time of initial launch, the Athena's operation is completely automatic.

The system dissipates about 800 watts and utilizes a high-speed magnetic drum storage unit for trajectory information.

Employing more than 100,000 parts, the system nevertheless has chalked up an enviable reliability record—99.89%. This is believed to be considerably higher than minimum AF specifications.

So far, eight Athena computers have experienced a total of 53 failures in a total operating time of nearly 26 thousand hours. Many of these 53 failures would have had no effect on missile performance since they occurred during routine maintenance.

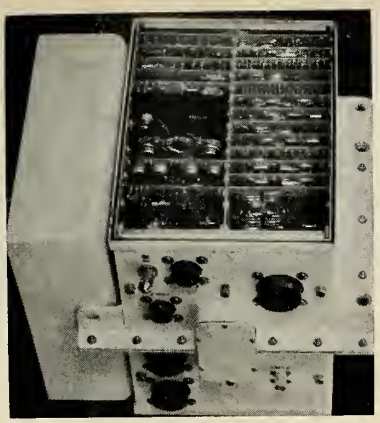
An important feature of the computer circuitry design is that momentary failure or transient error cannot cause permanent change in guidance. Also, to reduce speed (part of the quest for higher reliability and performance), operation is parallel rather than serial. Ample tolerance has been permitted throughout the system design for variations in signal delay due to component aging.

The system is self-checking, but to minimize operator error once the control switch is turned from "Test" to "Guidance" all other controls are disabled.

Maintenance for the system has been greatly simplified by broad use of one simple standard circuit which comprises 75% of the entire computer. Over 3000 of these circuits are used. Functions are varied by their interconnections within subsystems.

Based on the success of several developmental models under test for some time, the Air Force announced in June award of contracts exceeding $26 million to Remington for production and testing of operational-type Athena guidance computers.

• **Flight testing**—With nearly a score of flight tests attempted so far, the command guidance system is considered almost proved and ready for operational use. Advanced flight testing currently in progress probably will result only in slight product improvements. System successes have been numerous not only for *Titan I*, but for other space vehicles.



PCM MONITORING telemetry package (top removed) for Titan II is being developed by Radiation, Inc.

It served as guidance in the *Thor-Able II* Re-entry Test Vehicles and was used to place *Tiros I* in orbit on April 1, 1960. The same system will be used for NASA's second meteorological satellite in October, 1960.

Most recent use was in successfully placing *Echo I* in orbit Aug. 12.

All-Inertial Guidance

The widely sought *Titan II* all-inertial guidance contract finally was awarded to AC Spark Plug Div. of General Motors in April, 1959. The $84-million contract called for the design, development, limited production and testing of a two-package all-inertial system.

AC Spark's task essentially was to develop the Massachusetts Institute of Technology's Skipper inertial platform for *Titan* use. The company's experience in this field was solid, since it has been all-inertial guidance prime for the Air Force *Thor* IRBM with its AChiever system. Also among its many other guidance packages, AC was subcontractor to The Martin Co. for the *Mace* inertial guidance system.

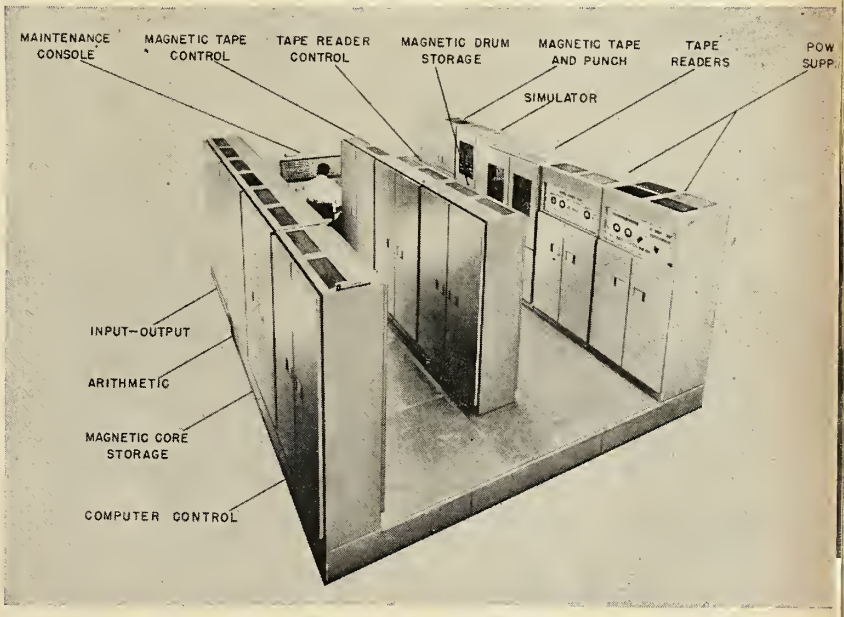
International Business Machines Corp. was selected to develop an advanced solid-state guidance computer for AC Spark.

• **Guidance platform**—The stable platform as developed by AC Spark makes extensive use of the lightweight metals. AC Spark-developed liquid-bearing gyros, for example, are fabricated from beryllium.

Heart of the platform is the three-gyro gimballed stabilization system. An associated system of three accelerometers is used to sense precisely speed and direction change—elevation and azimuth.

How precise is this system? Most of the facts are classified, but it is known that the *Titan II* all-inertial guidance is vastly better than that used in *Thor*. For the *Thor* IRBM, gyros are so sensitive that they sense—and in effect measure—angular velocities as low as 1 revolution in over 10 years.

It has been stated officially that the *Titan* advanced guidance will have to be at least five times more accurate



ATHENA digital computer developed by Remington Rand-Univac for use with Titan I radio-inertial guidance.

than *Thor* guidance just because of its vastly increased range. Actually, its accuracy is believed much better than that.

Size of the new system is believed to be similar to advanced versions of Arma's *Atlas* all-inertial guidance system. (Current *Atlas* guidance is large and is installed in a bulbous pod on the outside of the missile shell. Second- and third-generation subsystems — already in the hardware stage — have been reduced in volume by about 75%.) The AC Spark stable platform alone is reportedly about 1-1/3 cu. ft. in volume.

The system will be located in the *Titan II* second stage. Through the use of a porro prism on the platform, the system must be aligned in azimuth optically prior to launch.

• **Missileborne computer**—Almost no information is available concerning the guidance computer for *Titan II*. But, based on recent advances by IBM in miniaturizing complex computer systems it is certain that the package will be unusually small and lightweight.

The miniature 8-lb. solid-state memory drum recently revealed to the public by the company in Washington is believed to have been developed for *Titan II*.

The actual memory unit is a 6-oz. stainless steel drum having a magnetic film surface. The drum is housed within a 3-in. long by 3-in.-dia. metal frame. The frame holds the magnetic pickup and recording heads which are imbedded in rectangular blocks of plastic, called slider bearings.

The bearings slide over the drum surface, riding on a cushion of air 100-millionths inch thick. Drum capacity, according to IBM, is 100,000 bits of information.

• **First flight in 1961**—Both the inertial platform and the computer package are currently undergoing extensive laboratory test operation.

First flight of the complete system (believed to weigh roughly from 175-200 lbs.) is scheduled for early 1961, probably in the spring.

A PCM (Pulse Code Modulation) telemetry system developed by Radiation, Inc., will be installed during the test flights to monitor the guidance system. The RI system is currently undergoing rocket-sled tests at Holloman AFB, N.M.

Built for AC Spark, the missileborne telemetry features a capability for processing analog information along with bi-level digital inputs and a serial output from a digital computer. It is believed that this capability of telemetering plus digital processing approaches the ideal unitized instrumentation package and is a first in the telemetry field.

• **System components**—The PCM package is a solid-state system weighing less than 19 pounds and occupying approximately 0.36 cu. ft.

It contains a 64-channel analog multiplexer, 41-channel digital multiplexer, programer with word construction units, and an analog-digital converter and power supply. All inputs are multiplexed and programed with synchronization codes onto one serial NRZ (non-return to zero) output through a precision-designed filter which eliminates side-band splattering upon transmitter modulation.

Since the PCM system processes digital information from the guidance computer, it normally will accept a control signal from the computer to develop its basic bit rate frequency and be locked synchronously to the computer.

However, both a frequency and amplitude monitoring of these external signals for accuracy is performed within the PCM system. Should the computer frequency drift beyond acceptable limits the PCM system will no longer accept it as a bit rate control but rather switches over to its own crystal-controlled oscillator. This feature preserves the coding of analog information should the computer become erroneous.

System design of this PCM is such that RI predicts a probability of continuous operation of 0.998 for a 2-hour pre-launch environment and a 6-minute flight without loss of any information.

Underground Communications System

An error-free communications system that hangs underground is being installed in the *Titan* base at Vandenberg AFB. The system employs the first sub-surface switching apparatus in the U.S. missile/space program to launch the two-stage ICBM from an underground silo or hardened site.

Equipment is suspended in caissons below ground to provide a high degree of physical balance in shock waves and pressures generated by possible enemy nuclear attack.

The ITT-Kellogg system is designed for ultrareliability: an order or message must always get through, regardless of momentary situations, interferences, interruptions or human error. Any specific function built into the system is performed as needed, to the exclusion of all others.

The communications system is made up of eight separate operations: administrative communications, operational communications, page and countdown, camera control, fire alarm, operation direct line, maintenance and checkout, voice recording and range safety.

The camera control system provides sequential photographic documentation of each launch for engineering study, analysis and review. As the intense heat of the first firing engines melts the lenses of the cameras nearest the launch site, outlying cameras are automatically switched in to continue documentation.

A documentary record of all commands and instructions during countdown and firing is made by the voice recording system. This system is integrated with the operational direct-line communications systems which provides rapid push-button communications for selected command, operational, certain maintenance, and checkout activities.

The public address and alerting system provides emergency communication to the various operational, administrative and maintenance areas. This system is tied in with the telephone switchboard to permit telephone handsets to be used as microphones to broadcast messages over the p-a system.

The dial telephone system—which handles the communications for administrative functions of the complex—serves as an emergency communication facility for the command and operating activities should direct line capability be disrupted.

An executive-right-of-way feature permits high-priority telephones to over-ride a conversation on a dial telephone or a message broadcast over the p-a system from a telephone line.

Cubic to Modernize NOTS Missile Tracking Gear

Modernization of data processing and missile tracking equipment at the Naval Ordnance Test Station, China Lake, Calif., will be done by Cubic Corp.

Primary task in the 6-month program will be the addition of equipment for use with Cubic's MIDAS (Missile Intercept Data Acquisition System). Both a new data digitalizing system and a remote control capability for digital-to-analog conversion equipment will be installed.

MIDAS is used to track missile during operational and evaluation firings and can track simultaneously any two of four possible targets.

The new equipment is expected to speed up significantly the processing of missile performance data. Tracking information following initial processing will be recorded on magnetic tape and then fed into a computer.

Support Equipment Highly Integrated

Novel approach for operational Titan marries subsystems to ground control, checkout and simulation

by Hal Gettings

Support equipment for the operational *Titan* has two unique features: integrated launch control and checkout, and a novel systems approach between airborne subsystems and associated test equipment.

Martin Co.—*Titan* "associate prime"—divides the support equipment into GOE (ground operating equipment) and mechanical handling and associated hardware. GOE is primarily electronic and electrical, although hydraulic, air-conditioning, and missile release systems are included.

Titan GOE is a fully integrated launch control and checkout system made up of several subsystems interconnected with each other, with the missile, and with other facilities. It includes all equipment needed to control, monitor and check out the missile, as well as the operating components of the propellant loading system, associated equipment, and facilities.

Contractors for major subsystems—nose cone, guidance, communications, propulsion—design and build checkout equipment for their particular system. The various checkout hardware is then integrated into the overall GOE system.

According to Martin, such a procedure has definite advantages. Test equipment is built by the company most familiar with the system to be tested, yet the various pieces still fit together to form an integrated whole.

The GOE has three operating modes: launch, captive-firing, and checkout.

The launch mode is manually initiated by a switch-indicator on the launch complex control console. Control of the launch firing sequence is automatic, using timed or events-actuated signals. Should a malfunction occur during the launch mode, it is detected, isolated and indicated to the subsystem level of the missile or the GOE.

The captive-firing mode is initiated at the launch sequencer set and controlled in the same manner as the launch firing phase. The launch sequencer provides for a timed firing and automatic-shutdown initiation.

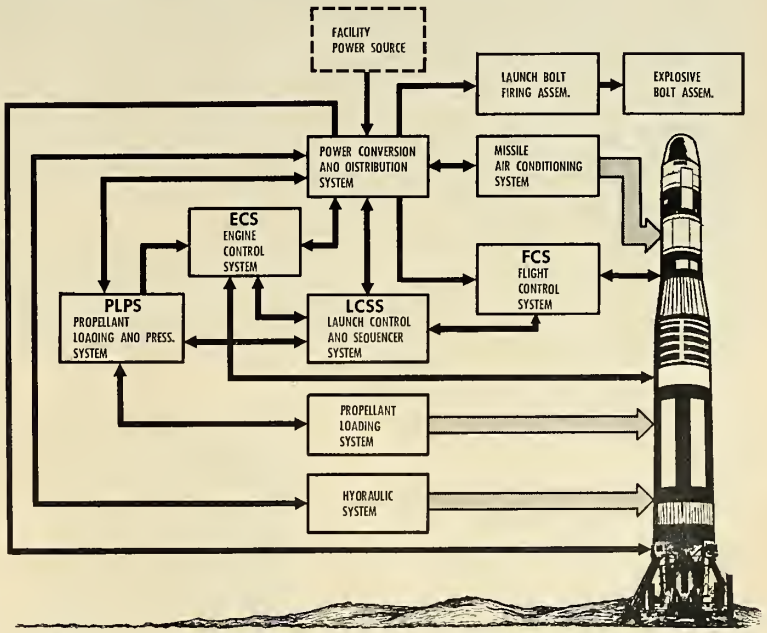


DIAGRAM SHOWS interrelationships between subsystems of the Titan I launch control and checkout system. Support equipment for Titan II will be somewhat simpler.

The checkout mode controls the post-installation and prefiring test of the missile, its associated facilities and the GOE. In this mode, the GOE permits evaluation of the functional status of the components of each subsystem, and isolates malfunctions by individual chassis or missile components. Malfunctions are isolated to the chassis level in the GOE and to the replaceable component of the missile.

• **Power conversion and distribution system (PCDS)**—The PCDS provides and controls power conversion, distribution, and monitoring within the launch complex. The system consists of a power switchboard, power supply units, and an accessory supply system.

The power switchboard distributes primary electric power to motor and subfeeder circuits.

A 28-volt dc supply starts and runs the missile accessory supply inverter during the launch operation until transfer to the missile battery. A second power supply furnishes nominal 28-volt dc power to the missile busses—until transfer to the missile battery in the launch mode—and to the launch control and checkout equipment for any mode of operation.

A battery power supply furnishes standby or emergency power for the missile and ground operating equipment to insure a safe shutdown should the primary or 28-volt dc supply fail.

A motor-generator provides 400-cycle, 120/208 volt ac power for the missile and GOE. The accessory supply system provides electrical apparatus for the control, distribution, and monitoring of electrical and hydraulic power to other ground operating equipment and missile equipment during ground operations.

• **Launch control and sequencer system (LCSS)**—This system provides initiation, actuation, and monitoring of missile launching, captive firing or shutdown functions. It consists of launch sequencer set, launch complex control console and time display board.

Titan Operational Checkout and Launch Equipment Units

Systems Equipment Required	Number of Chassis	Remarks
LAUNCH CONSOLE	(one unit)	Single operator required; one or more missiles launchable from one unit. Voice communications inside and outside blockhouse.
EQUIPMENT AND FACILITY CONSOLE	(one unit)	One operator required; monitors checkout of entire launch complex; control retained during readiness periods and launch.
EQUIPMENT PALLETS		
Accessory supply system	8	Serves as both launch control and checkout equipment.
Flight control system	7	" "
Propellant loading and pressurization	11	" "
Engine control	6	" "
Re-entry vehicle	6	" "
Airborne guidance	8	" "
Launch sequencer	4	" "
Control center	2 (per missile)	" "

The launch sequencer set generates the commands and performs the logic necessary for controlling and monitoring launch and status functions. The launch complex control console controls and monitors major events of a launch sequence and indicates the status of the equipment and facility.

The time display board provides timing information for launch or captive firing operations. It consists of a 24-hour clock displaying local or Greenwich time, and a 4-hour countdown timer clock indicating remaining countdown time in hours and minutes during the manual portion of the countdown sequence. An automatic countdown timer clock for the last portions of countdown indicates remaining time in seconds, as well as time after firing until liftoff or shutdown.

• **Propellant loading and pressurization systems (PLPS)**—The propellant system delivers propellants and gases to the missile propellant tanks. It also initiates and controls pressurization of the missile pneumatic system and missile propellant tanks, initiates disconnect of the propellant umbilical and tank vent connector, provides nitrogen for starting engines, and performs checkout functions.

The PLPS uses a unique method to fuel an operational missile at the fastest rate possible. When loading starts, a low-level sensor indicates that fuel is coming aboard. No further measure is made until the topping-off phase—which must be indicated with very high precision. Then the tanks are overfilled, the system pressurized, and tanks drained down to proper level.

Although fueling times are classified, Martin says that the *Titan* system gives a very fast and satisfactory fill rate.

• **Flight control system (FCS)**—The FCS checks out and prepares the missile flight control system for launching and flight. It consists of a flight control set and a targeting command chassis. The flight control set generates the commands and performs the logic necessary for controlling and monitoring the checkout and preparation of the missile flight control system for launching and flight. The targeting command chassis provides flight program setting signals to the flight controls set.

• **Engine control system (ECS)**—The engine control system prepares the first-stage engines for firing and initiates the firing. It also monitors engine parameters essential to safe and successful engine operation.

• **Missile air-conditioning system (MACS)**—MACS provides conditioned air for the second-stage compartments. Air is drawn through an intake opening, cooled and delivered through two discharge openings to pipes which direct it to the missile skin.

• **Hydraulic system**—The GOE hydraulic system is a pumping unit which pressurizes the missile first-stage hydraulic system.

• **Missile release system**—This system releases the missile for flight by detonating explosive tie-down bolts when the first-stage engine attains predetermined thrust. It consists of a launch-bolt firing assembly and an explosive bolt assembly.

The launch bolt firing assembly, upon receipt of signals from the accessory supply system, furnishes power to the explosive bolt assembly to detonate the bolts. The explosive-bolt assemblies restrain the missile at four points until the first-stage engine has reached its proper thrust level; then the four bolts are exploded and the missile released for launch.

Titan II—The advanced all-inertial ICBM—will use basically the same GOE system, modified to fit new equipment. A major difference will be in simplification brought about by storable propellant and inertial guidance and the consequent simpler countdown and checkout procedures.

MOC Spells Big R&D Savings

DENVER—*Titan's* automated countdown system is credited with saving months of time, several vehicles, and millions of dollars thus far in the R&D phase of the ICBM program. The system, called Master Operational Controller (MOC) links eight racks of equipment and two consoles for preprograming, monitoring, operation and control of all major functions of test and launch procedures.

The MOC checks out the vehicle itself, as well as the test devices, telemetry, transmitters and other R&D equipments that go along for the ride.

Heart of the system is the automatic sequencer, a four-rack unit located in the control building. At preprogramed times during a countdown, this sequencer initiates function control circuits providing power to the other MOC circuits at specified time intervals, and also activates hold-fire circuits at necessary times.

Approximately 120 function-control and 80 hold-fire circuits can be programed during the countdown.

• **Restraint**—During its launch sequence, the *Titan* is held to the launch pad briefly—usually from three to six seconds—until the MOC missile release system has ascertained that sufficient thrust for flight has been achieved. Explosive bolts are attached about the base to carry out restraining action.

The release system can also be operated manually from the test conductor's console. This unit supplies

the signal for engine ignition prior to liftoff.

At a preset time, the automatic sequencer provides function control circuit signals to energize the holddown explosive bolts and to check the hold-fire circuits which would stop the launch in event of any malfunction between engine ignition and actual liftoff.

The launching can be stopped by any hold circuit—even though the order to launch has been transmitted—up until the time the last umbilical connector drops away from the vehicle.

This system proved its worth very early in the flight-test program by stopping a launch after the engines had been started. The vehicle involved, which would have been destroyed by a malfunction if the original launch had not been stopped by the MOC, later flew on a completely successful mission.

Designed to contribute to the reliability of each launch, the MOC has eliminated the necessity for many human actions and snap judgments.

The automatic sequencer has the ability to check itself out prior to a test, to insure that the sequence of functions is as desired.

A simpler and more compact MOC has been designed for the operational version; further modifications will be made for the *Titan II* follow-on missile.

Besides the automatic sequencer with its four racks of equipment, the MOC setup includes four other racks which control the umbilical, water, missile release, and erector systems.

• **Spots troubles**—In addition to carrying out the countdown, MOC can act as a troubleshooter to pinpoint malfunctions during a hold period. Pen recorders monitor the functions being carried out and plot the curves against a ten-per-second time-pip operation, which aids in determining time and location of the cause of a hold in the countdown.

Aside from the final countdown operation, MOC has the capability of checking any subsystem of the missile prior to a test, in order to verify its proper operation. The subsystem, or combination of subsystems, being thus tested are run through the complete gamut of their required operation and the results are recorded.

Not only can the automatic sequencer and its accessory systems call a hold in the countdown, but operating personnel on the launch pad can initiate a manual hold should any situation require such action.

Martin-Denver points out that the MOC is not a thinking device. It will do what it is told to do—and no more. If the countdown steps are programed into MOC incorrectly, they will be carried out incorrectly.

Two hundred functions can be programed into the system.

Major Titan Subcontractors and Suppliers

COMPANY	ADDRESS	ITEMS SUPPLIED
ACF Industries	Buffalo, N.Y.	Aluminum spheres
Aerojet-General Corp.	Azusa, Calif.	Fittings, LOX compound
AiResearch Mfg. Co.	Phoenix, Ariz.	Regulator for pressurization system 2nd stage vent relief valves
Amphenol Electronics Corp.	Chicago	Electrical connectors, connector programing board
Amphenol Electronics	Los Angeles	Electrical connectors
Annin Co.	Los Angeles	Hydraulic valves
Baldwin-Lima-Hamilton	Waltham, Mass.	Thrust mount system
Bendix Corp.	Pacific Div. North Hollywood, Calif.	Relief valves, accumulators hydraulic valves
Bogue Electric Mfg. Co.	Paterson, N.J.	High-level sensor system
Cadillac Gage Co.	Detroit	Servo actuator
Cannon Electric Co.	Los Angeles	Connectors
Consolidated Electrodynamics	Pasadena, Calif.	High-level sensor system probes, transducers, elect equipment, special wire
Cook Electric Co.	Denver	Switches
Dunbar Kapple, Inc.	Batavia, Ill.	Flexible hosing, line assembly bellows
Electro-Mechanical Research, Inc.	Sarasota, Fla.	Telemetry package
Futurecraft Corp.	El Monte, Calif.	Shutoff and hydraulic valves
General Electric	Chicago	Tubes
General Electric	West Lynn, Mass.	Electrical products
General Electric	Skokie, Ill.	Circuit breaker relays
General Electric	Denver	Meters, motors, etc.
General Electric	Denver	Blanket load cell, temp. control lamp
G. M. Giannini & Co.	Pasadena, Calif.	Rate gyro system, transducers, probes
Grand Central Rocket Co.	Redlands, Calif.	Staging rockets
Gulton Industries, Inc.	Metuchen, N.J.	Amplifier, airborne filter, low-pass transducer accelerometer, transducers
Hallamore Electronics Co.	Anaheim, Calif.	Closed circuit TV equipment
Harvey Aluminum	Torrance, Calif.	Plate, sheet and extrusions
Hewlett-Packard Co.	Palo Alto, Calif.	Oscillators, counters, etc.
Kaiser Steel Corp.	Los Angeles	Steel fabrication
Leach Relay	Los Angeles	Relays
Minneapolis-Honeywell Regulator Co.	Aero Div. Minneapolis	Three-axis reference system control testers
Minneapolis-Honeywell	Philadelphia	G-load simulator
Minneapolis-Honeywell	Hopkins, Minn.	Electronics
Minneapolis-Honeywell	Denver	Galvanometer, oscillograph, Muller bridge
Moog Valve Co., Inc.	E. Aurora, N.Y.	Hydraulic valves, servo actuators
New York Brake Co.	Watertown, N.Y.	Hydraulic pump
On Mark Couplings	Los Angeles	Quick disconnects, helium lines
Parker Aircraft Co.	Los Angeles	Check valves, hydraulic fittings
Potter Aeronautical Co.	Union, N.J.	Transducer, flowmeter
Rheem Mfg. Co.	Electronics Div. Rivera, Calif.	Signal conditioner equipment
Rheem Mfg. Co.	Downey, Calif.	Aircraft sheet metal, general machining, elect. instruments
Robertshaw-Fulton Controls Co.	Anaheim, Calif.	Quick disconnects, LOX and fuel all sizes, and regulators for pressurization systems 1st-stage; low-level sensors, frequency converter, hydraulic valves
Scintilla Div.	Bendix Corp. Sidney, N.Y.	Electrical connectors, wiring assemblies
Trans-Sonics, Inc.	Lexington, Mass.	Transducers
Westinghouse Electric Corp.	Baltimore, Md.	Electronics components

—expansions—

NASA's George C. Marshall Space Flight Center has leased 96,720 sq. ft. from Brown Engineering Co. in the Huntsville Industrial Center complex. The contract becomes effective on Oct. 1 when 164 employees will move in.

LITTON SYSTEMS INC. officially opened its 180,000-sq.-ft. Computer Systems Laboratory on a 63-acre site at Woodland Hills, Calif. Manufacturing buildings, offices and other structures eventually will be built at the site, bringing the total to 750,000 sq. ft.

LOCKHEED'S Marietta, Ga., division is creating an aerospace design department in its engineering branch. Dr. H. S. Sweet will manage the department, which will work on preliminary design and related fields.

ATLAS CONTROLS, INC., designers and manufacturers of regulated power supplies, some used in Martin missiles, moves to a 12,000-sq.-ft. facility in Natick, Mass.

AMERICAN INTERNATIONAL ALUMINUM has opened a new automated and fully integrated aluminum extrusion plant in San Jose, Calif. The 50,000-sq.-ft. plant will extrude aluminum on a Youngstown Foundry and Machinery double entry press.

Financial

Kaiser Industries Corp.—Second quarter earnings were $2.2 million, bringing six months earnings to $3.5 million. First half earnings reflect power profits of Willys Motors, Inc., a wholly-owned subsidiary; elimination of the dividend on Kaiser Steel Corp. common stock; elimination of credit arising under an agreement relating to the filing of a consolidated federal tax return, such credit in the first half of 1959 amounting to $874,000.

Bourns, Inc.—Net sales reached $5.3 million, with earnings of $341,410 for the first six months. These totals represented a 19% jump in sales over 1959, with earnings not compared because of a change in accounting procedure. Backlog at June 30, 1959, stood at $1.3 million; current backlog is $1.8 million.

Victoreen Instrument—Victoreen nearly doubled its 1959 first-half total with net sales of $6 million. Profits rose to $260,770, compared to $219,465 in the previous year's first period.

Details of Norway's ASW Terne

Packaged antisub missile system to be bought by U.S. Navy can be put aboard ships as small as 500 tons

by Bernard Poirier

Kongsberg Vapenfabrikk, the company which won fame by producing high-accuracy whaling harpoon guns, has now developed a packaged antisubmarine missile system for use on small naval vessels.

The *Terne* went through rigorous sea trials before it was declared operational by Norway. The first photo of the ASW missile was published exclusively by M/R at the time the Navy announced the U.S. would purchase the weapon (M/R, July 18).

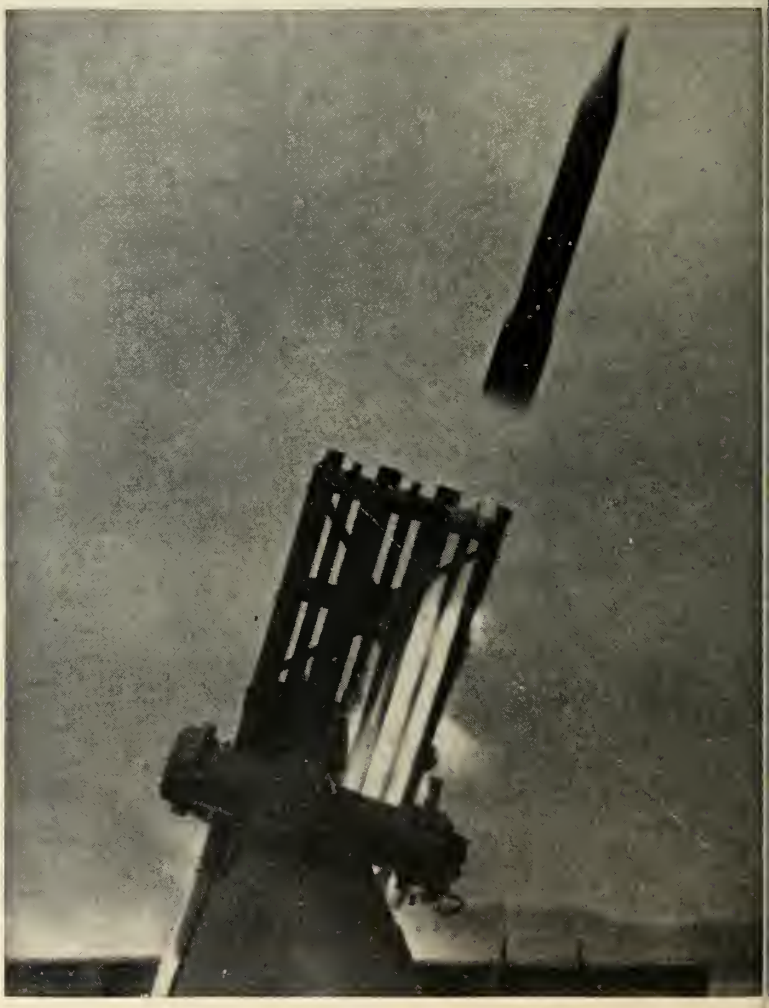
The missile is 6 ft. 5½ in. long and has a 7.9-in. diameter. The newest warhead—the MK 7 depth charge—weighs 105.6 lbs., which is more than one-third the total 264-lb. launching weight. This appears to be an unusually advantageous warhead-weight ratio—which might explain its value to other nations.

• **Sonar mounted beneath hull**—*Terne* can use a built-in selector for a time fuze or a proximity fuze which can be activated at the last second before launching. Special antisubmarine ships as small as 500 tons can have complete "*Terne* capability," according to a spokesman for the Norwegian defense firm. Full capability includes several full salvo loads of six missiles each, a 3400-lb. launcher, and 11.5 tons of electronics.

The transducers of the two sonar systems are stabilized in azimuth and mounted in a streamlined retractable dome with a rubber-covered, sound-transparent window. The window is reinforced with a steel grill and can withstand speeds up to 26 knots. Normal searching speed is 21-23 knots.

The sonar dome is mounted below the hull near the forward section of the vessel. The search sonar works on a low frequency of 11 Kc. and has a range of three miles. It is sensitive enough to detect a torpedo as well as a submarine.

• **Six operators zero in**—The attack sonar operates on a frequency of 30 Kc. and coordinates findings with the search sonar once the enemy submarine is within 3000 yds. The split beam principle is used for location in the vertical and the horizontal planes with a tolerance of about 1%.



EXPERIMENTAL FIRING of Terne ASW missile from a warship at the entrance of a Norwegian fjord during extensive sea trials. An exclusive M/R photograph.

Additional tracking is provided for range and bearing. An electronic vernier range scale with cathode-ray presentation is used to increase range accuracy.

The sonar readings are refined by operators before the information is cranked into the computer. Three operators for each of the sonar systems are located in the ASW control room.

• **U.S. provided assistance**—The Fire Control determines target bearing, range, depth and the ship's own course and speed. These and other variables such as wind speed and direction are fed to the computer, which relates the data to the program. One of the last factors is the actual temperature of the *Terne's* solid fuel when it is in firing position on the deck launcher.

The computer determines the auto-

ıatic setting for launcher elevation and earing. At this point the system is tabilized for roll up to 20° and pitch p to 5°.

Upon ignition, the *Terne* develops 1,700 lbs. deck thrust. Within ¾ sec., nother missile can follow. Six missiles an be fired in 5 secs. An additional ıll salvo load can be placed in the ıuncher in ¾ minute.

The *Terne* missile system was deloped by Kongsberg in conjunction ith the Norwegian Defense Research stablishment and the Royal Noregian Navy. Other assistance was proided by the United States Mutual /eapons Development Program.

Kongsberg is manufacturing various ɔmponents for the NATO *Sidewinder* roduction program, whose prime conactor is Bodenseewerk Perkin-Elmer mbH of Germany. The third top issile in Kongsberg's repertoire is the *S-11* antitank missile, produced for ıe Royal Norwegian Army by agreeent with Nord-Aviation, S.A. of rance.

.S. To Pay Building Cost f Aussie Tracking Site

The United States will pay the full b for constructing Project *Mercury* acking stations in Australia, the Aus-alian Minister for Supply has anɔunced.

The States will also meet nearly l costs of operation, including mann of the stations by Australians.

Two new posts were being estabıhed by the Americans near Wooera, he said. One was at Redlake, ɔout four miles from Woomera, for *'ercury,* and the other at Island Laɔon for a deep space tracking station. n 85 ft. dish radar is going up at land Lagoon, with technical and mess uildings to follow.

By agreement with the U.S., a initrack station, operating since 1957, ɔuld be moved from Woomera to land Lagoon.

hird BMEWS Station eing Built in Yorkshire

The third link in the Ballistic Mise Early Warning Systems (BMEWS) now under construction in Yorkshire, ngland. The other two bases are at iule, Greenland, and Clear, Alaska.

The Yorkshire site at Fylingdales loor, is being built under the joint pervision of the U.S. Air Force and byal Air Force, with RCA Great ritain, Ltd. as system contractor. Cost s been estimated at $115 million.

The installation will have three cking radars, each 84 ft. in diamet, enclosed in a 140-ft.-diameter plast dome.

names in the news


NOLKE


CROMPTON


ELMS


HERRMAN


WARREN

Fred H. Nolke: Former chief engineer for the Midwest Operating Group of General Telephone & Electronics Corp., joins Page Communications Engineers, Inc. as assistant director of the Telecommunication Directorate.

Dr. Charles E. Crompton: Named director of the Advanced Development Section in the Isotopic Power Department of The Martin Co.'s Nuclear Division.

James C. Elms: Joins the Aeronutronic Division of Ford Motor Co. as general operations manager of Electronic Systems Operations. Was formerly executive vice president of Crosley Division of Avco Corp., and prior to that with The Martin Co.'s Denver Division as manager of the Avionics Dept., responsible for engineering, design, and development of guidance, flight control and other electronic systems for the *Titan*.

William H. Herrman: Joins Stromberg-Carlson's Electronics Division as manager of advertising and sales promotion. Was formerly director of advertising and public relations for the Hoffman Laboratories Division of Hoffman Electronics Corp.

Francis A. Warren: Joins Rocketdyne's Solid Propulsion Operations as senior technicial specialist to **Dr. E. F. Fiock,** chief of propellant research. Previous posts: Manager of the propellant section, Southwest Research Institute; head of the Internal Ballistics Branch, U.S. Naval Ordnance Test Station; and research engineer at Battelle Memorial Institute.

Robert H. Davis: Named chief engineer of Motorola Inc.'s Microwave Dept., responsible for product development, systems engineering and field engineering.

Frank P. Brennan: Joins Metal Control Laboratories, Inc., as director of technical sales. Was previously assistant sales manager of United States Testing Co., Inc.

P. C. Swan: Elected field station manager for the Douglas Aircraft Co.'s *Nike-Zeus* missile testing operations on Kwajalein Island. He is a 24-year veteran with the firm.

Martin R. Amsler and **C. Wesley Michaels:** Appointed manager of marketing, Surface Communications Division, Defense Electronics Products and manager, planning and market research, for Industrial Electronic Products, respectively, with RCA. Amsler was previously manager of marketing administration and Michaels was with the General Electric Co. prior to joining RCA.

Jack B. Lindsey: Former assistant to the president named marketing manager of Microdot Inc.

John W. Allen: Appointed manager, engineering, Non-destructive Testing, Instruments Division of The Budd Co. Was formerly with The Atomic Energy Commission's Oak Ridge National Laboratory, where he was in charge of the Non-destructive Testing Laboratory of the Metallurgy Division.

Irving Rutstein: Formerly with the Missile Systems Division of Republic Aviation Corp., appointed engineering manager of Loral Electronics Corp.'s Countermeasures Division.

Dr. John Mason: Chief of preliminary design for The Garrett Corp.'s AiResearch Mfg. Co., appointed to the Research Advisory Committee on Nuclear Energy Systems, National Aeronautics and Space Administration.

George N. Mangurian: Director of the Technical section of Northrop Corp.'s Norair Division, appointed to the Research Advisory Committee on Aircraft Structures, National Aeronautics and Space Administration.

John F. Moore: Appointed manager of the Product Development Dept., Information Technology Division of Lockheed Electronics Co. Was formerly director of research and engineering at the ASCOP division of Electro-Mechanical Research, prior to that was engaged in design of microwave and tropospheric scatter systems as Communications Group leader for Hycon Eastern, Inc.

Ted Dunnegan, Jr.: Named acting division manager of the Electronics Division of Temco Electronics & Missiles Co., subsidiary of Ling-Temco Electronics, Inc. He succeeds **A. R. Teasdale,** now with The Martin Co.

Cmdr. Samuel A. Forter (USN-ret Elected assistant director of Massach setts Institute of Technology's Instrume tation Laboratory.

Dr. Harold M. Sonnichsen: Joi W. R. Grace & Co.'s Dewey and Aln Chemical Division as director of fiber a saturant research in the Polyfibron di sion. Was formerly vice president and r search director of the Permacel Divisi of Johnson and Johnson.

Albert E. Keleher, Jr.: Joins Labor tory for Electronics, Inc. as director Systems Marketing Division. Prior joining the firm he was manager marketing planning for Raytheon Co Equipment Division.

Marion E. Hines: Joins Microwa Associates in the newly created positi of senior scientist. Was previously ass ciated with Bell Telephone Laboratori Inc.

Kenneth E. Hunter: Former manag of Special Equipment for Hycon M Co., appointed vice president of engine ing.

H. R. Dettwyler: Appointed chief en neer of the Cooper Development Divisi of The Marquardt Corp. Was forme supervisor of the flight test section of t firm's Propulsion Division.

Gerhard Schilling: Former chief of t lunar and planetary sciences programs NASA, joins The Rand Corp.'s Engine ing Division as a member of the Planeta Sciences Group where he will conduct search on problems of space exploratio

James W. Noland: Former manag manufacturing, appointed general manag of Young Spring and Wire Corp.'s Gon Division.

William L. Hill: Elected manager The Martin Co.'s Huntsville office, su ceeding **G. J. Rauschenbach,** who has signed. Hill was formerly assistant ma ager and previously participated in t *Titan* program at Denver.

Edward J. Gately, Jr.: Named ma ager of Clifton Precision Products C Inc.'s Systems Division.

—reviews—

UCLEAR FLIGHT, edited by Lt. Colonel enneth F. Gantz, USAF, Duell, Sloan & earce, New York, 216 pp., $4.00.

This is an excellent text on the Air orce's program in the development of uclear propulsion for aircraft, missiles nd space rockets.

During the spring of 1959 the Editors f "Air University Quarterly Review," e professional journal of USAF, learned at a significant, unclassified discussion f nuclear flight propulsion had become ossible. Plans were laid to exploit it.

Authors were chosen who were inately concerned with the official nuear-propulsion program. They were inted to explain their specialized work oroughly but in terms understandable the non-specialist reader. The results ere published in a special issue of the eview, released in February 1960. The ntent of the issue was then made availle to the present publisher for wider iblic dissemination.

LECTRONICS AND NUCLEONICS DICONARY, Nelson M. Cooke, and John Mars. McGraw-Hill Book Company, Inc., New ork. 543 pp. $12.

More than 13,000 terms used in the ectronics and nucleonics fields are deed in this newly published dictionary. shows the exact meaning and correct age of technical words, synonyms, and breviations currently being used in such eas as avionics, space electronics, nuear science, nuclear engineering, radio, dar, industrial electronics and medical ectronics.

The book is an updated and enlarged rsion of an earlier edition.

UDIES OF HEAT-RESISTANT ALLOYS, A. Coldren and others. Order PB 161667 om Office of Technical Services, U.S. Dept. Commerce, Washington 25, D.C. 108 pp., .50.

Three metallic substances were evalued as part of an Air Force study to ercome air and space vehicle design trictions caused by creep-rupture propies of heat-resistant alloys under proction conditions.

There are separate discussions of test sults for each of the three types of terials as well as descriptions of extrimental procedures.

E HILL REACTION AS A MODEL FOR HEMICAL CONVERSION OF SOLAR ERGY, R. J. Marcus. Order PB 161462 m Office of Technical Services, U.S. Dept. Commerce, Washington 25, D.C. $.50.

Two ways were used in investigating t possibility of storing solar energy for u during dark periods by decomposing ter into its elements.

The first method investigated the elecn transfer spectra of inorganic ions. e second method concentrated on ious Hill reaction oxidants. Two new ctron acceptors were found to be ac-

Magnetic System Inspects Welds

Recordaflux, a magnetic particle inspection system, has been put on the market by Instruments Division of The Budd Company.

Recordaflux, formerly known as Permaweld, is used to detect defective welds, cracks, inclusions and other flaws in the materials which are currently being inspected by magnetic particle systems. The new Recordaflux system has been very successfully used by The Budd Company to determine non-destructively the diameter of spot welds in stainless steel, such as types 301 and 201 and the precipitation-hardening grades.

The Recordaflux patterns of magnetic particles show the shape and size of a spot, or other type of weld, making it easy to detect a defective joint. It will also pinpoint other flaws, such as cracks and inclusions. The patterns may be viewed on the part and washed away, or they may be stripped from the part, viewed, and filed away for reference. Copies of the patterns are readily obtained by passing the Recordaflux films through reproduction equipment.

Circle No. 225 on Subscriber Service Card.

Hole Bottom Adapter

An adapter for the Surfindicator (a precision instrument for measuring surface finish), used to measure the surface roughness of the bottoms of holes, slots, counter bores, and any area below the surface level is available from Brush Instruments, Division of Clevite Corp.

The hole bottom Adapter may be used either for hand-held or for motor driven operation with Brush Motor Drive BL-117 to measure surface roughness in the range from zero to 250 microinches. It measures the surface in bottoms of holes as small as 3/8-in. ID., to a maximum depth of one inch.

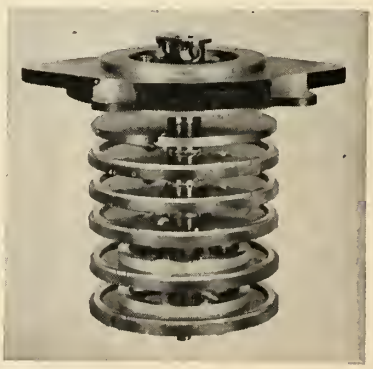
Circle No. 226 on Subscriber Service Card.

Sine-Cosine Switcher

A slip ring assembly of concentric ring type construction for switching from positive to negative for sine and cosine functions in radar antenna mounts has been announced by Breeze Corporations, Inc.

The unit accomplishes switching within 0°20′. Switching is either break-before-make or make-before-break. Phasing accuracy is 0.20′ electrical and 0.005 in. mechanical. The slip ring assemblies operate in an ambient temperature range from −65°F to 165°F.

Circle No. 227 on Subscriber Service Card.



Liquid Fuel Detection

A series of Quartector Liquid Detection Systems have just been introduced by Trans-Sonics, Inc. Designed specifically for use with storable propellants, rocket fuels, and liquefied gases, these Systems make possible positive fail-safe sensing and control of such liquids as UDMH, N_2O_4, liquid H_2, anhydrous hydrazine, liquid O_2, liquid N, RP-1, and JP-4.

Quartector Systems utilize a point sensor that is actuated by the damping effect of a liquid on a vibrating quartz crystal.

Circle No. 228 on Subscriber Service Card.

Coiled Delay Line

A new coiled step-variable delay line provides X-band waveguide line lengths of from 13 to 1228 feet in short steps. It can be used to check out as many as 64 different positions in 15 minutes.

Manufactured for commercial use by Turbo Machine Co., the portable microwave line was based on a Diamond Ordnance Fuze Laboratory technique developed some years age.

Advantages include elimination of drift inherent in long-time measurements, and eliminations of the necessity of coupling and uncoupling joints with consequent possible contamination.

Circle No. 229 on Subscriber Service Card.

Fastest Silicon Switcher

Texas Instruments has available industry's fastest guaranteed silicon mesa switcher, the 2N706A.

It is an NPN silicon mesa ultra high-speed switch designed for saturated circuitry where speed, reliability and performance are a necessity.

Along with the 2N706A, TI has announced the 2N753—a high-gain version of the same transistor.

These units are expected to be designed into aircraft and missile circuits

and to be used in industrial, guidance and control computer circuitry. Specific uses include such circuits as computer logic, flip flops, binary counters, trigger generators, and electronic switches.

Circle No. 230 on Subscriber Service Card.

High-Pressure Transducer

A miniature, high-pressure, high-temperature pressure transducer, capable of measuring up to 15,000 psi, and weighing less than 0.25 lb., is available from Colvin Laboratories, Inc.

Designated Series 8416, the transducers represent a reduction in the previous size of such devices of approximately 50%. They are designed to measure pressures in any range from 0 to 400 psi to 0 to 15,000 psi and are available in various resistance values. The transducers are an exact complement of Colvin Laboratories Series 401 miniature transducers, which are limited to pressure ranges from 0-1 to 0-400 psi.

Circle No. 231 on Subscriber Service Card.

Rotary Motion Transducer

Latest in Arnoux Corp.'s Transipot line of linear and rotary motion transducers for critical indicating or feedback control systems are the Transipot Models 10-R-60-1 and 10-R-30-1.

Transipots are available with ac input and ac or dc output. Typical specifications for the Size 10 linear-motion, ac to ac Transipot: Input range: ±30° and ±60°; Input voltage: 26 v ac, 400 cps; Output impedance: 5000 ohms; Independent linearity: ±.3%; Null (tuned): .1% of Full Scale; Useable frequency range: 300 to 3000 cps.

Circle No. 232 on Subscriber Service Card.

Glass-Enclosed Resistor

A glass-enclosed, precision film resistor has been put into mass production by Corning Electronics Components, a department of Corning Glass Works.

The glass enclosure is hermetically sealed; the resistor has zero moisture absorption. The NF-60 and NF-65 are 1/8-watt and ¼-watt models respectively, having a resistance range of 100 ohms to 360K ohms. Voltage ratings are 250 and 300v respectively. Derating is to 150°C.

Circle No. 233 on Subscriber Service Card.

Print-Punch Cartridge

Off-line preparation of Recomp computer data tapes has been greatly speeded through use of new Print-Punch equipment being marketed by Autonetics, a division of North American Aviation, Inc.

Developed for use with Autonetics' Recomp general-purpose digital com-

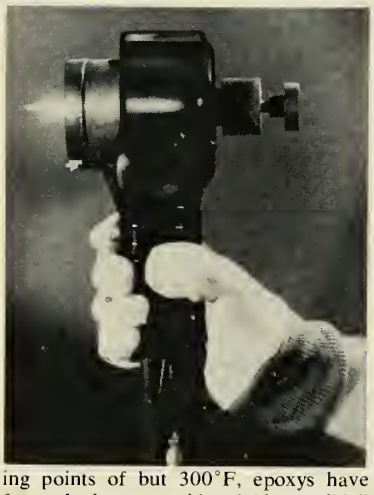
puter, the new equipment is completely self-contained. It comes in two table-top units, the 10-key input keyboard and the paper tape punch. The equipment makes it possible for Recomp users to produce manually prepared tapes conveniently off-line for rapid input of data through the computer's photo-electric tape reader.

Circle No. 234 on Subscriber Service Card.

Low Temp Spray Nozzle

Spray and spray nozzle design techniques which permit spraying of materials of lower melting temperatures with plasma spray devices, are available from Plasmadyne Corp.

The technique permits the spraying of epoxy powders at will. With melting points of but 300°F, epoxys have formerly been considered "impossible" for plasma treatment.



In addition, such materials as zinc, lead or soft solder obtainable in a powdered form may be readily sprayed.

Circle No. 235 on Subscriber Service Card.

Leadthrough Terminal

Ceramics for Industry Corp. is manufacturing ceramic-metal seal composite suitable for insertion into envelope structures by use of high temperature braze material.

This primary ceramic-metal seal is relatively isolated from terminal and envelope stresses. This feature permits the use of large diameter copper leadthroughs and high temperature seal-in procedures.

Circle No. 236 on Subscriber Service Card.

Reuseable Explosive Valve

A complete series of patented Conax Normally Closed Con-O-Cap Explosive Valves, with exclusive reuseable bodies and replacement kits, is being produced by the Conax Corp.

This series of lightweight standard models are dead-tight, shut-off valves for long- or short-time storage of gases or liquids up to 5000 psi, and operate in .002 sec. by firing a small completely contained explosive squib. Dual primers provide a reliability factor of 99.99+% at −65°F to + 160°F temperature range.

Circle No. 237 on Subscriber Service Card.

No Slide Sampling Switch

The Magnavox Research Laboratories have developed a magnetically actuated sampling switch for high-speed, low-level operations. The elimination of sliding contacts, which are inherently noise and heat generators and are also short-lived, has made possible a switch design capable of fast operation at extremely low signal levels, with life exceeding 200 million operations.

In many applications the switching unit introduces less than 10 microvolts of extraneous signal into the circuit being commutated regardless of impedance level. Dwell periods as brief as 300 microseconds and dynamic resistances of less than 1.0 ohms enable fast, accurate multiplexing of low-level transducers.

Circle No. 238 on Subscriber Service Card.

new literature

OPTICAL QUARTZ—A detailed technical description of the optical properties of Suprasil and Infrasil grades of fused quartz glass has been published in data file form by the Amersil Quartz Division of Englehard Industries, Inc. Numerous graphs and tables compare transmission, absorption, dispersion and refractive indices of Suprasil, Infrasil and other quartz types for a wide range of wavelengths and in various thicknesses. Further data, including color photographs, indicate the degree of fluorescence exhibited and the reaction of the various types to X-ray, alpha, beta and gamma radiation.

Circle No. 200 on Subscriber Service Card

BERYLLIUM APPLICATIONS—Pure beryllium tubing is described in Data Memorandum No. 26 published by Superior Tube Co. The memo gives complete information on available sizes and properties of pure beryllium tubing. Included are its physical and mechanical properties and the composition limits of the material from which the tubing is made.

Circle No. 201 on Subscriber Service Card

ELECTROMAGNETIC BALL BEARINGS—Complete engineering information on the Dynamic Bearing developed by The Barden Corp. is available in a two-page engineering data sheet. Operating qualities of the Dynamic Bearing are particularly suited to applications requiring extremely sensitiv ultra-low-torque characteristics such gyro gimbals, stable platforms, scal and static balancing devices. Maximu benefits are derived at very low velo ities, particularly those at, or approac ing, zero RPM.

Circle No. 202 on Subscriber Service Card

QUENCHING OILS—A bulletin pub lished by Sun Oil Company contain data on Sunquench 1070 fast-quenc oil, and Sunquench 1021, a "hot oil type of quenching medium. Typic characteristics of the new oils ar cited, together with the benefits ob tained from their use. Quenching speed measured by three widely used tech niques (including GM Quenchometer are reported for each oil.

Circle No. 203 on Subscriber Service Card.

MOLYBDENUM METAL—A 110 page handbook which provides ma terials engineers with comprehensiv information on properties, productio and fabrication of unalloyed molyb denum metals is available from Clima Molybdenum Co. The handbook place special emphasis on new advances i arc casting and powder metallurg which have made it possible to produc ingots up to 12 in. in diameter an readily convert them into billets, forg ings, sheet, tubing and bars. Describe also are fabrications and joining tech niques which now make possible pro duction of molybdenum metal parts o conventional equipment for missile space, nuclear and other applications.

Circle No. 204 on Subscriber Service Card

EXPLOSIVE CARTRIDGES—Tech nical data sheet No. 2100, describing a standard series of electrically-initiated pressure-producing explosive cartridge, is available from Holex Inc. Nineteen units cover a range of energy output capacities from 10 to 135 foot pounds. Data includes space requirements, functioning time and electrical characteristics, propellant load computation data and a brief guide to the sele ction of properly rated explosive pressure cartridges.

Circle No. 205 on Subscriber Service Card.

VACUUM IMPREGNATION—Improving the dielectric efficiency of large distribution transformers, the armatures of generators and motors, ignition wiring systems, coils and capacitors, and components for radar and other electronic systems are some of the principal current applications for vacuum impregnation whose advantages are presented in detail in the revised edition of a 16-page brochure published by F. J. Stokes Corp.

Circle No. 206 on Subscriber Service Card.

contracts

NASA

,645,730—**Trailmobile, Inc.**, Springfield, Mo., for missile body shipping containers.

,382,540—**Lockheed Aircraft Corp.**, Marietta, Ga., for engineering, fabrication and associated services in support of experimental, development and research work under various space programs.

13,060—**Aerolab Development Co.**, Pasadena, for modification of *Argo D-4 (Javelin)* vehicle.

5,000—**Compressed Gases, Inc.**, Cleveland, for bulk hydrogen gas for Lewis Research Center.

4,949—**The R. Hansen Co.**, Cleveland, for furnishing and erecting cryogenic lab prefabricated building for Lewis Research Center.

5,103—**Hughes Aircraft Co.**, Culver City, for rigidication of Project *Echo* research satellite.

NAVY

lvania **Electric Products, Inc.**, Needham, Mass., for study of requirements for a composite terminal data distribution system for the Pacific Missile Range. Amount not disclosed.

6,047,000—**Westinghouse Electric Corp.**, Pittsburgh, for design, development and production of nuclear reactor compartment components for the fleet ballistic missile submarines.

508,000—**Solar Construction & Engineering Co.**, Houston, for construction of strategic missile facilities.

273,201—**Lasko Metal Products, Inc.**, West Chester, Pa., for metal containers for guided missiles, *Mark 33*.

200,000—**Elgin National Watch Co.'s Elgin Micronics Division**, Elgin, Ill., for production of high-precision fuses for the *Sidewinder*.

175,000—**Ford Motor Co.'s Aeronutronic Div.**, Newport Beach, Calif., for investigating the feasibility of an undersea warfare device.

99,878—**ACF Industries, Inc.'s Electronics Div.**, Riverdale, Md., for services, labor, material and facilities to manufacture guided missile warheads and extra rod bundles.

53,172—**ITT's Federal Div.**, Fort Wayne, Ind., for services, material and equipment to fabricate electronic firing devices.

35,635—**Minneapolis-Honeywell Regulator Co.**, Los Angeles, for magnetic tape recorder/reproducer system.

5,500—**U.S. Rubber Co.**, Wayne, N.J., for development and study of high-temperature-resistant polymeric materials.

1,235—**Elgin Watch Co.'s Micronics Div.**, Los Angeles, for labor, services, material, facilities to develop, fabricate and test fuze-triggering devices.

ARMY

Westinghouse Electric Corp., Pittsburgh, for production engineering measures for silicon controlled rectifiers. Amount not disclosed.

Nuclear Corporation of America, Denville, N.J., for the development of a Tactical Beta Gamma Monitoring Instrument designated Radiacmeter IM-145 (XE-1)/UD. Amount not disclosed.

14,455,000—**General Electric Co., Heavy Military Electronics Dept.**, Syracuse, N.Y., for production of high-power acquisition radars (HIPAR) for use with the *Nike-Hercules*. Subcontract from **Western Electric Co.**

2,067,414—**Chrysler Corp.**, for production of miscellaneous spare parts for the *Redstone* missile system.

739,382—**Raytheon Co.**, Waltham, Mass., for replenishment repair parts for the *Hawk* system (three contracts).

. . . contracts

$726,904—Southern, Waldrip & Harvick Co., Long Beach, Calif., for SAC missile facilities at Beale AFB.

$624,099—Arvol D. Hays, Lubbock, Tex., for strategic *GAM 77* missiles for Walker AFB.

$168,972—Duval Engineering & Contracting Co., Jacksonville, Fla., for construction of *Saturn* unloading facilities, Patrick AFB.

$151,482—International Builders of Florida Inc., Coral Gables, for construction of two theodolite tower structures at Cape Canaveral.

$92,900—M. W. Hills Construction Co., Salina, Kan., for construction of re-entry vehicle, Schilling AFB.

$55,194—Raytheon Co., Waltham, Mass., for retrofit kits for *Hawk* system.

AIR FORCE

Atlantic Research Corp., Alexandria, Va., for development work on high volumetric heating value slurry fuels for ramjet engines. Amount not disclosed.

$6,000,000—Sylvania Electric Products, Inc., Waltham, Mass., for inter-site communications systems at two *Atlas* missile squadron bases.

$1,500,000—Aeronautical & Instrument Div. of Robershaw-Fulton Controls Co., Richmond, Va., for production of six helium regulators to be used in the *Titan*.

$1,200,000—Hughes Aircraft Co., Culver City, Calif., for production of electronic checkout equipment for the *Titan*. Subcontract from The Martin Co.-Denver.

$967,000—Avco Corp.'s Advanced Development Div., Wilmington, Mass., for design and production of satellite re-entry shield. Subcontract from Lockheed Aircraft Corp.

$500,000—General Motors Corp., AC Spark Plug Div., Flint, Mich., for depot level maintenance of the *Thor* inertial guidance system including associated ground and operating equipment.

$440,000—United Electrodynamics, Inc., Pasadena, for production of telemetry equipment for use with the *Minuteman*. Subcontract from Boeing Airplane Co.

$429,930—Wheeler Electronic Corp., Waterbury, Conn., for R&D for high-reliability transformers for use with the *Minuteman*. Subcontract from North American Aviation Inc.'s Autonetics Div.

$300,000—HRB-Singer, Inc., New York City, for special airborne electronic countermeasure equipment for the Quick Reaction Capability facility at Wright-Patterson AFB.

$153,000—American Bosch Arma Corp., Arma Div., Garden City, N.Y., for depot test equipment required to support the *Atlas* inertial guidance system.

$102,833—General Electric Co., Missile & Space Vehicle Dept., Philadelphia, for depot-level maintenance of MK II reentry vehicle airborne and ground support equipment and components.

$100,000—Douglas Aircraft Co., Inc., Santa Monica, for system integration and in-service engineering support of *Thor* weapon system.

$100,000—North American Aviation, Inc., Rocketdyne Div., Canoga Park, Calif., for in-service engineering and propulsion subsystems and related ground support equipment.

$50,000—General Motors Corp., Flint, Mich., for services and supplies to operate a contractor storage site in support of the *Thor* guidance system.

MISCELLANEOUS

$190,000—Summers Gyroscope Co., Santa Monica, Calif., for spring-wound gyros for missile use. Subcontract from The Martin Co.-Orlando.

—when and where—

SEPTEMBER

13th General Assembly of the International Scientific Radio Union, University College, London, Sept. 5-15.

International Summer Course on Solid State Physics, sponsored by: Italian Physical Society, in cooperation with NATO, CURATOM and National Committee on Nuclear Research, Italian Nuclear Energy Center, Varese, Italy, Sept. 5-24.

Society of British Aircraft Constructors Show and Flying Display, Farnborough, England, Sept. 6-11.

Electronics Industries Association, Second Conference on Value Engineering, Disneyland Hotel, Anaheim, Calif., Sept. 7-8.

Joint Automatic Control Conference, Massachusetts Institute of Technology, Cambridge, Sept. 7-9.

AGARD, Seminar jointly sponsored by AGARD and the Instituto Lombardo di Scienze e Lettere, "Propulsion for Astronautics," Varenna, Italy, Sept. 8-12.

American Chemical Society, 138 National Meeting, New York City, Sept. 11-16.

Second International Congress in the Aeronautical Sciences, sponsored by the International Council of Aeronautical Sciences, Zurich, Switzerland, Sept. 12-16.

IIIrd International Congress on Surface Activity, Cologne, Germany, Sept. 12-17.

Electronics Industries Association Fall Conference, Sheraton-French Lick Hotel, French Lick, Ind., Sept. 13-16.

Engineering Management Conference, sponsored by American Institute of Electrical Engineers and American Society of Mechanical Engineers, Morrison Hotel, Chicago, Sept. 14-16.

Armed Forces Chemical Association, 15th Annual Meeting, Sheraton-Park Hotel, Washington, D.C., Sept. 15-16.

Institute of Radio Engineers, National Symposium on Space Electronics & Telemetry, Shoreham Hotel, Washington, D.C., Sept. 19-22.

Ninth Annual Symposium on Industrial Instrumentation, sponsored by Institute of Radio Engineers and American Institute of Electrical Engineers, Manger Hotel, Cleveland, Sept. 21-22.

ASME-AIEE Power Conference, Bellevue-Stratford Hotel, Philadelphia, Sept. 21-23.

Air Force Association, National Convention and Aerospace Panorama, San Francisco, Sept. 21-25.

American Ceramic Society, Electronics Division, Schroeder Hotel, Milwaukee, Sept. 22-23.

American Institute of Chemical Engineers, Mayo Hotel, Tulsa, Okla., Sept. 25-28.

Electronic Industries Association, National Convention, Pittsburgh-Hilton Hotel, Pittsburgh, Sept. 26-28.

American Welding Society Fall Meeting, Penn-Sheraton Hotel, Pittsburgh, Sept. 26-29.

Wants Positive Thinking

To the Editor:

(Regarding the editorial, "The Leaden Feet of NASA's Mercury," M/R, Aug. 15), did you recommend *Dyna-Soar* as the man-in-space project when *Mercury* was started? The world is full of cracker barrel experts with "hindsight." How about some usable constructive thinking which might lead to a solution to problems?

John Nicol
Fairview Park, Ohio

Titans Welcome

To the Editor:

As a native of Tucson, as well having been employed in several phases of missile engineering during the last 11 years, let me assure you that the opinion of Mr. J. E. McDonald with reference to the Tucson *Titan* bases definitely does not reflect the opinion of a majority of the population of Tucson. Mr. McDonald's group is, indeed, an exceptionally small but noisy minority.

The Tucson *Titan* sites were, in actuality, quite well chosen with respect to logistic requirements and ESCAPE ROUTES. Lethal fallout would be just as likely from an attack on any other sites in the area which would be suitable or available for *Titans*.

Mr. McDonald's group has also failed to take into consideration the fact that Tucson proper is considered a primary target for enemy attack due to the location of Davis-Monthan Air Force Base, a SAC installation.

By far the greater majority of the citizens of Tucson welcome the *Titan* bases, regardless of location. The feeling is that the bases will definitely prove beneficial to the economy of the Tucson area, while not necessarily increasing the likelihood of enemy attack.

William J. English
Field Engineering Rep.
White Sands Missile Range
New Mexico

Colonists by Sufferance?

To the Editor:

Mr. Truax may be the foremost authority on rockets and a pioneer in rocket development, but his article entitled "Planets to be Colonized in 50 Years" (M/R, Aug. 8, p. 38) only points up the fact that he and all too many other scientists and engineers today are very narrow-minded and even possibly egoists about Man's intelligence.

Their implication that Man is the highest order of intelligence (on this planet)—ergo, the only intelligent being in the entire Universe—is just too limited for my way of thinking.

It is my contention that the miniscule bit in the vastness of space on which we live is not the only place inhabited by intelligent beings. These others may not be fashioned after our mold, but are undoubtedly intelligent—perhaps further advanced than we.

It is not inconceivable to one who believes in God also to believe in the Steady-State Theory or to anticipate and accept the fact that in His infinite wisdom there were created other beings in other environments, and that these beings may be of a higher and more advanced intelligence than Man's.

Another thought that has occurred to this writer is the fact that our planet Earth—by whatever name these other intelligent beings may know it—may well be called by them "Experiment Earth," and that our pitifully meager beginnings at probing this solar system, our galaxy, or the galaxies beyond are being carefully watched—much as we keep careful watch over our microbe cultures, test tubes, etc.

With the foregoing thoughts in mind, the so-called "permanent colonies on the moon, Mercury, Venus, Mars and, perhaps, on the moons of Jupiter and Saturn," following the explosive spaceflight expansions predicted over the next 5(years, may be possible—but only with th permission of these intelligent beings wh may be inhabiting those self-same planet and/or their natural or mechanical orbit ing satellites.

Perhaps these thoughts have been pu too sharply, but I have been reading s many papers, articles and newspape stories along these lines that I though someone should speak out about thes possibilities. I would be very much inter ested to know whether there are other with similar, unstated thoughts.

Vehig S. Tavitian
Managing Editor
Special Publications
Institute of the Astronautical Sciences
New York City

P.S. The editorial, "How Bold, How Imaginative?" on p. 50 of the same issue takes the same premise (as the article).

P.P.S. This is a personal reaction—*not* an official communication.

LOX Relief Valves

To the Editor:

I noticed that the COUNTDOWN in the Aug. 1 M/R referred to the giant cryogenic valves installed by Elmco. Of equal interest are 14-in. LOX vent relief valves designed and manufactured by Anderson, Greenwood & Co. for Rocketdyne. They are used on the same system at Edwards AFB and I believe they are probably the largest single relief valves to be made, certainly the largest and finest ever made for this service.

W. W. Hering, Sales Mgr.
Industrial Products Div.
Anderson, Greenwood & Co.
Houston, Tex.

Telescope Engineering

To the Editor:

On page 19 of the Aug. 1 M/R you show a photo of a rendering of a 1000-ft.-diameter radio telescope. The caption under the photo did not indicate the organization responsible for the engineering.

Our office provided the drawing appearing in the photograph and our Mr. T. C. Kavanagh is acting as chief engineer of the joint venture responsible for the engineering: Von Seb, Inc.; Developmental Engineering Corp.; Severud-Elstad-Krueger Associates and Praeger-Kavanagh.

Benjamin Gray
Praeger-Kavanagh Engineers
New York City

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editorial . . .

The Aerospace Strategic Force

IN A RECENT SPEECH at Fort Worth, General Curtis LeMay took the time to state some old and some new military doctrine as it applies to the U.S. military situation today.

General LeMay is presently Vice Chief of Staff of the Air Force. He has held that position almost four years and will almost certainly succeed soon to the post of Chief of Staff. Before that, he was commander of the Strategic Air Command almost from the inception of SAC.

There are those who tend to discount the LeMay opinions as those of a rabidly partisan air doctrinist. But there are few if any who do not regard him as a tough-minded, realistic and competent general officer.

Significantly, General LeMay apparently regards our present mixture of unmanned missiles and aircraft as an interim step toward a strategic aerospace force wherein the manned spacecraft and possibly the manned missile would be dominant.

Warning that our deterrent force is not a true deterrent unless it has the capability of absorbing a surprise attack and still striking and restriking back, LeMay says:

"Our counterforce capability must be a carefully prepared, maintained, modernized and controlled blend of strategic weapons. We must select the best systems devised, in the proper quantity, and attain simplicity of operations for assurance of victory."

"Having both fixed and mobile missile systems in our force adds to our overall capability . . . But the number of missiles in each type of delivery system must be carefully weighed." And he continues:

"We are not placing all our reliance on the unmanned systems. With manned *aerospacecraft* . . . a nation can react to a variety of situations in a variety of ways . . . Manned *aerospace* forces give a nation options ranging from ground alert to launch of the force subject to recall. Manned *aerospacecraft* can be effectively used as a show of force . . ."

We have long held that earthly wars as we know them are outmoded and unfeasible and that both the danger and the deterrent of the near future will be in space.

This does not mean that we can or will neglect our earth-bound forces and fail to keep them just as strong and as diverse as the enemy's. It does mean that with present-day weapons no nation can start a great war with the expectation of anything except his own destruction.

In this aerospace strategic force LeMay speaks of—what do we have? Not the B-52 or the B-58. Not even the B-70, although all three could launch comparatively long-range missiles for which there is little defense.

NO, AN AEROSPACE weapon is an actual space-flying weapon system—*Dyna-Soar* and its successors. They will be of infinite variety, from manned missiles to huge spacecraft. They can be boosted from the earth by external means as we now know them. Or they can be large enough to create their own oxygen-hydrogen fuel as they climb into orbit.

Whatever they are or will be—they should be on this nation's drawing boards now, and in the development stage just as soon—the day or week—as our capabilities permit. Not months or years later.

For the Russians will have a man in space soon. Their gainful occupation of space is just a short step further. If they reach the point where they can dominate space—then they can find a way to dominate the world.

Clarke Newlon

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