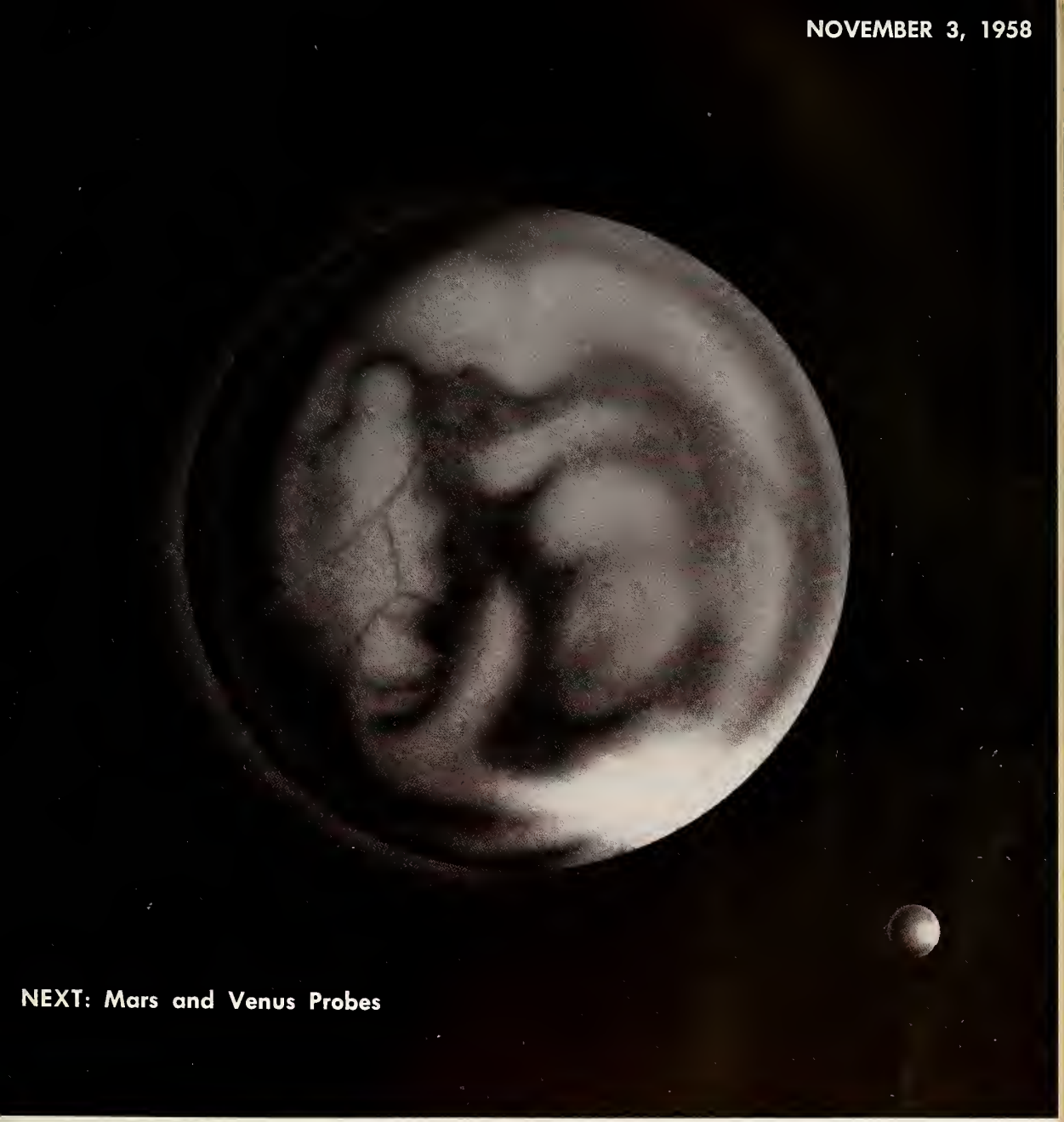
NOVEMBER 3, 1958



NEXT: Mars and Venus Probes

missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS

Engineering and Electronics Edition

AN AMERICAN AVIATION PUBLICATION

NEW

Transistorized

Digital Voltmeters for Missile Check-out Systems

MODEL 24
4-DIGIT VOLT-OHMETER
Measures DC Volts, Voltage Ratio, and Ohms

The *first* digital voltmeters designed specifically for missile and weapons system check-out . . . the *first* compact, single-unit instruments to automatically and continuously measure and display DC voltages, voltage ratio, and resistance . . . the *first* digital voltmeters to attain the high standards of performance listed to the right! With their many exclusive features, NLS Model 24 instruments provide greater reliability and far more flexibility than have ever been offered before in digital voltmeters. See these new ultra-reliable, high-speed instruments in action! *Wire or phone collect* to arrange for an on-the-spot demonstration of the NLS Model 24 Digital Voltmeters.

ACCURACY

Scale factar and linearity accurate ta 0.01%, approaching accuracy of standards labaratary equipment. 10 megahm input impedance.

RELIABILITY

Utilizes transistars and mercury-wetted relays. Provides highest degree of reliability ever attained in any digital valtmeter.

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Easiest ta aperate, easiest ta read. Only NLS provides all af these features in ane compact instrument: automatic range changing, autamatic decimal placement, autamatic palarity indicatian . . . exclusive snap-in readaut with na-glare haad . . . plug-in campanent madules thraughaut.

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Plug-in cannectars allaw for simple attachment af such accessaries as AC/DC canverter, law-level amplifiers, remate readauts, and serial canverters ta permit driving af autamatic typewriters, flexawriters, and tape ar card punching units.

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NLS manufactures the most complete line of three, faur, five, and six digit instruments far automatically measuring and displaying DC and AC valtages, valtage ratia, and resistance.

Originators of the Digital Voltmeter

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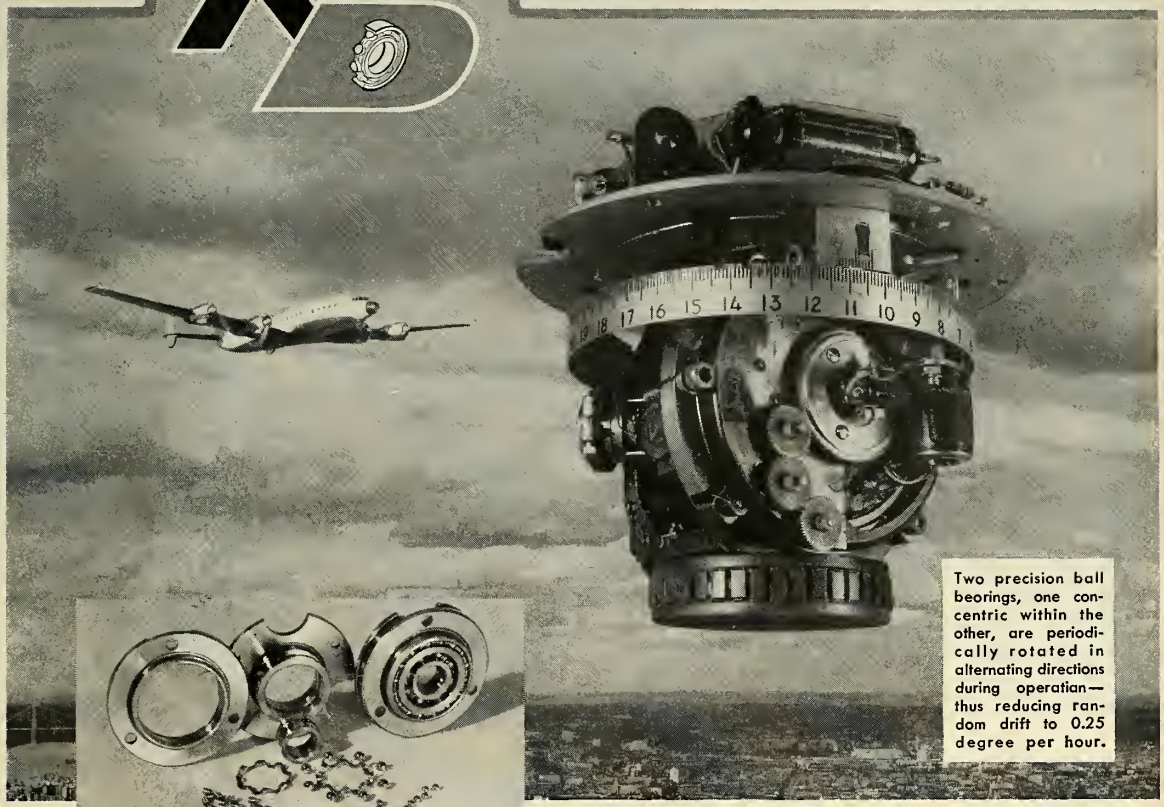
CASE HISTORIES



Two precision ball beorings, one concentric within the other, are periodically rotated in alternating directions during operation—thus reducing random drift to 0.25 degree per hour.

Photo: courtesy Sperry Gyroscope Co.

1,200% Gain In Gyro Accuracy With N/D Ball Bearings

CUSTOMER PROBLEM:

Get new, advanced gyro bearing design "off the board" and into production. Sperry Gyroscope Company, in developing its new Rotorace (TM) gyro, designed a special bearing capable of "averaging out" error-producing effects of friction on sensitive gyro gimbals. New manufacturing techniques would be required to achieve high degree of precision required by Sperry design.

SOLUTION:

N/D Engineering, when approached by Sperry, created special manufacturing techniques for the high precision production of these unique piggy-back gimbal ball bearings. Used in the Rotorace design, the bearings helped achieve reduction of the gyro's random drift rate. The 2 or 3 deg. per hour drift, recently considered very good, is now cut to as little as 0.25 deg. per hour, with still lower rates in sight. Another example of New Departure's ability to meet exacting instrument bearing requirements through broad engineering experience and precision manufacturing techniques.

For immediate engineering analysis of your current high precision instrument and miniature ball bearing problems, write New Departure, Department K-11.

NEW DEPARTURE

DIVISION OF GENERAL MOTORS, BRISTOL, CONN.

NOTHING ROLLS LIKE A BALL

NOW! SPECIFY MIL-C-21180(Aer) TO GUARANTEE 42,000 psi

Now you can specify MIL-C-21180(Aer) for high-strength aluminum castings, and eliminate approval delays.

High-strength aluminum castings meeting the specifications of MIL-C-21180(Aer) are produced by American Brake Shoe Company in Ductaluminum 356T and Ductaluminum 356S. These castings provide guaranteed* mechanical properties in highly stressed areas specified by the design engineer. Greater design freedom, improved production economy, and complete service reliability result.

Brake Shoe produces sand, permanent mold, and plaster mold castings—from a few ounces to 500 pounds—in both high-strength and standard alloys. Government certified heat treat, Zyglo, and X-ray. Send drawings of your problem parts and let our engineers show how critical, hard-to-make designs can be produced as high-strength aluminum castings. Delivery from our plant at Mahwah, New Jersey, or our Gaines Works at Rivera, Calif.

**Guaranteed Properties in highly stressed areas.*

	T.S., psi	Y.S., psi	%El.
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Ductaluminum 356S	42,000	35,000	3

Other grades available to all military specifications.

AMERICAN Brake Shoe COMPANY

LIGHT METALS DEPARTMENT
MAHWAH, NEW JERSEY

COVER: *The planet Mars is ready and waiting for scientific exploration. First exploration will be by ONR's Strato-Lab IV balloon (page 14), but the "red" planet will be in favorable position for a rocket probe in November, 1960, which probably will be undertaken by NASA.*

missiles and rockets Vol. 4, No. 18, Nov. 3, 1958

Published every week by American Aviation Publications, Inc., 1001 Vermont Ave., N.W., Washington 5, D.C. Printed at the Telegraph Press, Harrisburg, Pa. Second class mail privileges authorized at Washington, D.C., with additional entry at Harrisburg. Copyright 1958, American Aviation Publications, Inc.

Subscription rates: U.S., Canada and Postal Union Nations—1 year, $8.00; 2 years, $12.00; 3 years, $14.00. Foreign—1 year, $20.00; 2 years, $30.00; 3 years, $40.00. Single copy rate—$.75 Subscriptions are solicited only from persons with identifiable commercial or professional interests in missiles and rockets. All subscription orders and changes of address should be referred to: FRANK R. WILLIAMS, circulation fulfillment manager.

in this issue

NOV. 3 HEADLINES

ASTRONAUTICS ENGINEERING

MISSILE ELECTRONICS

DEPARTMENTS

Sixth sense for Republic's F-105

Advanced versions of Republic's F-105 will be able to nail targets on the head, night or day, cloudy or clear—even if the targets are hidden deep in rugged mountains. This remarkable capability stems from NASARR—the F-105's monopulse radar system—developed and manufactured by Autonetics for the AN/ASG-19 armament control system.

Lightweight, compact NASARR is the only system in production that provides these radar functions for both low-level and high-level missions...air search, automatic tracking, ground mapping, and terrain avoidance.

Like Autonetics' other advanced guidance and control systems, NASARR is reliable *and* available. Years of R & D... of working ahead of the field...have made it so.

Please write for more detailed information.

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A Division of North American Aviation, Inc. • Downey, California

washington countdown

Battlefield mobility . . .
concept of Army has industry buzzing with proposals with prospects that the service will spend a reported $5 billion annually for three years. There are three missile systems—A, B, C. *Mauler,* surface-to-air infra-red against low-flying aircraft, which Martin and Convair reportedly have study contracts for is one. Another system involves Chance Vought, Douglas, Minneapolis-Honeywell, General Electric, Armour Research, and Cornell. C-V calls its small diameter, swiveled rocket, *Project Firepower,* and may test fire it in January. C-V reportedly has invested $6 million of own money in developing 70-mile range missile. Other system may involve missile called *Little Jim.*

First independent . . .
action of NASA may be an equatorial test range—long advocated for satellite launchings. U.S.-owned Howland, Christmas and Baker Islands in South Pacific may be good guesses.

New Red China sell . . .
is the lethal *Sidewinder,* displayed for propaganda to 50,000 persons recently in Peiping. Missile took precedence over a display alleging U.S. "germ warfare" in Korean war.

Space leadership . . .
can be obtained by U.S. only if there is high priority in erecting a manned laboratory in space, according to Dr. Arthur Kantrowitz, director of Avco Research Lab. He said last week the U.S. could do it at a cost of $1,000 a pound with the lightest capsule proposal weighing about 1,400 pounds.

USSR ballistic missile . . .
production is about 2,000 per month, with intelligence sources estimating goal of 20,000. About 30% will be IRBM's with remainder being medium and short range.

Soviet rocket bases . . .
in Czechoslovakia are at Joachimsthal, Karlsbad, southwest of Reichenberg, northeast of Olmutz, near Bohmen-Budweis, and Javorina. Hungarian bases are near Tapolca, Papa, and Hajmasker. East German bases are Kolberg, Libau, Memel, and Reval.

Rickover's promotion . . .
to vice-admiral is getting a luke-warm reception in large segments of top Navy brass. Personal feelings and jealousy have little to do with it. Reason: by creating billet, another vice-admiral slot will have to go. Number is specifically limited by law.

House space committee . . .
plans to look into future propulsion system and fuels; will review national space program, accomplishments of IGY, and probably will lay ground rules for international space cooperation.

Soviet espionage . . .
has been unusually successful in British missile program. Secret performance figures on *Black Knight* have fallen into Red hands.

American missiles . . .
will not be manufactured in Britain, says Assistant Defense Secretary Quarles. However, Britain will manufacture U.S. rocket engines under license.

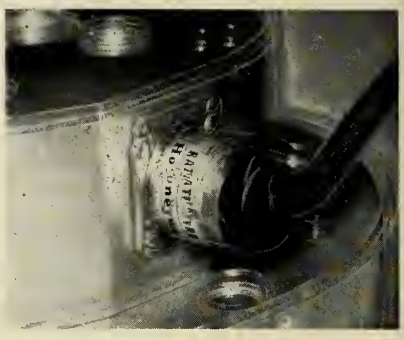
Competitive bidding . . .
has a basic flaw, according to one top defense official, and it's statistically interesting. A number of bids on a statistical scale will show a grouping around the middle with a few scattered on top and bottom. Statistically, middle bidders know more about the subject than the other two, but the bottom one usually gets the contract. Officials complain that the bottom man will usually come back for more money, bringing total cost back up to what the middle bidders thought it should be.

Look for appointment . . .
of Dr. Joseph V. Charyk, director of missile technology of Aeronutronic Systems, Inc., to replace Dr. George E. Valley, Jr., as Air Force chief scientists.

NASA-ABMA compromise . . .
was in the works as m/r went to press. And the compromise reportedly was acceptable to both. One proposal reportedly was that JPL would be transferred to NASA while the Huntsville scientific team would remain with the Army, but would do work for NASA on a project basis (same as it now does for ARPA). Subject probably held a high place on Wednesday agenda of President's Space Council.

HONEYWELL MINIATURE RATE GYROS

Rugged enough to withstand 100 G shock



Typicol M Series Gyro undergoes 20 G Linear Vibration Test with no deterioration of performance.

Model M-1
shown actual size

Sensitive enough to detect 0.005° per second

Honeywell's newest miniature rate gyros, Type M Series, are rugged enough to withstand repeated shocks and linear accelerations up to 100 G yet sensitive enough to detect turn rates of only 0.005 degrees per second. A damping ratio variation of 2 to 1 or better is maintained without heaters by a unique fluid damped, temperature compensated system that assures reliable operation over the entire operating temperature range.

Type M Series Gyros are specifically designed for autopilot damping, radar antenna stabilization and fire control applications. Their small size, high performance and ruggedness suit them particularly for high performance military aircraft and guided missile applications. Write for Bulletin M to Minneapolis-Honeywell, Boston Division, Dept. **45**, 40 Life Street, Boston 35, Mass.

DESCRIPTIVE DATA

FULL SCALE RANGE: to 400 degrees per second

THRESHOLD-RESOLUTION: 0.005 degrees per second

LINEARITY: 0.1 % to 2 % depending on ronge

DAMPING: 2 to 1 (or better)

TEMPERATURE RANGE: −65 to +200 ond +250°F

SHOCK AND ACCELERATION: 100 G

VIBRATION: 20 G to 2,000 cps

PICKOFF: Variable Reluctance type providing infinite resolution ond high signol-to-noise ratio

MOTOR EXCITATION: 26 volts, 400 cps Istandord) 2 phase ond 3 phase

SIZE: 1″ diameter, 2¾″ long

WEIGHT: 4.5 ounces

Honeywell

Military Products Group

industry countdown

First tests for nuclear rocket . . .
reactor will be started with in the next few weeks. The reactor, dubbed *Kiwi-a,* is the result of three years of secret, low-level research and development activity in the Air Force-Atomic Energy Commission Project *Rover* program. The AEC is charged with reactor development and the Air Force with non-nuclear components.

Rocketdyne and Aerojet-General . . .
are working on the reactor and nuclear fuel materials furnishing valves, pumps, and other system components. ACF Industries has built the reactor vessel for *Kiwi-a* with instrumentation for the tests the responsibility of Edgerton, Germeshausen & Grier, Inc. Some 12 other firms have subcontracts.

Large Tracts of land . . .
have been picked up by Rocketdyne in the Nevada area for anticipated facilities expansion connected with Project *Rover.* With some $25 million spent on *Rover* to date and approximately $35 million anticipated for the next fiscal year, a steadily increasing budget is looked for on *Rover* and *Pluto* (nuclear ramjet). Air Force predicts that billions will be spent on the projects before a successful rocket or missile is a reality.

***Bumblebee* program . . .**
has received a much needed boost with the Navy award of $17 million for continued research and development on surface-to-air missiles at the Johns Hopkins Applied Physics Laboratory. *Bumblebee* is a pioneer project with such accomplishments as *Terrier, Tartar,* and *Talos.*

New propellant battle . . .
has developed, this time storable package liquids versus storable package liquids. Package liquids proponents say the battle in the near future will overshadow the present solid vs. liquid hassle and solid long range missiles such as *Minuteman* and *Polaris* will fight for existence. All that's needed by the package people is the same old bugaboo—money for development. Top competitors at the moment are Aerojet and Thiokol-Reaction with Reaction making the strongest bid. Production heads say it is only a matter of scale-up to any size unit needed. To date scale-up has been meager (*Sparrow* and *Bullpup*) but ample enough to confirm feasibility.

Communication with space-vehicles . . .
or other planets may soon require the serious attention of the Federal Communication Commission. Press Wireless has requested confirmation of FCC's understanding that its present license would permit communication with outer space. Press Wireless stated it wants to provide an informational communications service with manned satellites, space platforms, or space expeditions.

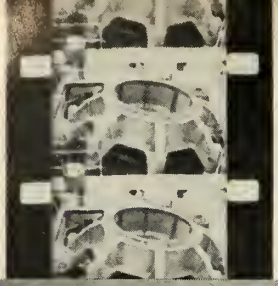
***Major Minuteman* subcontractors . . .**
to assist Boeing in the assembly and testing research and development program are: American Telephone & Telegraph Co., for communications; Bechtel Corp., for sites; and Four Wheel Drive Truck Co., for ground handling equipment.

***Bomarc* weapon support equipment . . .**
at Eglin AFB, Fla., first installation of the Air Force surface-to-air weapon system, is receiving finishing touches. Palu Hardeman, Inc., is responsible for installation, calibration, and check-out of the equipment for the first four or seven launching shelters. *Bomarc* will be test fired from Eglin. Construction on the *Bomarc* base at Riverhead, Long Island has progressed and contractors have been given approval to open the base to public view on November 20.

Army has spent $564 million . . .
for construction of air defense sites in the continental U.S. in the six-year period from fiscal years 1953 through 1959. The same amount reportedly will be spent in fiscal year 1960 for *Nike Hercules* and *Hawk.*

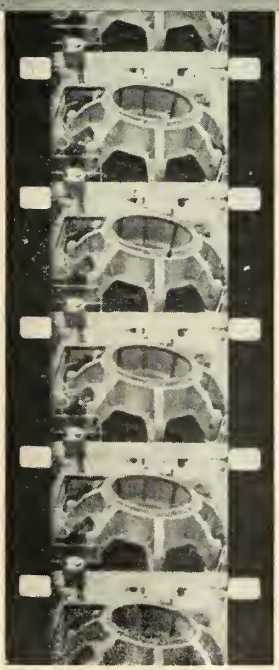
AFMTC expects to spend . . .
an all-time high of about $306 million during fiscal year 1959. This includes payrolls, new construction, maintenance, and supplies and services incurred by the Center and missile contractors at Patrick AFB, the Cape Canaveral Missile Test annex, and downrange activities.

We are accustomed to look upon rocketry . . .
as a relatively unpracticed art. However, an Air Force researcher discovered that more than 72,000 ground-to-air rockets have been fired in this country in the last 15 years.



"Shaker" pitching

"Shaker" rolling



"Shaker"—Loewy's giant rocking horse—paves way for ballistic missile firing at sea

The giant ship motion simulator called "Shaker" has come to life. Designed and built by Loewy-Hydropress under prime contract with the U.S. Navy for its Fleet Ballistic Missile Program, the 40-ft.-tall rocking horse moves up and down, fore, aft and athwart under the electronic fingertips of a distant operator in a thick-walled concrete blockhouse.

"Berthed" at Cape Canaveral not more than 800 feet from the beach and nested in a 47-ft.-deep pit, "Shaker" performs all the important movements of a seagoing vessel. Sliding up and down, she imitates the vertical heave motion. Tilting port and starboard, she acts out rolling. Rocking forward and backward, she duplicates pitching. An intricate mechanism of giant gyrating joints makes these rock 'n' roll moves and their innumerable combinations possible. By proper setting, the typical behavior of an oceangoing vessel in seas ranging from calm to stormy can be recreated precisely by "Shaker."

Polaris, the Navy's Fleet Ballistic Missile, will soon be tested on "Shaker."

For creative engineering and design, research and development in your defense and industrial contracts, direct your inquiries to us at Dept. S-11.

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NOVEMBER 3, 1958
VOL. 4, NO. 18

missiles and rockets
MAGAZINE OF WORLD ASTRONAUTICS

Krushchev-Mao Bargain Known

Intelligence Reports Show That Talks Between Leaders Resulted in Missiles for Red China Use

by Alfred J. Zaehringer

WASHINGTON—Through recent intelligence reports from the Far East, m/r has learned that the same Krushchev-Mao bargain which brought about the bombardment of the off-shore islands also gave Red China the capability of being able to bombard not only these islands but Formosa as well with short and medium range ballistic missiles.

Just before the present off-shore islands crisis, Nikita Krushchev visited Red China's Mao Tse-tung. Some high-level missile, satellite and nuclear weapons decisions were made. It is believed that Krushchev sought permission to make ICBM and IRBM tests over China territory. In exchange, the Soviets were to make available to the ChiComms:

1. Short range ballistic missiles. The T-5, T-5B, and T-5C, plus the T-7A solid artillery missiles (ranges of 25-100 miles) have been operational with the Soviets for several years. Old stocks, plus new models, would make it advantageous to use these missiles in the China conflict. Immediate uses: bombardment of the Quemoy and Matsu Islands which are in the hands of Chang. Thus, the Reds could place missile batteries well inland.

2. Medium range ballistic missiles. The Soviet T-1 (range of about 500 miles) has become obsolete with the advent of the T-2 IRBM and the T-3 ICBM. Placing the T-1 in Mao's hands would:

(a) allow the direct bombardment of Formosa, and

(b) allow the establishment of a Red China satellite.

Mao has said that Communist China will establish a satellite. A satellite of *Vanguard* or *Explorer* equivalent could be established with the T-1 plus other stages of the T-series of short range artillery rockets. Which will come first is hard to say. By establishing a satellite, Red China will immediately display to the world the capability of hitting Formosa.

3. Nuclear technology. Though it is probable that Russia has not given Red China nuclear weapons, it is clear that Soviets are rendering technical assistance in setting up research reactors. At the present time, all technical help and supplies are accompanied by Russian technicians. In the near future, however, nuclear weapons will have to be furnished to the ChiComms. Initially, such weapons will be under the control of the Soviets.

Krushchev may also have made a deal to set up Soviet missile bases in China.

Red China's Theory

By using rockets, the ChiComms can bombard the off-shore islands from bases well out of range of Chiang's artillery on Matsu and Quemoy. The U.S. is reluctant, or has been, to give the Chinese Nationalists missiles to fire back.

The only missile available is the *Matador*, now stationed on Formosa in limited numbers. The *Matador* is a subsonic air-breathing missile and greatly effective only when equipped with an atomic warhead. Army says it has no ground to ground missiles there.

The U.S. Air Force or Navy will not attack the ChiComms shore batteries unless Formosa itself is attacked. But the pressure will eventually force the U.S. to give up the off-shore islands as gracefully as possible, giving into ballistic blackmail.

The situation of Formosa, already under the bomb sights of hundreds of ChiComms jet bombers based on the mainland within easy range, will be even more critical. The Formosa defense set up is oriented to protect Formosa from conventional attacks. *Sidewinder* equipped aircraft, *Nike-Hercules* and conventional antiaircraft batteries are useless against ballistic missiles. Thus the same ballistic blackmail will eventually force a bargained solution to Formosa, the ChiComms believe.

Thule in Range

The Air Force's Thule SAC base is under range of Soviet ballistic missiles. The Reds have set up ballistic missile bases on Franz Josef Land.

During the IGY tests this year, some 25 launchings have taken place from this base. IRBM's and ICBM's reportedly equipped with nuclear warheads, have been launched from the base and were included in the current Soviet Arctic atomic tests. The U.S. made high altitude tests reportedly with a *Redstone* in the South Pacific this summer.

About Pioneer

Air Force Changing Guidance Cutoff

In the third Air Force try with the lunar probe, the guidance system on the second stage will be changed from accelerometer cutoff to doppler cutoff, m/r has learned. The firing will be in the early morning hours of Nov. 7 from Cape Canaveral.

In the second attempt last month the accelerometer was set to cutoff at a certain initial velocity based on a precalculated flight path. Due to an over-performance of the first stage, the missile lofted in flight. Thus when the second stage cut off as programmed, the initial velocity was not the true velocity due to the error in the flight angle.

With some 4 or 5 seconds of burning left in this second stage, the maximum velocity reached by the missile was only 34,750 feet per second at burnout.

Due to the error angle the missile reached out only some 68,000 nautical miles. At the correct angle, 35,200 feet per second speed at burnout is necessary to carry it to the exact 162,897 apogee for orbit.

The following table shows how great a variation in velocity and height at apogee only a slight differential in burnout velocity produces:

Burnout Velocity	Apogee Velocity	Earth Radius, Apogee Height
33,000 ft/sec	5010 ft/sec	22,862
34,000	3045	58,611
34,500	2070	79,344
34,750	1600	95,946
35,000	1120	108,466
35,200	750	162,897
35,250	640	191,166
35,300	540	222,760
35,500	170	689,252
35,570	000	infinity

. . . Pioneer

First stage of the lunar probe is a *Thor* with about 160,000 pounds of thrust. Second stage is a second stage *Vanguard* with about 20,000 pounds of thrust. The third stage, a solid propellant rocket has approximately 8,000 pounds thrust, plus eight small verniers which can be fired for either added boost or correction of flight path. Fourth stage has one "retro" rocket. As this fourth stage cuts loose from the third, it will be travelling at right angles to its longitudinal axis. The "retro" thrust is not designed to slow down the rocket but to give it a thrust parallel to the moon's surface and at right angles to the direction of payload travel.

This fourth stage or payload will again contain radiation measurement equipment, and possibly different scanning equipment, it has been learned.

Scientists on the project estimate that if the final stage approaches within 50,000 miles of the moon it can be placed in orbit. This means, however, as a glance at the table shows, that the burnout velocity still must be controlled between 35,200 and 35,250 feet per second.

If there is to be an error in burning time of the second stage on next firing, an AF spokesman said, it will tend to be on the liberal side. He explained:

"It is a little like rolling a ball uphill and balancing it exactly on the crest. Last time it didn't quite get there and rolled back. This time we are going to give the ball enough 'oomph' to get it to the crest. It can roll over and still go into orbit on the other side—if it doesn't roll too far." Even should that happen AF and NASA, which controls the project, feel that it may scan some part of the dark side of the moon as it goes by.

And, there are many other things to be learned. Astronomers have theorized, for instance, that beyond the moon lies a belt of micro-meteorites. Data from a far-flying *Pioneer III* could measure the width and density of such a belt, or probe whatever else might be there.

Critical Orbit Plan for *Explorer*

by Norman L. Baker

The National Aeronautics and Space Administration's latest scientific satellite attempt, *Explorer VI*, although a noteworthy endeavor, was bucking heavy odds attempting to achieve an extremely critical orbit plan.

Even had the *Jupiter-C* rocket vehicle performed perfectly, the need for an almost unheard of satellite attitude stability at the apogee of its orbit, reduced the chances of success considerably. For this reason many scientists feel that an attainment of a near circular orbit would have been as great an achievement as the successful orbit of the *Beacon* inflatable satellite.

Explorer VI's orbit path was calculated to give the payload an apogee of 400 miles, where, at the slowest position of the orbit, the fifth-stage rocket in the nose of the payload section would have boosted the velocity enough to hold the satellite at that altitude.

This final stage rocket, traveling nozzle forward at the perigee (burnout of the fourth stage) would, because of its 750 rpm spin-stabilized condition, be in a position at the apogee to add its thrust to the momentum of the package.

Of course any variation in the longitudinal axis of the satellite package at the time of firing of the fifth stage would have sent the payload into either a more pronounced elliptical orbit or sent it back to earth in less than one earth revolution.

The total mass of satellite material that would have been sent into orbit with the *Explorer IV* shot was the heaviest to date. The weight of the payload case before separation of the fourth stage was 42.77 pounds, or about 10 pounds more than earlier *Explorer* satellites. This is probably the major reason for the reduced apogee altitude. The empty fourth stage rocket would have separated from the payload case at burnout but would have continued to follow the payload until the fifth stage rocket was fired. In the earlier *Explorers* the fourth stage remained attached to the instrument package.

About 60% of the payload case is occupied by the folded *Beacon* satellite and its auxiliary equipment. The deflated balloon is packed into the aft end of the case at the junction of the fourth stage rocket and the case.

At one revolution from the point of launch (location of new apogee) a nitrogen inflation bottle (opened by a timer) would extend an ejection bellows forcing the balloon out of the case. Simultaneously, gas from the bellows would overflow into the balloon inflating it to its 12-foot diameter.

After balloon separation, the gas would escape into space to prevent decompression destruction in case of meteorite impact. The balloon remains inflated after expulsion of the gas due to lack of atmospheric pressure and the induced balloon rigidity from the laminated aluminum foil.

Remainder of payload consists of a 24 milliwatt telemetering transmitter operating on 108.03 megacycles and the small high-fifth stage rocket. Shortly before the final apogee rocket is fired the nose cap is ejected.

With an estimated lifetime of one week, *Beacon* once in orbit, will enable trackers to make precise analysis of the atmosphere layer and confirm density data obtained from preceding satellites.

ARPA Awards Solid Contracts

Washington—The first step towards setting up a solid propellant supply from the nations' rocket engine industry was taken last week with major research contracts going to four chemical companies.

In making the announcement, Roy W. Johnson, Director of the Advanced Research Projects Agency said the characteristics of solids put them out front.

"Their efficiency, speed of operation, safety and ease of handling making solid propellants a forerunning answer to missile propulsion of the future," Johnson said, and "the long range importance of these research contracts to our ballistic missiles program for all ranges and to our AICBM program cannot be overstated."

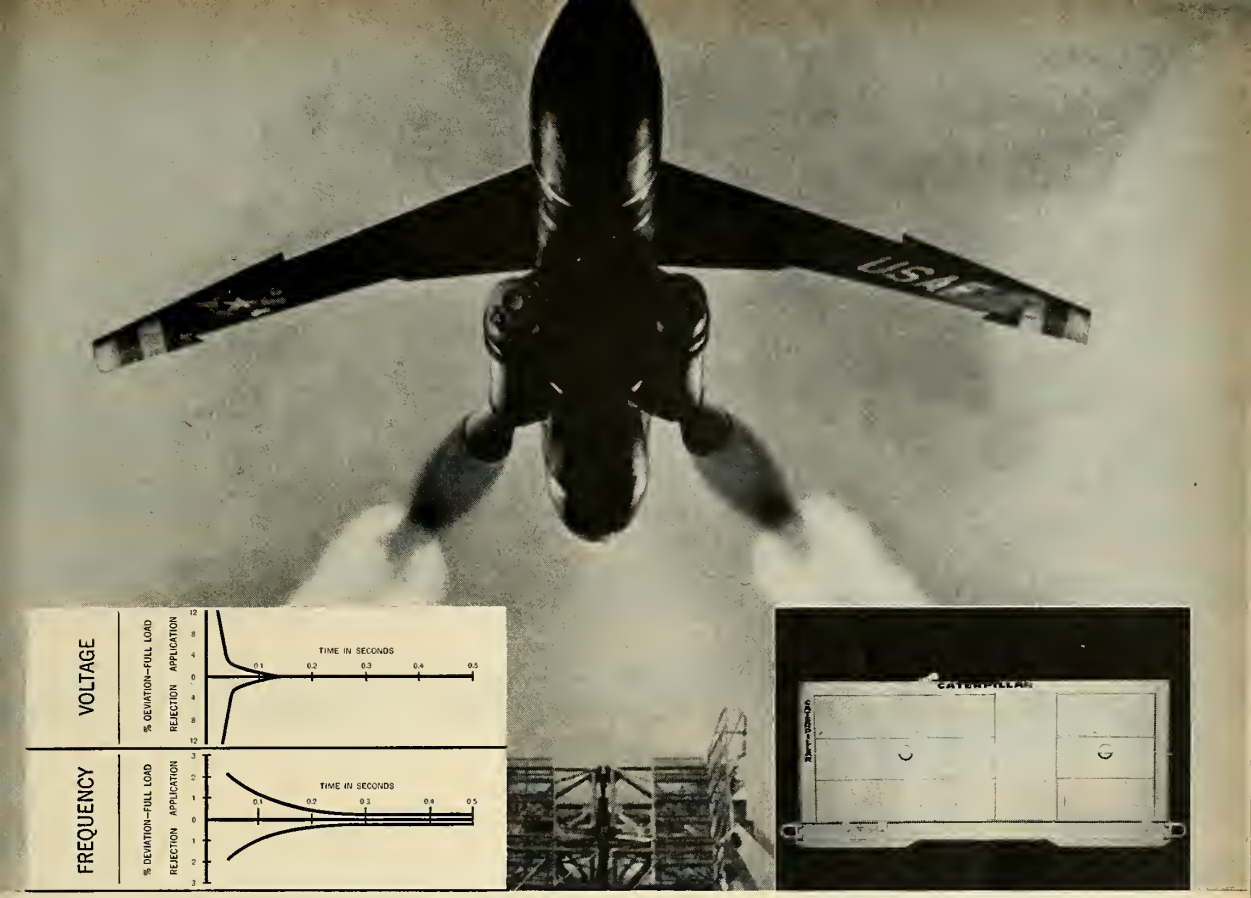
Johnson said solid propellants are becoming increasingly important in the nation's space programs and that the search is for more energetic solids to extend present capabilities.

"The use in upper stage rockets is well recognized," Johnson noted, "however, we have just begun to tap their effectiveness for space applications."

The four companies were chosen from among 30 who participated in the bidding. Eight finalists were selected by the three services. ARPA chose the four companies for negotiation of contracts leading to an integrated solid propellant program. They were: American Cyanamid, Dow Chemical, Esso Research & Engineering, and Minnesota Mining and Manufacture.

The contracts, worth between one and two million dollars each, are unusual because detailed specifications are not given but rather, end objectives. Talent and facilities available were major criteria in making the selection, ARPA said.

The contracts are a result of studies made early in 1958 and a $20 million appropriation to ARPA to step up advanced research in solids in fiscal year 1959.



The almost instantaneous return to normal of the new low-silhouette Cat power unit under conditions of full-load application, and load rejection (117.4 volts), is shown in the above graph.

Low-silhouette Cat power unit with close voltage regulation is now being used in connection with ground support for jet starting and firing. The 400-cycle phase is specifically adapted to missilry.

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Creative engineering and quality of manufacture have made Caterpillar the diesel leader for more than 25 years. For detailed information on the Cat 60 KW 400-cycle portable power unit with close voltage regulation, send in the coupon below.

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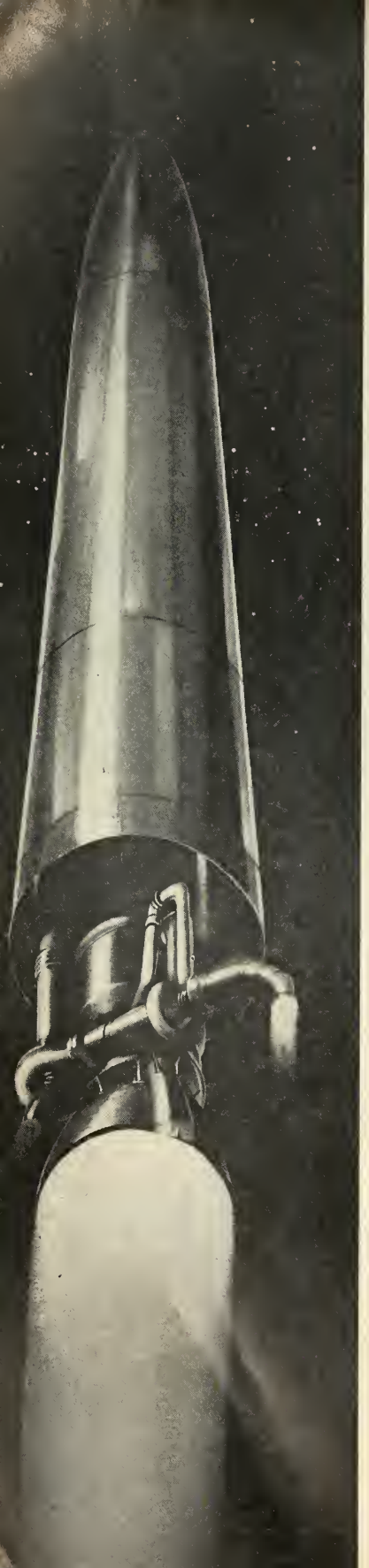


DR. JOHN STRONG, professor at Johns Hopkins University, will be first scientist to bring instruments to edge of space.

MODEL OF STRATO-LAB IV which Cmdr. M. D. Ross will pilot during ascent to obtain data on Mars' atmosphere.

ONR Readies Stra

by Peer Fossen

As m/r goes to press, members of the Office of Naval Research and The Johns Hopkins University's Laboratory of Astrophysics and Physical Meteorology are jointly engaged in final preparations for the launching of a balloon at the Stratobowl near Rapid City, S.D.

Many balloons have left the Stratobowl before, but this huge plastic sphere will probably be considered one of the most significant in the history of balloon flight, since it will enable man, for the first time, to closer investigate conditions on Mars.

The project—sponsored by ONR and known as **Strato-Lab IV**—calls for Dr. John Strong, director of the Laboratory of Astrophysics and Physical Meteorology at Johns Hopkins, to make an ascent to an altitude of 80,000 feet or more in a pressurized gondola to determine the water vapor content in the Martian atmosphere. This is the first time a scientist has gone to the edge of space with his instruments.

Second member of the two-man gondola team is Cmdr. Malcolm D. Ross, veteran Navy balloonist and ONR physicist, who will serve as pilot.

The feasibility of using balloons for research flights into the stratosphere was demonstrated by Cmdr. Ross this summer when he and Lt. Cmdr. M. Lee Lewis, USN (Ret.) went to 82,000 feet in a record breaking 34-hour balloon ascent.

Project operation—Strato-Lab IV is scheduled to be launched before the middle of the month. The flight will start in mid-afternoon, so the balloon can reach its 15-mile altitude prior to sunset and remain there until mid-morning the following day. The flight, scheduled at a time when Mars will be in the most favorable position for astronomical observations—at a distance of some 45 million miles—is expected to last approximately 24 hours.

Dr. Strong plans to conduct his Mars observations during the night. Soon after sunrise he will focus his attention and instruments on the sun for calibration of its spectrum. The optical system of the observatory will consist of a Schmidt telescope with a 16-inch primary mirror, specially designed by Dr. Strong, for mounting on top of the gondola; a special spectrograph and an automatic star tracker. In addition, manual controls will be provided for orientation and leveling of the gondola.

At the ceiling altitude of about 80,000 feet, the balloon will have left behind it more than 95% of the earth's atmosphere. The little remaining atmosphere between the observatory and

---

ROCKETDYNE'S single-stage nuclear rocket theoretically capable of carrying large interplanetary payloads.

CMDR. ROSS and M. L. Lewis ready to enter Strato-Lab gondola prior to 34-hour record-breaking ascent this summer.

PRINCETON UNIVERSITY astronomers Dr. Martin Schwarzschild (left) and Dr. Lyman Spitzer, Jr. discussing plans for Project Stratoscope. In foreground is model of proposed 36-inch balloon-borne telescope to be flown by unmanned balloon in 1961.

ab IV Balloon for Mars Study

Mars will be insignificant in terms of hindering the scheduled observations. A substantial improvement in the scientific results expected from **Strato-Lab IV** could only be achieved if the observatory were taken outside the stratosphere to an altitude of more than 100,000 feet.

A study for extension of the **Strato-Lab** research program, initiated in 1954, is under way. Under an ONR contract, Vitro Laboratories, Silver Spring, Md., is researching a manned stratosphere laboratory that will be a platform for scientific and technological studies from 100,000 to 120,000 feet above the earth's surface.

Until such a platform becomes a reality, however, observations will have to be limited to the 15-mile altitude level. The team of Strong and Ross has planned a second "Mars-flight" to take place in January next year. The objective of the second flight will be to investigate the oxygen content of Mars.

Future exploration—Balloon astronomy will undoubtedly be replaced to a major degree by satellite-exploration and observations from manned space ships, but prior to that it will have played an important role in paving the way for actual travel in outer space, both through present and future programs.

In a speech before the American Astronautical Society, Cmdr. Ross stated: "Plastic balloon astronomy is not only a stepping stone to satellite and/or true space observatories; it is destined to make its own very positive and important contributions over the next decade or so to a more complete understanding of the universe."

The following studies appear to be the ones made in the near future with Strato-Lab and Stratoscope (see m/r June 1958, p. 73, and October 20, 1958, p. 77): a) observations of the center of the Andromeda galaxy; b) investigations of the gaseous nebula of Orion; c) photography of the aurorae

Plastic Balloon Requires No Ballast

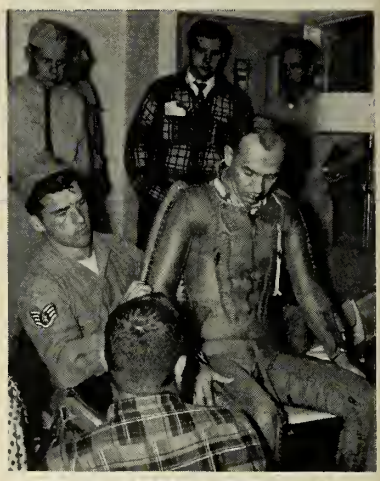
WASHINGTON—An Office of Naval Research balloon of improved plastic design, capable of maintaining constant altitude despite temperature differentials, has completed its first test flight from Stanton, Minn.

Conventional balloons are partially inflated at launch, and as altitude is gained and the sun's rays heat and expand the helium, excess gas must be valved off. At sunset when the helium contracts and the balloon loses buoyancy, ballast is dropped to maintain altitude.

The new balloon design eliminates the need for ballast, since the .002 inch plastic skin is strong enough to withstand daytime expansion without bursting. At predetermined altitude, the gas expands sufficiently to completely fill the balloon and cause some superpressure which prevents further expansion and precludes contraction at sunset. Because of the constant cubic displacement, the balloon seeks a constant level.

The G. T. Schjeldahl Co. of Northfield, Minn. developed the balloon for the Navy.

. . . mars study



CMDR. MALCOLM D. ROSS being fitted with pressure suit prior to last summer's record-breaking Strato-Lab ascent.

on Venus; d) measurement of the planet diameters; e) photography of Mercury; f) photography of the infrared spectra of all the planets; and g) stellar spectroscopy.

While the balloon astronomers are paving the road for further space exploration, scientists over the world are heavily engaged in research which eventually will lead to satellite and exploratory vehicles for probing Mars, Venus and other bodies. U.S. space scientists have already come up with several proposals for such vehicles, both manned and unmanned.

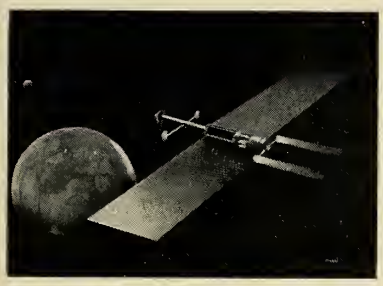
Boeing proposal—One of the more recent proposals for a Mars reconnaissance vehicle came from Boeing Airplane Company. The vehicle, which would measure about 40 feet across and weigh about 600 pounds including payload, could be launched from an earth-bound satellite orbiting 400 miles above Earth. Powered by an ion accelerator, it would escape at low continuous thrust to an Earth-Mars transfer orbit and then descend slowly into an orbit around Mars and scan the planet from an altitude of eight to 9,000 miles.

Payload could include a cosmic-ray counter, meteroid measuring equipment, radio altimeter, radio-noise-scanner, instruments to explore Mars' atmosphere, and a large tracking telescope. The image picked up by the telescope would be scanned by TV equipment on board the reconnaissance vehicle and transferred to earth by an optical system.

The suggested probe would be constructed of beryllium for all major compression members, piano wire for tension wires, Invar honeycomb core sandwich for the large reflectors, and quartz for the lenses in the navigational system.

The total time elapsed from launching of the vehicle until recovery would be about three years for a reconnaissance trip to Mars. A vehicle of this type could also be used for reconnaissance of other planets.

Neither the National Aeronautics and Space Administration nor the Advanced Research Projects Agency are known to be backing any definite project involving Mars or Venus probes at the present time. However, two months ago, ARPA's Roy Johnson directed the Air Force to make available two additional *Thor-Ables* for scientific use. With Venus in favorable astronomical position relative to Earth in June of next year and Mars coming within "reachable" distance in November, 1960, attempts undoubtedly will be made.



ARTIST'S CONCEPT of Rocketdyne's *Snooper*, an ion-propelled interplanetary vehicle for exploration of Mars.

BOEING'S Richard D. White and Henry K. Hebeler with 1/20 scale model of vehicle for close-up Mars studies.

photos in the news . . .

President Views TITAN

FIRST OFFICIAL photograph of the Titan ICBM, had President as onlooker.

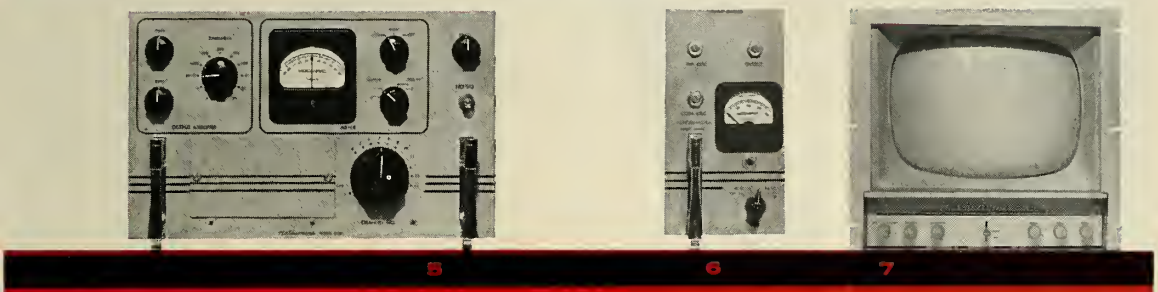
Moon Structure

MOON BUILDING design by Wonder Building Corp. for permanent lunar base.

Banana Split?

THIS DEVICE folds up to give enclosure for personnel working on *Jupiter*.

No. 90



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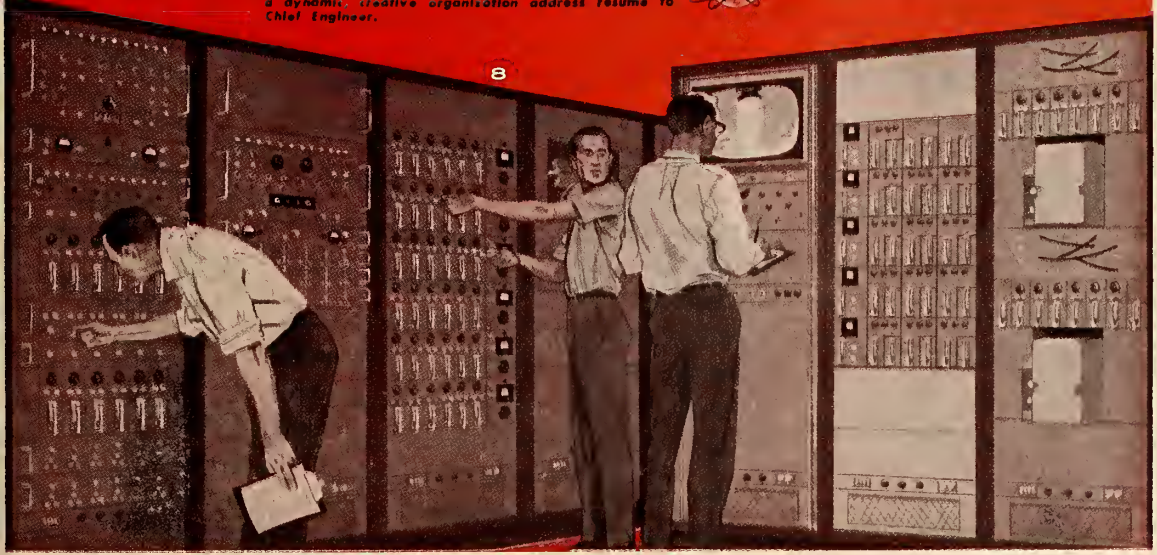


 Circle No. 40 on Subscriber Service Card.

LOX Systems: Still Problem Area

This principal oxidizer continues to provide troubles that can be solved only by new methods and equipment

By Ernest Edward Lindros*

Before LOX is finally taken aboard a missile at a launching site, as many as four different transfer functions must be completed: from manufacturing facility to mobile trailers, and from the trailers to storage tanks and other points on the launching site itself. Frequency in transfer has made it mandatory that reliable, safe and efficient techniques be developed in handling and transferring large quantities of LOX in the equipment design and storage facilities. An additional problem is the necessity of handling LOX in an extremely short span of time.

LOX becomes dangerous only if incorrectly handled or if exposed to conditions that are unreasonable with any compressed gas or liquid. Under normal circumstances, it is safe and predictable and creates no corrosive or toxic dangers.

• **Transfer Methods**—Two basic methods have evolved in the transfer of LOX from one container to another. In the first, gaseous oxygen (GOX), or another inert gas pressurizes the first storage tank, forcing the LOX into the second. In the second method, pumps transfer LOX from one container to another.

Both of these methods have obvious advantages, as well as disadvantages, and LOX users are still in the process of determining the best system for each specific application. Neither the military nor liquid oxygen users can yet make generalized recommendations since the quantities handled in the past have always been minute compared to today's requirements.

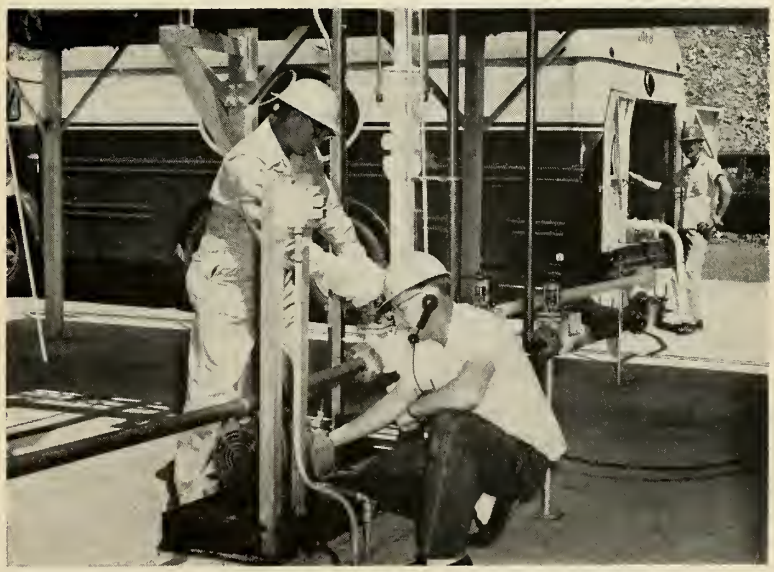
It now seems certain, however, that with the huge missile firing sites now being planned, proper and adequate ground support facilities will soon be standardized. U.S. Government appropriations of almost $2 billion for launching sites and equipment will necessitate a decision in the optimum methods of LOX transfer and fueling.

The tank pressurization technique for missiles dates back to the German V-2 sites. Before that the basic technique was successfully used in chemical and medical fields. Probably the main reason for its early adaption in missile fueling was that reliable pumping equipment for LOX service had not been developed. Such pumps were not required when quantities handled were relatively small and applications few. However, in the missile era, large quantities must be handled quickly and frequently under field or mobile conditions, and positive-action systems based on pumps are felt to be the most reliable answer.

• **Gas Pressurized Systems**—Ideally, the most suitable gas to pressurize a LOX tank would naturally be oxygen itself. There are several drawbacks to this approach. In order to boil off LOX to produce gaseous oxygen, the LOX itself must be allowed to boil off within a container, therefore, pressure within the tank can be obtained only at the cost of allowing the temperature of the entire liquid mass to rise.

This problem has been alleviated to a certain extent by the transfer of a small quantity of LOX to a heat exchanger where it is boiled and converted to GOX. This gaseous oxygen is then re-introduced into the LOX storage chamber without increasing the over-all temperature of LOX. This technique, however, has the inherent disadvantage that it requires exchangers and associated plumbing. Also, this sort of pressurization increases the percentage of GOX bubbles trapped in the LOX. This "aerated" LOX is highly unacceptable and undesirable for missile applications.

Some attempts have been made to get around the gaseous and liquid oxygen mixing problems by pressurizing storage containers with compressed helium or nitrogen. This operation requires separate storage and additional equipment and handling for the compressed gases. However, since nitrogen gas also dissolves quite readily in



TECHNICIANS TRANSFER LOX with pumps from truck to storage tanks at Rocketdyne's Neosho plant.

**Storage and handling of liquid oxygen for the nation's large ballistic missiles has long been a serious problem. While much has been done, more research is still needed before the missile systems achieve a reliable readiness capability. This article by Ernest Edward Lindros, chief hydraulic engineer, Pump Products Division, Byron Jackson Division of Borg-Warner Corp., is particularly timely.*

LOX and a small percentage dissolved in LOX will render it useless for propulsion purposes, the combination is very unsatisfactory.

As storage tanks increase in size and scope, the pressurizing system required becomes more complex. Gas must be introduced at the same rate that LOX is being withdrawn because of the increase in gas volume and the decrease in LOX. Thus, the maintenance of a steady flow rate in emptying tanks by pressurizing with gas presents control problems of complexity.

An additional disadvantage to the gas pressurization system is the tremendous increased cost of the storage facilities. Storage vessels must be capable of withstanding pressures of 100 psi or more. Therefore, both the liquid and the gas storage facilities must be fabricated of thicker metal than required for the pumping system.

• **Pumping system**—LOX users have encouraged a number of engineering groups to devise pumping techniques and equipment that would satisfy rocket launching site needs.

Centrifugal pumps have proven a satisfactory and reliable method for moving cryogenic liquids. One important advantage of this type of unit is that any number of pumps with proper characteristics can be manifolded for reliable parallel operation. The capacity of a parallel system may be controlled by throttling the main discharge line. This causes all units to operate at an equal pumping load at a constant speed. The pumps can be operated over the entire performance range, even back to almost zero capacity, without damage when proper design is provided for internal radial and axial hydraulic force balance.

Experience has shown that standard process pumps, when constructed of metals with the proper impact strengths and sealed by a low temperature seal, are reliable and practical. New seals have been developed making possible the adaptation of process pumps to cryogenic service. To effect the required modifications on process pumps, the equipment manufacturers have had to solve four basic problems:

1) method of pumping low viscosity fluids.

2) large temperature variations.

3) material selection.

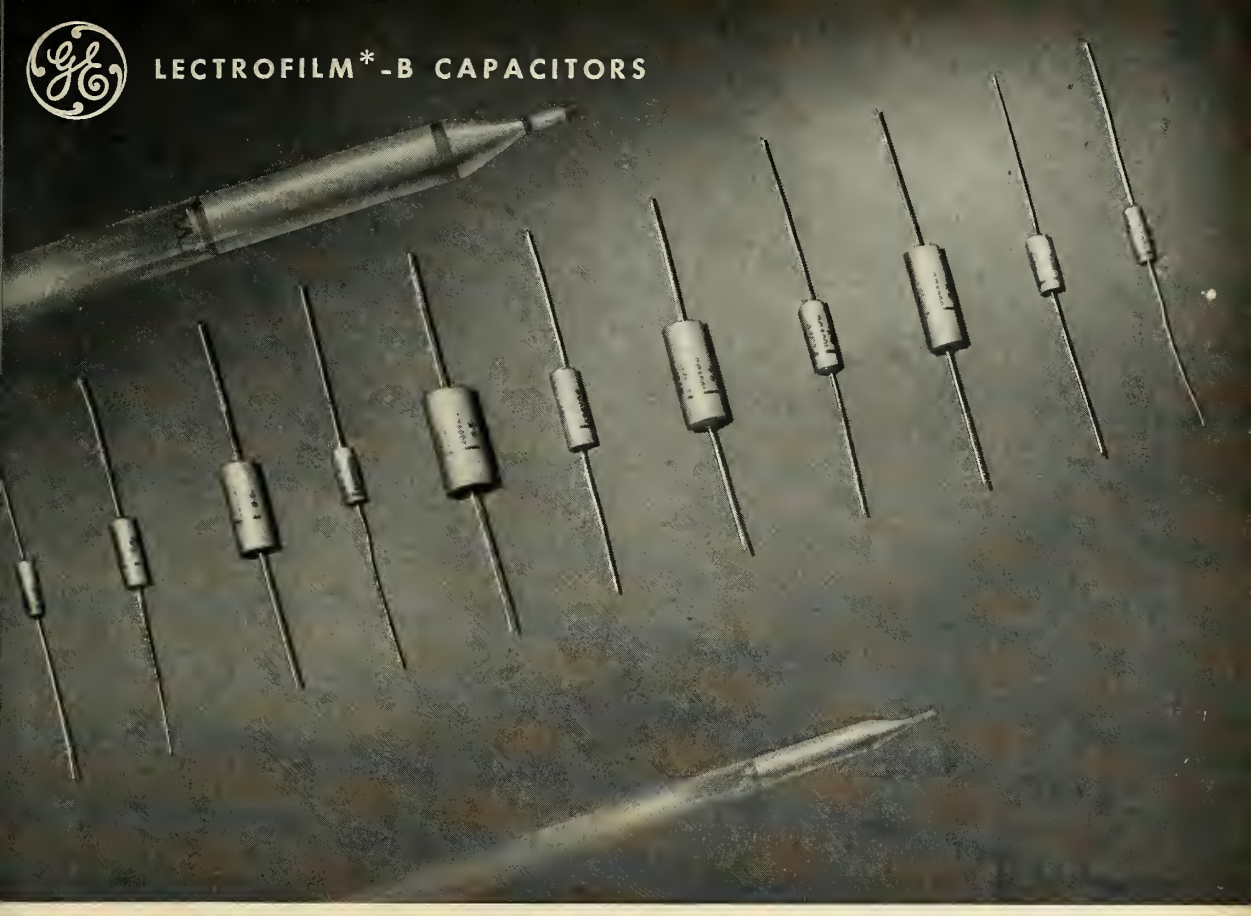
4) adequate shaft sealing techniques.

The precise reaction of the low viscosity cryogenic liquids is of prime importance to the pump designer since he must know how to shape and engineer fluid passages within the pump. However, the years of experience gained by the process pump manufacturers in pumping low viscosity fluids such as methane and ethane have provided a wide and useful background of knowledge.

• **Temperature parameters**—Any changes from ambient-temperature to the range of –300°F require that some provisions be made for dimensional changes of mechanical components. When a LOX pump is first filled, it will be at the ambient temperature, but after a certain time in operation some portions of the pump will drop in temperature to that of the LOX itself.

On the other hand, when the pump is shut down, the reverse holds true in that operating parts in contact with LOX will change in temperature to that of the ambient. Therefore, definite provisions must be made in the design to allow for the shrinkage and expansion of operating components.

For example, design engineers have long agreed that when temperature differentials between ambient and fluids being handled exceed 250°F, certain definite provisions in the design must



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. . . LOX systems

be made to cope with thermal expansion problems.

Indirectly, the solving of the temperature problems indicated that material selection was not as critical as had initially appeared. The solution centered on the selection of materials that did not become brittle when in contact with ultra-low temperature gases and liquids. Thus, it was decided that conventional metals such as austenitic stainless steels (Type 304), certain aluminum alloys and bronzes were quite acceptable.

While stainless steel offers a distinct advantage in strength over either bronze or aluminum, its added weight makes it less acceptable for mobile installations. Aluminum offers an additional advantage in that there is less boil-off during the start up period. A combination of a relatively low specific heat and density requires that less heat be transferred to aluminum than other metals to cool it down to the temperature of the cryogenic liquid.

• **Seal Design**—Shaft sealing has presented one of the most difficult problems in completing pump designs for cryogenic liquids. The several methods used for sealing cryogenic pump shafts can be divided into the following four categories:

1) packing against gas.
2) packing against cryogenic liquid.
3) mechanical seal against gas.
4) mechanical seal against cryogenic liquid.

The first LOX pumps used the packing-against-gas technique since it was the only effective type of seal that would work at that stage of development. However, it operated satisfactorily only when stuffing box pressures were low. With pressures above 10 psi, packing became ineffective and excessive stuffing box leakage occurred.

Packing cannot be used to seal directly against LOX because it loses all of its resiliency and becomes rock hard in the range of –300°F. Pumps using packing must, therefore, provide some method of converting liquid to gas at the points where the packing is to be employed. Byron Jackson pumps have an isolation chamber for this conversion.

Liquid oxygen under suction pressure enters the pump, and some of it goes through the shaft sleeve into the nozzle head. Since the nozzle head is considerably warmer than the boiling point of LOX, due to the friction of the seal, a good portion of the LOX vaporizes. Therefore, only a small amount of LOX is contained in the isolation chamber above the pump.

"ECLIPSE" a recent painting by Simpson-Middleman, gifted artistic interpreters of the physical sciences. About this new expression they write: "Eclipse was painted as a result of watching an actual eclipse of the sun. We were particularly struck with the curious light that was both dim and glowing and the unusual pattern of the shadows on the leaves of the trees around us. We had never seen anything like it before." Painting courtesy of John Heller Gallery, Inc.

Space projects at Boeing

Engineers and scientists at Boeing are at work on advanced projects that include a space weapon system based on a manned orbital vehicle capable of re-entry into the atmosphere and normal landing. This major contract-supported program is a result of recognition of Boeing's space-age orientation, its tremendous technical and research capability and its extensive weapon system management experience.

Among other space efforts at Boeing is a study for an unmanned Martian reconnaissance vehicle powered by an ion accelerator. The vehicle would escape at low continuous thrust to an Earth-Mars transfer orbit, then descend to a Martian orbit where it would optically observe the surface of the planet. The controllable-thrust capabilities of ion propulsion would permit correction of flight-path deviations from a "memory" electronically pre-programmed into the vehicle. Fine corrections would be made possible by an optical star-tracking system.

These and other rapidly expanding space flight programs have created exceptional career opportunities at Boeing for scientists and engineers of all categories. For complete details, drop a note now to Mr. Stanley M. Little, Department R-81, Boeing Airplane Company, Seattle 24, Washington.

BOEING

TEST EQUIPMENT ENGINEER John W. Lloyd tells why his work on the B-70 Weapon System at IBM Owego affords him the creative engineering career he always wanted.

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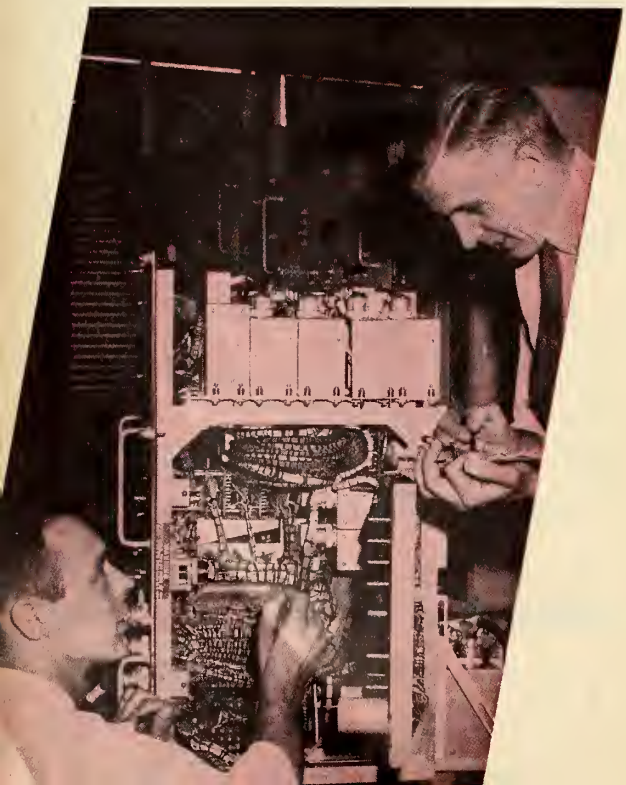

The liquid level is controlled by stuffing box leakage. Proper design keeps the liquid level well below the packing so that the packing seals only against the gas.

Packings suffer from a number of other disadvantages, including the amount of maintenance required. The packing fit on the shaft must be precise. If the packing is too tight, it will seize, overheat, and possibly damage the shaft or packing sleeve. If it is too loose, it will allow excessive leakage.

• **Mechanical seals**—Because of these packing deficiencies, it was quickly recognized that a mechanical seal would prove the most efficient and reliable method. A dry mechanical seal for gas could only be installed in a vertical position and for this reason all early LOX installations featured vertical pumps.

While the liquid seal development was being carried on, another program was in progress for the development of a vertical LOX pump for 1000 gpm at 100 psi. The pump was originally designed with an isolation chamber and packing to seal against gas.

During the manufacture of the pump, the liquid mechanical seal was perfected. The Air Force was so impressed with the test performance of this seal that they requested that the liquid mechanical seal be utilized in place of packing. This was accomplished by using external piping to carry the LOX up to the seal.

Mechanical sealing against LOX is undoubtedly the most satisfactory method at this time and is preferred because it offers all the advantages of reliability and economy. The design has been proven by many months of successful field operation.

• **Vertical Vs. Horizontal pumps**—Due to the non-availability of satisfactory seals in the early stages of development for LOX applications, most centrifugal pumps were vertical units. These incorporated an isolation chamber where LOX could be converted to its gaseous form.

Vertical units are better adapted to effective insulation, and with the added reliability afforded by the liquid mechanical seal, they are more desirable for certain critical or continuous operations. A distinct advantage of the vertical unit is its ability to operate at extremely low net positive suction heads (NPSH), eliminating the need for pressurization and assuring reliability of starting.

One of the basic criteria used in determining the pump type is the

. . . LOX systems

amount of NPSH available. The available NPSH is the height of liquid above the centerline of the pump impeller that exceeds the vapor pressure of the liquid.

Horizontal pumps incorporating the liquid mechanical seal have now been proven practical for cryogenic fluid service. Due to weight and space advantages, a horizontal unit is more desirable for mobile installations, and in addition offers a substantial first-cost saving plus lower maintenance.

However, horizontal units require more available NPSH than equivalent vertical units. If a horizontal pump is used where tank pressurization is not available, it must be located sufficiently below the tank, either by raising the tank or lowering the pump in a recess to provide the necessary NPSH.

• **Lubricant limitations**—Hydrocarbon-base bearing lubricants are not desirable due to the possibility of explosion in the presence of LOX or GOX. In general, non-hydrocarbon lubricants compatible with the cryogenic liquid being handled are preferred. However, some of these lubricants liberate acids when coming into contact with moisture, resulting in corrosion of bearing surfaces.

Two things have been done to eliminate this corrosion problem. A heating element with thermostatic control is provided around the bearing housing to prevent expansion of air into the housing due to temperature changes. In addition, dry nitrogen gas is injected into the housing to purge out all the moisture-laden air.

In general, design selection of any specific type of pump should depend on its ultimate application and operational considerations. As stated, both types have distinct advantages, and since these are of a complex nature, pump buyers would do well to discuss a pump's selection and performance requirements with pump manufacturer's engineers.

USSR to Produce 400 Science Films

The Soviet Union has announced plans for the production of more than 400 popular science films.

The film titles planned include "Explorers of the Universe" dealing with Soviet rocket techniques; "Television from Earth Satellites"; "Automatons in the Cosmos," on the use of high altitude rockets; "Cosmic Medicine"; and "Four-Footed Astronauts," on the training of animals for flights.

R-652 actuates the tailwheel power steering installation in De Havilland of Canada's famous DHC-3 Otter.

The R-652 operates at 10 rpm at maximum operating torque of 1000 lb-in. Overload slip clutch adjusted to slip at 1200 lb-in. Magnetic clutch will hold maximum load with 17 v min. applied. R-652 weighs 8.2 lb.

Drawing courtesy De Havilland Aircraft of Canada, Ltd.

Design of Airborne large special actuator proved in rugged bush-line service

First installed on Otter aircraft some five years ago, the Airborne R-652 special design actuator has been subject to almost every conceivable extreme of bush-line operating conditions. Yet despite bitter cold, intense heat, wrenching, pounding and shock, it has proved as rugged and reliable as the Otter itself. Says De Havilland, "We have used this actuator in aircraft all over the world, from the Arctic to the tropics, with very little service trouble."

The R-652 typifies Airborne's capabilities in the design and development of large special electromechanical actuators—rotary and linear. And where requirements are not unique, we also offer a line of modular-type actuators, originated by Airborne to simplify design and specification. Write or phone for further information.

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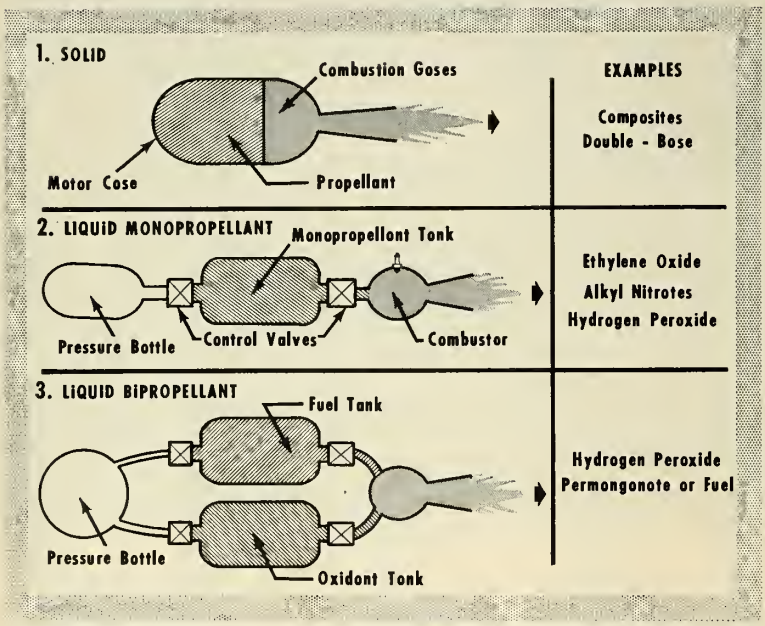
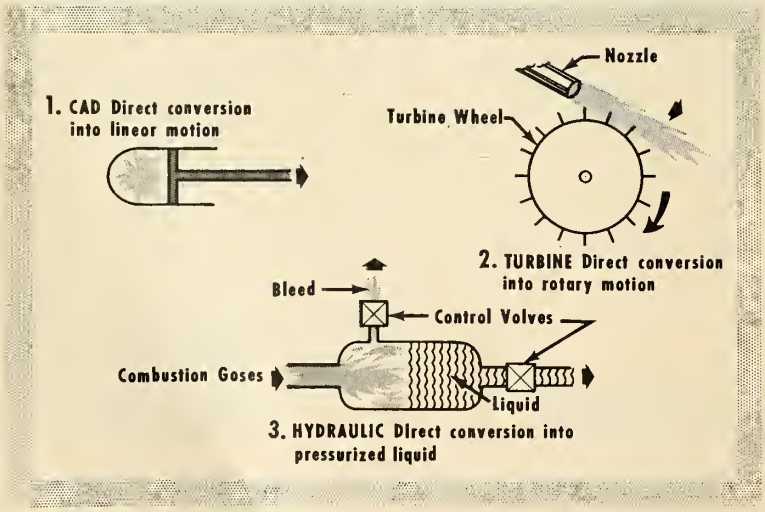
Auxiliary Power Systems Challenge Chemicals

APS Business Should Have Sales of $100 Million by 1970, With Chemical Systems Still Needed for Earth Use



EXAMPLES OF propellant auxiliary power systems.



UTILIZATION of propellant power.

by Alfred J. Zaehringer

Large earth satellites, lunar probes, and other long-duration space missions are forcing a serious look at advanced auxiliary sources of power. Steadily increasing power demands for instrumentation, electronics, and even for propulsion systems will see chemical propellants seriously challenged by nuclear, solar, and other non-chemical systems.

Chemical propellants will continue to grow for terrestrial applications such as recoverable satellites, long range rocket aircraft, and high performance ballistic missiles.

Thus, by 1970, the auxiliary power business, chemical or non-chemical, will have hit the $100 million per year sales level. What chemicals will lose in space auxiliary power systems (APS), they will gain for earth use.

• **What they are**—Chemical APs are illustrated in an accompanying figure. Sketch, left, shows the simplest, and theoretically the most powerful from a weight or volume basis—the solid propellant system. With no moving parts, combustion is "pre-programmed" by choice of chemical and ballistic properties of the propellant.

Reliability is 99% or better. One cartridge-actuated device (CAD)—the solid propellant trigger for nuclear weapons—has established a record for only three misfires in ten million runs. Present problems are concerned with improving gas generating efficiency while reducing the flame temperature. Typical flame temperatures now run from 2,000° to 5,000°F.

Another concern is obtaining decomposition gases that can be utilized for direct pressurization of liquids (viz., liquid rocket propellants).

RMI, Frankford Arsenal and the French Vernon Labs are working in this vital area. Solution of this problem would allow simple, storable, and highly reliable small liquid propellant rockets. It is interesting to note that solids will

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thus help liquids to "compete" with them for small rockets—heretofore an almost exclusive domain of solids.

An accompanying drawing outlines the typical liquid monopropellant APU: Gas from a pressure bottle forces the liquid monopropellant into the combustion chamber. Most liquid monopropellants that are safe enough to handle do not have the performance or reliability exhibited by solids. A good monopropellant APU is being used in the Sundstrand ethylene oxide system for *Atlas*.

An accompanying illustration is an example of the bipropellant system. A miniature rocket motor, the hydrogen peroxide-permanganate unit used on the V-2 and current US ballistics missiles, has achieved a good deal of success for powering turbo-pumps.

Tables 2 and 3 give a line-up for US groups working in the auxiliary power area. Table 1 is a glossary of current terminology.

Table I
Glossary of Auxiliary Power Terminology

APS	Auxiliary Power System. Any non-propulsive system, usually self-contained, used to provide mechanical, hydraulic, or electrical power for missiles, rockets, spacecraft, aircraft. Includes power generator, controls, and all operating parts & components.
APU	Auxiliary Power Unit. Same as above.
CAD	Cartridge Actuated Device. Usually a rechargeable APS using a solid propellant or propellant explosive.
GG	Gas Generator. Used to provide a source of gas, usually resulting from the combustion of a solid or liquid propellant.
Hot Gas Systems	Motors, valves, turbines, pistons, servos, etc. which can operate directly from power of hot combustion gases.
Propellant	A self contained combustion system—solid or liquid—(monopropellant or bipropellant). Used to furnish hot gases suitable for work. The term propellant includes both oxidant and fuel. Propellants furnish power at rates lower than propellant explosives.
Propellant Explosive	Usually a solid explosive that can detonate or explode and deliver energy at a very high rate.
Squib	A heat sensitive device, initiated usually by electrical energy, which furnishes hot gases or hot solids which can ignite other propellants.

How they work—Once we get energy from the propellant (viz., hot, high-pressure, high velocity gases), it must be converted into satisfactory form for work.

Small amounts of energy can be transformed directly into linear motion by the rapid detonation of explosives in cartridge-actuated devices (page 30). This system offers extremely high power-to-weight ratios and appears attractive for operation of landing skids, flaps, etc. in manned rocket aircraft. Other rocket applications include staging and warhead separation in ballistic missiles.

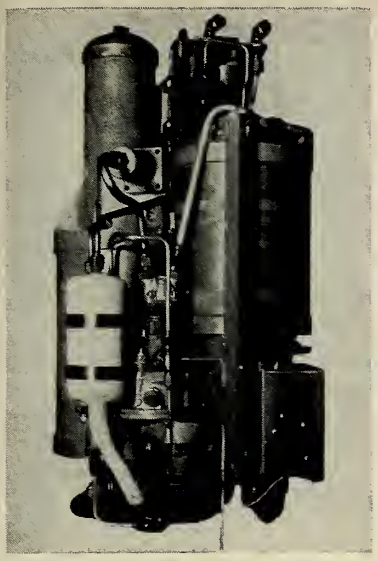
One of the most popular methods of converting the linear motion of exhaust gases into rotary motion is through the use of a hot gas turbine.

Though present units are capable of operating at high turbine speeds, a limiting factor is that of temperature. Most hot gas turbines experience serious difficulties with operation above 1,600°F. There are "cool-burning" solid and liquids below 2,000°F. High performing solids and liquids, however, operating at 3,000° to 5,000°F, pose serious engineering difficulties in hardware development. Clearly, a materials and/or propellant breakthrough is needed here.

A method of converting propellant energy into hydraulic power would be extremely useful for pressurizing liquid rocket propellants or elimination of present accumulator systems. Of course, once rotary motion has been produced, electrical power (through the use of an alternator or DC generator) or hydraulic power (through the use of a pump) is available.

Problems are compromised—Some of the problems that face designers of APU's are things like the compromise with performance, structural limitations and reliability that must be considered for proper turbine diameter and shaft speed. Shaft speed is generally limited to somewhere around 60,000 rpm to attain proper bearing life and unit reliability.

Missile turbine power unit performance is roughly proportional to turbine peripheral speed so the largest possible turbine diameter for any given shaft speed is the most desirable. In actual practice, peripheral velocities are limited by structural considerations to 1000 to 1200 feet per second. Wind-



THIS AMF hydraulic power supply weighs 69 pounds including propellant and fluid. The accumulator power supply it replaces weighed 175 pounds. Dimensions are 14 in. long, 12 in. wide, and 26 in. deep.

age losses and package size also impose restrictions.

If you consider the gas generator of a propellant gas turbine as a small rocket motor in which the exhaust jet is directed at the blading of a turbine wheel (which supplies torque to the turbine shaft), the selection of a proper type is clearer.

For times of 60 seconds or less, solid propellant generators are simpler and more compact. Of course, all solids have the disadvantage of no control over stopping and starting if an irregular duty cycle is required. Grain size also can become a problem where space restrictions exist.

Gas generators better—Liquid monopropellant gas generators are better. They allow considerable flexibility in packaging since the fuel container does not have to adhere to a fixed size. Operation is as simple as turning the fuel supply on or off. There are disadvantages such as high weight in relation to burning time and complexity of the system, but these are generally easy to live with when the application calls for a system of this type.

Looking into the future, some of the areas which need (and are getting) investigation are the research of elastomers for seal and fuel-expulsion systems with commonly used mono-propellants, the evaluation of mono-propellant characteristics and the research of ultra-high speed rotating machinery for bearings and lubrication at extreme tem-

peratures.

Another item is the development of high-speed hydraulic pumping machinery so that it is not necessary to use a gear box for driving a pump with a high speed turbine. Considering all the problems the missile program has had with gearboxes in the past year, this last development would probably be welcomed more than any other.

In the selection of an auxiliary power unit for a missile, few "rule of thumb" criteria can be applied. In almost every instance, the power unit is so completely integrated into the missile system, physically and functionally, each power unit is "tailor-made" for the particular application. Similar problems are true for other phases of the electronics-missile industries, whether it be for ground support equipment, or hardware itself. The problem will still carry over into manned space flight, which means that standardization will be virtually unachievable in these vital components.

Companies Involved in APS

Table 2

Auxiliaries for the Auxiliaries

Firm & Location	Products
Atlas Powder Co., Wilmington, Del.	Squibs, explosives
Bermite Powder Co., Saugus, Calif.	Black powder, igniters
E. I. duPont de Nemours & Co., Wilmington, Del.	Squibs, explosives
Hercules Powder Co., Wilmington, Del.	Squibs, explosives
Remington Arms Co., Bridgeport, Conn.	Propellant explosives
Picatinny Arsenal, Dover, N.J.	Propellant explosives

Table 3

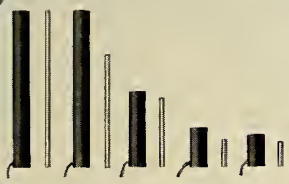
The APS Scene in the United States

Firm & Location	Type	Products
ABMA, Huntsville, Ala.	L	APS, hydrogen peroxide
Aerojet-General Corp., Azusa, Calif.	S&L	APS, composites, double base, liq. monoprop., CAD
Allegany Ballistics Lab.	S	APS, CAD, double base
American Rocket Co., Wyandotte, Mich.	S&L	APS, CAD, composites, liquids
Amoco Chemicals, Seymour, Ind.	S	APS, solids (composites)
Armour Res. Found., Chicago, Ill.	S&L	APS, CAD
Astrodyne, Inc., McGregor, Tex.	S	APS, composites
Atlantic Research Corp., Alexandria, Va.	S&L	APS, CAD, composites, gels
Buffalo Electrochemical, Buffalo, N.Y.	L	APS, hydrogen peroxide
Experiment, Inc., Richmond, Va.	S	APS
Garrett Corp., Los Angeles, Calif.	S&L	APS, APS
General Electric Co., Schenectady, N.Y.	S&L	APS
Grand Central Rocket Co., Redlands, Calif.	S	APS, CAD, composites
Frankford Arsenal, Philadelphia, Pa.	S	APS, CAD
McCormick-Selph Associates, Hollister, Cal.	S	APS, CAD
National Northern Co., West Hanover, Mass.	S	APS, CAD
Olin Mathieson Chemical, E. Alton, Ill.	S&L	APS, CAD, composites, double base liquid fuels
Phillips Petroleum Co., Bartlesville, Okla.	S&L	APS, CAD, liq. monoprop.
Propellex Chemical Corp., Edwardsville, Ill.	S	APS, CAD, composites, double-base
Rocketdyne, Canoga Park, Calif.	S&L	APS, turbopumps, etc.
Rohm & Haas, Redstone Arsenal, Ala.	S	solid propellants
Reaction Motors, Inc., Denville, N.J.	S&L	APS, composites & liquids
Southwest Research Inst., San Antonio, Tex.	S	APS
Standard Oil Co. (Ind.), Whiting, Ind.	S	APS, composites
Stauffer Chemical, Buffalo, N.Y.	L	monopropellants
Sundstrand, Pacoima, Calif.	S&L	APS
Thiokol Chemical Corp., Trenton, N.J.	S	APS, composites
Thompson Products, Cleveland, Ohio	S&L	APS, solids, gels
Universal Match, St. Louis, Mo.	S	APS, CAD
USNARTS, Dover, N.J.	L	monopropellants
USNOTS, China Lake, Calif.	S&L	double base, comp., monoprop.
US Naval Propellant Plant	S	propellants
Vickers, Inc., Detroit, Mich.	S&L	APS, hot gas systems
Wyandotte Chemical, Wyandotte, Mich.	S&L	solids & liquid monoprops.

GROWTH OF THE auxiliary power systems is reflected heavily in these tables of companies active in this promising field. The large, the small and the medium-sized companies are involved. The table is not conclusive, but is merely representative of the scope of activity in auxiliary power systems field.

SANBORN *Transducers*

FOR LINEAR MEASUREMENTS...



DISPLACEMENT

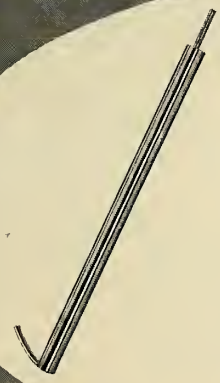
LINEARSYN Differential Transformers

Six series of Sanborn Linearsyns — three of the shielded type, three unshielded — are available, with five models in each series. Linearity is better than 1% of full scale output in all models. Temperature range is from −50° to 205°F.
Special design features include coil assemblies hermetically sealed in epoxy, laminated phenolic jackets (unshielded types) or heavy plated steel jackets (shielded types), improved lead wire strain relief, high permeability alloy cores. Models with axial leads are also available on special order. Within each series all models have identical diameters, tap sizes, lead wires; only the lengths of coil assemblies and cores vary.

Typical Linearsyn Characteristics

Series* (Unshielded)	(Shielded)	Strokes* (±Inches)	Freq. Ranges	Sensitivities* (Volts/inch per volt at excitation at std. carrier freq.)
5750T	5850T	.050 - 1.00	400 cps - 10 kc	.56 - 3.70
5760T	5860T	.050 - 1.00	60 cps - 400 cps	.70 - .90
5900T	5950T	.005 - .100	400 cps - 20 kc	1.60 - 2.60

*Maximum and minimum values available within each series; data on individual models on request.



VELOCITY

LVsyn Velocity Transducers

LVsyn pickups may be used to measure *linear velocity* directly, *displacement* with a simple integrating circuit, or *acceleration* with a differentiating circuit. There are twenty-four models, all self-generating with shielded cylindrical coil assemblies and high coercive force permanent magnets. Twelve models use regular magnet cores; twelve have *non-breakable* magnet cores. Characteristics of the two groups are the same except for output sensitivity, core length and weight. Features include high sensitivity, single-ended or push-pull output, accurate and stable calibration, unlimited resolution, wide range of sensitivities and sizes, temperature range of −50° to 200°F. They can be immersed in hydraulic fluid. No mechanical connection between coil and core permits low friction level. End stops or displacement limits not needed; undamaged if limits are extended.

Typical LVsyn Characteristics

Model	Displacement Nominal Working Range (Inches)	Displacement Maximum Usable Stroke (Inches)	Electrical Characteristics Voltage Output mv/inch	Total Impedance Series R ohms	Connection L henrys
3LVA5*	0.50	1.30	120	2,000	0.085
6LV2*	2.0	3.4	500	19,000	2.4
6LV2-N	2.0	3.4	250	19,000	2.4
7LV9*	9.0	11.0	350	17,000	2.8

*Four of the twenty-four models available, selected to show minimum, approximate mid-range and maximum working ranges as well as the difference in sensitivity between a regular magnet core model (6LV2) and a non-breakable magnet core model (6LV2-N).

NEW!

COMPLETE DISPLACEMENT TRANSDUCER

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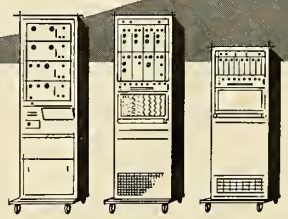

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(All data subject to change without notice)

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Power In Space: New Developments Seen Promising

by Peer Fossen

With the missile and space era came demands for new and better electrical batteries, both for ground use and for auxiliary power applications in missiles and satellites. Stimulated by this demand, scientists set out to come up with what was asked for—long-life small units with high efficiency—and an enormous amount of money together with tens of thousands of man-hours was poured into improvement of existing batteries and research and development of new devices. However, although there has been a steady progress along these lines, much remains before the ultimate in the field is attained.

Power systems for missile, rocket, satellite and space craft electronics can be divided in three main groups according to the mode in which they derive their energy:

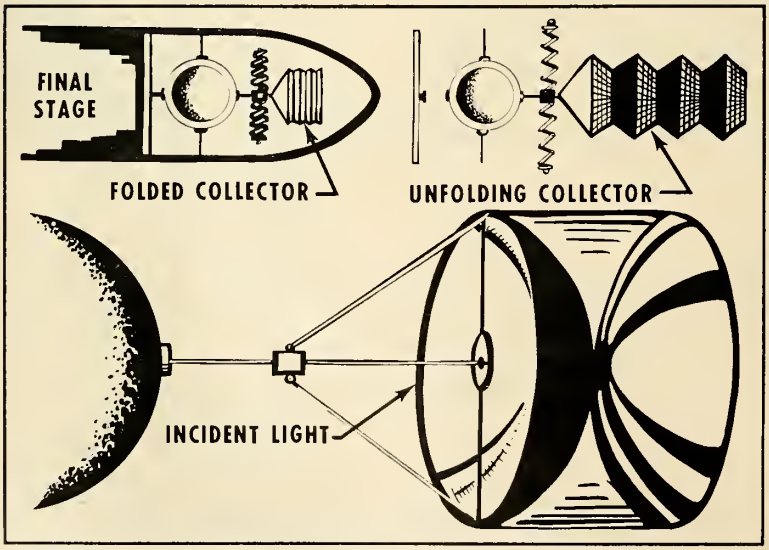
(1) Electrochemical
(2) Solar
(3) Nuclear

This article will review some of the more important within each category over the past few years, and discuss what can be expected in the future.

Electrochemical Conversion—One of the oldest members of the electrochemical battery family, the dry cell, is still widely used for missile and research rocket applications, since these vehicles normally are intended for a one-shot deal, and require power for short periods only.

The electrochemical field, however, has seen two important developments during the past few years, viz; the zinc-silver oxide cells and the hydrox fuel cells, both types suitable for missile applications.

Zinc-silver batteries are widely used as airborne electrical sources because of their high energy output, excellent voltage regulation and relative small size and weight. To gain maximum power at the time of activation these batteries are stored in a dry-charged



EXAMPLES of proposed systems to obtain larger amounts of solar energy.

EXPLORER **SOLAR ring could deliver as much as one watt of power if all cells were illuminated at the same time.**

condition and liquid electrolyte is added just before the battery is used.

The theoretical maximum performance of the zinc-silver battery is 176 watt-hours per lb. At the present time, on the order of 50% of this performance is available.

Originally, electrolyte was manually added to the individual cells. To overcome the disadvantages of hand filling, automatically activated Zinc-silver batteries have been developed.

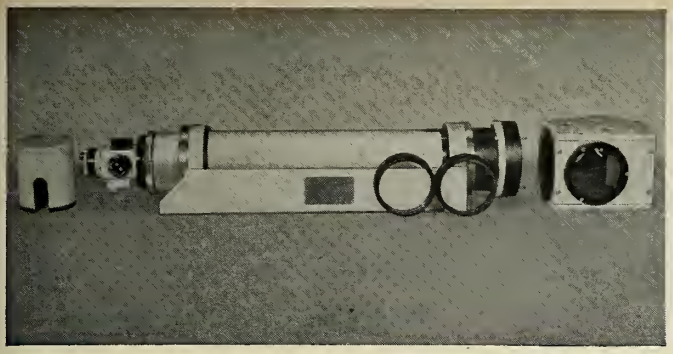
Automatically activated silver-zinc batteries consist of a dry-charged battery pack and an activator containing the electrolyte and a device for moving the electrolyte from a reservoir into the pack. Some method of heating the battery is also needed to permit effective operation at low temperatures.

The hydrox cells—also known as fuel cells—work on a principle which is basically a reversal of the process of electrolysis of water. That is, the hydrogen used as the fuel is oxidized to water, and electrical energy is produced. The hydrox battery has a substantially higher theoretical maximum performance than the zinc-silver device —on the order of 1700 watt-hrs per lb.

The currently available performance is approximately 300 watt-hours per lb. and 3 watt-hours per cubic in., including the weight and volume of the containers for the feed-gases needed to operate the system. Work is being carried out to develop containers of materials with high strength-to-weight ratio.

The 300 watt hour per lb. performance was achieved with liquid oxygen stored at 600 psi and hydrogen at 6000 psi. With light weight containers the watt-hours per lb. figure would have been considerably higher, maybe as much as 150%.

The zinc-silver and hydrox cells



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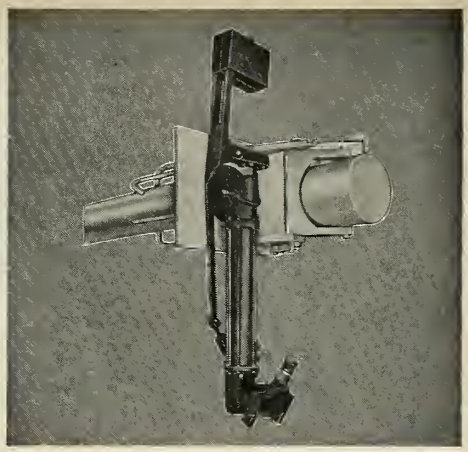

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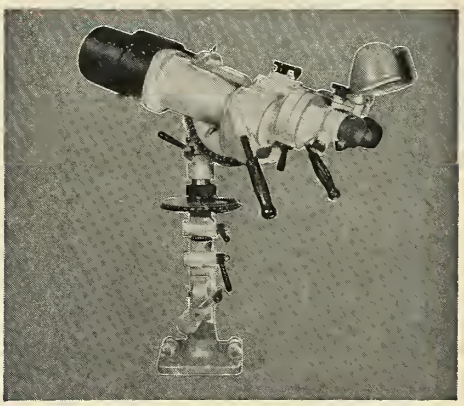
A letter to us with a simple sketch illustrating your remote viewing problem will place one of America's most respected and versatile designers and manufacturers of optical instruments at your service. For more information write Department 10N.



Problem Detailed, long-range observation at sea under varying weather conditions.

Solution Kollmorgen 20X, 120 Ship Binocular. Wide, bright field. Hermetically sealed, super lightweight.

Problem Internal inspection of inaccessible areas of tubing, long bores, mochinery, engines, aircraft structures.

Solution Zeiss-Kollmorgen Self-illuminating Borescopes. Diameters from .100", lengths to 45 feet. Bright, clear field.

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. . . missile electronics

are only two of many developments within the electrochemical field important to missile and satellite power requirements. Other projects currently in the research stage include lead-silver oxide, iron-silver oxide, zinc-nickel dioxide, and cadium-mercuric oxide batteries.

Solar Conversion—On October 17, the *Vanguard* I satellite had been in space for seven months. That in itself is a milestone since no other man-made satellite has been orbiting that long, but of equal significance is the fact that one of its radio transmitters is still in operation, and that the power used to operate this transmitter is generated in outer space.

The satellite utilizes six solar clusters, each containing 18 cells, distributed over the surface of the sphere in such a manner that the equivalent of one cluster is always turned toward the sun. The solar cells, developed and produced by Hoffman Electronics and made into clusters at the U.S. Army Signal and Development Laboratory, work on the photo-voltaic principle by which light energy is converted directly into electrical power, without the intermediary of rotating equipment.

The second transmitter in *Vanguard* I, as well as the transmitters in our *Explorers* and Soviet *Sputniks*, with the exception of *Sputnik* III, were supplied with power from conventional batteries and ceased operation after only a few weeks in space. *Sputnik* III, which was launched on May 15 this year, and which is reported to be equipped with solar devices for generation of power, is also transmitting at the present.

• *Vanguard* **is first**—The *Vanguard* solar energy converter undoubtedly will be remembered as a "first" in the history of science, but it and other photo-voltaic systems are far from the ultimate in solar conversion in their present state for satellite and spacecraft application. The main drawbacks are fairly low efficiency and sizeable weights. The units being produced at the present operate at an efficiency on the order of 10 to 11%. Another problem is the high cost of materials used in the manufacture.

There are many research projects underway to explore new materials to overcome the inefficiency in present solar cells and to develop new and improved methods for clustering these cells to obtain more electrical energy.

This article shows two possible methods for drawing more of the power the sun has to offer.

For example, there is a satellite,

MAGNETIC TAPE TESTS

17

AMPEX CORPORATION

AMPEX INSTRUMENTATION TAPE improves recorder performance

Some significant differences will show up in tests that you can make

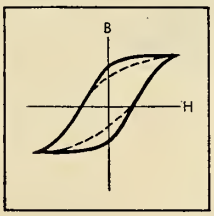
It's like buying premium gasoline to get the most out of a new 10-to-1-compression automobile engine — (except that this is the deadly serious business of collecting elusive facts). After you've acquired the best instrumentation tape recorder you can buy, you will get the most out of it by using the best tape that knowledge and skill can produce. In instrumenting a jet engine, programming a computer or firing a missile, great sums are expended solely for the data they produce.

By comparison, a small extra price you pay for Ampex's premium-quality tape shrinks to insignificance. Highly tangible differences in Ampex Instrumentation Tape are a smoothness of surface, squareness of hysteresis curve, and precision of reel. The latter is optional — usually well worth its price.

EXTRA SIGNAL-TO-NOISE RATIO

In direct recording the tape generally determines signal-to-noise ratio. This is of particular importance on frequency-multiplexed data where combined peaks can result in high signal levels. Unless the tape has exceptional qualities, the consequent intermodulation distortion gives severe interchannel interference and signal degradation. Ampex attacks the problem on both ends, extending the linear portion of the tape's recording curve and reducing noise components.

The hysteresis curve of a magnetic tape is the key to this extended linearity. Call it the tape's personality. It can sluff over in a lazy curve, or like Ampex tape it can sit up straight and square. The effect is easy to measure and compare. Set your recorder for optimum bias for each tape. Then record increasing signal levels until 1% third harmonic distortion is measured. One of our published papers gives full details.



And about the noise. Amplitude modulation is an important source that we can reduce. On sine waves it looks like whiskers on the peaks. It is due to incremental variations in effective magnetic characteristics — whether caused by changes in coating thickness and composition, or by surface roughness that lifts the tape slightly away from the heads. Ampex pays special attention to oxide preparation and coating techniques. And the exclusive Ferrosheen process gives a smooth polished surface. For a test comparison, saturate sample tapes in one direction. Then measure the comparative noise levels on playback.

FM-carrier recording and NRZ digital are also improved by tape-surface smoothness and Ampex's squareness figure of merit — (subjects for future numbers in this series). In the meantime if you like your facts in depth and want to make your own tape tests, we would be pleased to send our recently published technical papers on tape. A technique for setting optimum bias is included and will be particularly useful. Write Dept. B-17.

AMPEX INSTRUMENTATION DIVISION • 930 CHARTER STREET • REDWOOD CITY, CALIFORNIA
Phone your Ampex data specialist for personal attention to your tape needs. Offices serve U. S. A. and Canada. Engineering representatives cover the free world.

together with a folded, solar-cell covered collector contained within the nose cone of a missile. The satellite and collector are ejected at the same time and the collector is expanded, exposing the large solar cell surfaces to the sun. A design such as this can be developed to deliver up to several hundred watts.

The second method, involves concentrating light on a small number of solar cells. This would result in a major increase in electrical output. The system consists of a supporting container—expanded by gas pressure after ejection—which holds simple reflectors that focus the incident solar rays on the active solar converter surface. The effect would be the same as having the reflecting surface covered with solar cells.

There are several projects in the research stage which would completely abolish the solar cell for power conversion. One of the most interesting is the photoelectric generator being developed by the Astronautics Institute of the Westinghouse Air Arm Division. (The basic principles of this generator were described in m/r, Sept. 22, 1958, p. 15).

• **Design is flexible**—The design of this device is extremely flexible, and the generator can be made in any size and power category—within practical engineering limits.

For satellite and space-craft applications, the sun-ray collecting surface of the generator apparently will be some inflatable device of round shape trailing the vehicle, with dioxide used for inflation. By using the round shape, the problem of proper orientation is eliminated.

The maximum theoretical conversion efficiency for the photoelectric converter appears to be about 25%, which would mean power yields of about 375 watts per square meter. A crude working model in the Westinghouse Laboratories has performed at efficiencies of about 1/10 of one percent. Efficiencies of a few percent are expected before long, and a 10% efficiency will perhaps be attained within one year.

• **Nuclear conversion**—The interest in finding methods to convert nuclear energy into electrical energy for auxiliary power application in space has grown tremendously over the past few years. The interest is shared equally by industry, research organizations, universities, branches of government and the military services. Much good work has been accomplished in the nuclear field, and according to Congressional testimony earlier this year, the project of providing nuclear auxiliary power for space vehicles (*Rover*, *Pluto* and *Snap*) looks promising.

Several types of nuclear batteries have been developed and are available, but their use is limited to applications with extremely low power demands, since they supply only a few microwatts. Some of the conversion methods in these batteries are:

a) direct charging (high impedance and low current); b) contact potential difference (very low efficiency); c) semiconductor junction (higher current and lower impedance than the direct charging type, but having short life); d) thermo junction (low efficiency and short life); or e) photovoltaic (constant voltage).

In spite of the fact that many problems have been solved in connection with nuclear conversion, there is still much work to be done, especially for devices to answer high power demands.

High on the list of unsolved problems is that of shielding, which presents an obvious drawback, particularly to small space vehicles. Much effort is being put into projects tending to rectify this situation, and hopes are that the weight problem will be re-

An invitation to senior scientists and engineers

A $14,000,000 R & D Center, housing 9 new laboratories, was revealed as core of Republic's $35,000,000 Research and Development Program at recent announcement by Mundy I. Peale, President, and Alexander Kartveli, Vice-President for Research and Development.

.... To join Republic Aviation's new $35 million Research and Development Program for spacecraft, missiles and advanced aircraft

In announcing Republic's $35 million research and development program, designed to arrive at major breakthroughs in the aviation industry's transition to astronautics, Mundy I. Peale, President, set the following objectives:

"...ACCELERATION OF PROJECTS ALREADY UNDER WAY AT REPUBLIC ON LUNAR PROGRAM FOR MANNED SPACE VEHICLES, AND MISSILES TO DESTROY ORBITING WEAPONS, AND INITIATION OF INVESTIGATIONS LEADING TO NEW CONCEPTS FOR INTERPLANETARY TRAVEL."

"...RADICAL NEW FAMILIES OF LONG-RANGE AIR-TO-AIR MISSILES AND AIR-TO-SURFACE BALLISTIC MISSILES FOR STRATEGIC AND TACTICAL AIRCRAFT."

"...VERTICAL TAKE-OFF FIGHTER-BOMBERS, HIGH-MACH FIGHTER-BOMBERS, AND SUPERSONIC TRANSPORTS."

Alexander Kartveli, Vice-President for Research and Development, emphasized that Republic's program "will not duplicate in any way investigatory work currently in progress elsewhere, but will stress novel concepts and new approaches to basic problems of missiles and space technology."

The program includes construction of a $14 million R & D center to house 9 new laboratories, and anticipates doubling the present research staff.

Senior men interested in the new possibilities created by a simultaneous exploration of all aspects of Flight Technology are invited to study the functions of the new laboratories for more detailed information:

SPACE ENVIRONMENTAL DEVELOPMENT LABORATORY
To simulate space flight conditions and test missile, satellite and spacecraft systems and components; investigate human engineering problems.

RE-ENTRY SIMULATION & AERODYNAMIC LABORATORY
To study hypersonic shock dynamics, real gas effects, heat transfer phenomena and magnetohydrodynamics.

MATERIALS DEVELOPMENT LABORATORY
Study effects of high velocity, temperature, and space environment on materials for spacecraft, missiles and advanced weapons.

GUIDANCE & CONTROL SYSTEM DEVELOPMENT LABORATORY
To develop and test guidance and control systems for spacecraft, missiles and aircraft.

ELECTRONICS DEVELOPMENT LABORATORY
Study and explore all problems connected with highly specialized, complex electronic systems required for advanced forms of spacecraft, missiles and aircraft.

ADVANCED FLUID SYSTEMS DEVELOPMENT LABORATORY
To develop and test fluid power systems for spacecraft and missiles capable of operation under extremely high temperature, high pressure conditions.

MANUFACTURING RESEARCH & DEVELOPMENT LABORATORIES
To develop advanced manufacturing processes and techniques for materials used in missiles and spacecraft. Laboratories for each of the following areas: *Non-Metallics, Metallics, Welding.*

Qualified men are invited to write directly to:
A. Kartveli, Vice President, Research and Development

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AERO-THERMODYNAMICISTS EXPLORE HIGH-SPEED RE-ENTRY

A report to Engineers and Scientists from Lockheed Missile Systems — where expanding missile programs insure more promising careers

Advanced weapon system technology has brought to the forefront problem areas requiring attention to interaction between aerodynamic and thermodynamic phenomena. Typical of these is the problem of high-speed atmospheric re-entry.

Expanding research and development activities have coincided with acceleration on top priority programs like our Polaris IRBM. At the same time, positions for qualified engineers and scientists have opened up that are unequalled in responsibility or in opportunities for moving ahead.

Positions in **aero-thermodynamics** include such areas as: aerodynamic characteristics of missiles at high Mach numbers; missile and weapon system design analysis; boundary layer and heat transfer analyses in hypersonic flow fields; and calculation of transient structural and equipment temperatures resulting from aerodynamic heating and radiation.

In addition, openings exist at all levels in **Gas Dynamics, Structures, Propulsion, Test Planning and Analysis, Test Operations, Information Processing, Electronics,** and **Systems Integration.** For these and other positions, qualified engineers and scientists are invited to write Research and Development Staff, Dept. 2911, 962 W. El Camino Real, Sunnyvale, California.

Lockheed / **MISSILE SYSTEMS DIVISION**

SUNNYVALE, PALO ALTO, VAN NUYS, SANTA CRUZ, VANDENBERG AFB, CALIFORNIA
CAPE CANAVERAL, FLORIDA • ALAMOGORDO, NEW MEXICO

Maurice Tucker, Aero-Thermodynamics Department Manager, right, discusses combined aero-thermodynamic re-entry body tests being conducted in Division's new "hot-shot" wind tunnel. Others are Dr. Jerome L. Fox, Assistant Department Manager, Thermodynamics, left, and Robert L. Nelson, Assistant Department Manager, Aerodynamics.

THEORETICAL maximum performance of zinc-silver batteries like this is about 176 watt-hours per pound.

duced to a considerable degree before long.

A second problem in the development of nuclear devices is the high expense and low availability of pure isotopes. Also on the list is the development of power conversion equipment for systems not using direct conversion of nuclear energy.

Telemetering

Bureau of Standards Tests Transducers

Because telemetering of flight data is often limited by lack of information on the performance of the telemetering transducers, the National Bureau of Standards (NBS) is extensively investigating these important measuring links.

The program, carried on by NBS for all services calls for development of test methods which can be applied to the selection, application, and improvement of transducers.

Several important findings, including data on the inherent characteristics of the principal types of transducers and a clearer understanding of the requirements for various applications, have already resulted from the program.

Main elements of the program so far have been studies to predict transducer performance under the environmental conditions encountered in flight and the calibration of transducers in terms of their dynamic response. The environmental conditions imposed on the units under study are the usual ones of temperature, shock, pressure, vibration, acceleration; extremes of humidity, pressure shock, or acoustic vibration.

In the studies of dynamic response, the Bureau is especially interested in pressure and acceleration measurements since, in missile testing, more measure-

ments are made of pressure than of any other quantity. One serious limitation on the use of transducers in this area has been lack of information of the dynamic performance of transducers.

In the work at NBS, a shock tube —designed and built for this purpose by R. O. Smith and P. S. Lederer— is being used. The tube provides a pressure step-function of known value, which can be applied to the transducer pressure gage under study. Gage response is then displayed on an oscilloscope and photographed for futher analysis.

The shock tube is used because it is most effective in generating step-function pressure changes of known amplitude. It is constructed of flanged steel sections, has a cross-sectional area of 3 sq. in., a variable length compression chamber (from 3.4 to 12 feet) and an expansion chamber 8 feet long.

The tube has three pairs of optical glass windows, each pair provided with a schlieren system and photomultiplier tube to give a pulse when the shock wave passes. Possible pressure steps last 4 to 5 msec with a step rise time of less than 10^{-8} sec.

Pressures in the compression chamber range up to 1000 psi and expansion chamber pressures reach 350 psi. By using air on both sides of the diaphragm, shock step heights up to 600 psi are generated. The use of helium instead of air in the compression chamber allows the shock step heights to reach 1000 psi. Amplitude of the step is determined from the measured value of the initial expansion chamber pressure and the shock wave velocity.

In the studies of transducers used as accelerometers, one method is to rotate the accelerometer in the earth's gravitational field and another uses a specially designed dual centrifuge. Calibration of acceleration transducers does not present problems at frequencies from 10 to several hundred cps, but when the frequency of interest lies below this, satisfactory test equipment has not been available.

In the dual centrifuge, a known frequency is introduced to the accelerometer under test and the resulting response curve presents a convenient way to read the dynamic characteristics of the unit. The dual centrifuge is a rotating table carrying a second smaller spinning table which the accelerometer is fastened.

The tables are rotated in a horizontal plane at a speed where the transducer under test is carried around a circular path without rotation.

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space age

by Norman L. Baker

First *Sentry* shot near—Preparations for what may be the first reconnaissance satellite launching attempt are now being finalized. The first launch may be undertaken at Cape Canaveral in December or January, instead of Vandenberg AFB as originally planned, using an *Atlas* booster instead of a *Thor*. One of the *Atlas* gantrys at Cape Canaveral is being modified and extended to facilitate working space for the added upper stages.

Satellite's payload is reported to be a 250-lb. test prototype of the large (1000 to 1500-lb.) version to be launched later. Direction of launch is expected to follow the northeast flight path of the last two *Explorers* in order to sweep a near-maximum area of the earth's surface.

Bell leading *Dynasoar* contender?—The Space Flight and Missiles Division of Bell Aircraft is favored to win a large slice of the *Dynasoar* space system whatever the outcome on prime contractor selection. The Bell and Boeing designs for the piloted final stage of the system are similar in configuration and power output. For example, early designs of both systems called for a flat underside for optimum glide characteristics and heat dissipation.

Although all vehicle designs are far from the selection stage, two boost systems are under consideration. One would use an extensively modified *Navaho*-type system and the other would use the first stage of the *Titan* ICBM. Bell early pioneered the rocket glide bomber concept in this country through the efforts of Dr. Walter Dornberger, military leader of the A-9/A-10 project for bombing New York City during World War II. Dornberger tried to sell the concept then known as BOMI, to the Air Force some five years ago. Another notable boost-glide study was General Electric's C-3 program, a joint operation with Republic, which is now all but forgotten.

Rocketdyne to be dropped from X-15?—An upswing in development progress of the XLR-99 *Pioneer* rocket engine at Reaction apparently has convinced the Air Force that Rocketdyne, the back-up engine contractor for the X-15, could be dropped from the program. Reaction, bogged down earlier in the year for lack of hardware support, has been able to regain a lot of lost ground with delivery expected in time for first powered flight.

The National Aeronautics and Space Administration's budget is expected to jump considerably during the next fiscal year as more money is needed to carry for the "exploration of science and space at high priority." NASA currently has about $301 million available for fiscal year 1959, with close to $250 million of this being devoted to space activity and facilities construction. Many observers feel that $1 billion will be made available to the space administration as annual working capital by 1960.

What's new in TITANIUM pricing:

Recent price reductions in titanium metal—the seventh initiated by Titanium Metals Corporation of America since 1954—have provoked renewed interest in the design properties of the material.

With prices down 45 percent from levels four years ago, and weight, heat, and corrosion problems severely increased in aircraft and missiles now being devised, titanium metal's role is growing ever more important.

The purchasing of titanium can sometimes be a complex task. TMCA hopes it can help you in that task by passing along some reminders on methods to save money on the "price extras" that apply to all orders of titanium metal. Of course, design considerations are paramount, but sometimes slight changes that can be tolerated by engineering can mean large cash savings.

✱ QUANTITY

Production costs decrease as the amount of material being processed increases. Therefore, quantity schedules have been established to pass along economies to the purchaser. A customer can often benefit by careful consideration of the amount of material he is ordering, compared to the quantity schedule as outlined in TMCA's Buyer's Guide. In many cases, because of applicable quantity extras, upwards of 1,000 pounds of titanium metal are available at no charge to the purchaser. For example, a 10,000 pound shipment of heat-treatable forging billet can cost exactly the same as a 9,074 pound order; a 5,000 pound shipment of plate can cost exactly the amount of a 4,802 pound order. TMCA's district sales managers are always willing to help you take advantage of the price breaks.

✱ PATTERN SIZES

Although ordering by pattern sizes is an established procedure with more common engineering materials, it isn't always the most economical method with titanium. For example, when small parts are to be cut from sheet, ordering "random size" will save you 75 cents per pound of material. The price allowance is applicable when *specific sheet sizes are ordered,* but shipment is permitted in widths ranging from −6" to +2" and lengths ranging from −18" to +12". Weight of random size sheets and exact size sheets of the same gage can be combined when computing quantity prices for a given order.

✱ TOLERANCE

Here important weight saving advantages are accorded designers and cost savings accrue to purchasing. Material specified ½ AISI tolerance weighs 10% less than standard-tolerance material.

TMCA's district sales manager will be happy to provide you information on grades and products where this tolerance schedule applies.

✱ WIDTH

If you determine the end use of metal before ordering, you will sometimes realize important cash savings. For example, titanium metal 24" wide is classified as "sheet," and sheet prices apply. However, by ordering material 1/16" less in width, strip prices apply at a savings of 50 cents to $1.00 per pound.

✱ THICKNESS

A more substantial saving is possible in specifying plate rather than sheet where the substitution meets design requirements. Metal 0.187" thick is priced as sheet. However, metal 0.1875" is priced as plate at a savings of $2.10 per pound.

✱ SIZE

A size extra of 20 cents per pound applies to billets 8" or less in diameter. However, billets 8 1/16" in diameter are supplied at base price. If the additional 1/16" can be tolerated by design, the financial savings on material can be realized.

These are just a few examples of the money savings possible through careful study of the "price extra" sections of your Buyer's Guide.

Fixed, published schedules are vital in guaranteeing standard quotations to all customers in highly competitive work. By the same token, TMCA customers will receive every pricing benefit possible under these schedules.

* * * * * *

If you are placing an order for titanium, or considering purchase of titanium, contact the TMCA sales manager in your district. He can help save you money and time.

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Axial Flow Ram Jet Has Rocket Application

An axial flow ram jet development by Strato-Missiles, Inc., New York, may mean a technological advance in missile propulsion.

The patent application for the system is classified. However, the jet reportedly can be adapted for use as an anti-missile missile, a surface-to-air missile, or short range surface-to-surface missile. The basic elements, according to the company, can be incorporated in any diameter or length of missile configuration. The company calculates that a 15-inch diameter missile will have an initial acceleration of 2,300 feet per second, or 1,800 miles per hour.

Strato-Missiles said the system is much cheaper to manufacture than the conventional type of airplane jet engine. Peak variations in the combustion chamber reportedly amount to only 5% of the minimum combustion chamber pressure.

The system centers around the development of a differently designed turbine. The turbine is bladeless, therefore there are no buckets to lose nor a need for stator blades. Because of the absence of any blades, the inlet gas temperature can be very high without the fear of blade cracking or aging. There is no creep or interference, and the speed of the turbine is limitless.

If used in a missile, launching could be accomplished with almost no preparation and in a very short time, the company said.

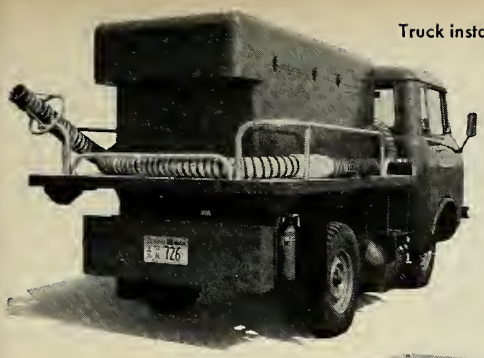
Operational data has been accumulated involving tests conducted with various sized turbines. An 18″ diameter turbine, 3½″ wide, spinning at 9,000 RPM, has produced 300 horsepower with an inlet pressure of 135 psi (steam) freely exhausting to atmosphere. With a vacuum exhaust, the horsepower could almost be doubled. A 9¾″ diameter turbine, 2″ wide, spinning at 16,000 RPM, has produced 110 horsepower.

Strato-Missiles is completing a prototype test turbine.

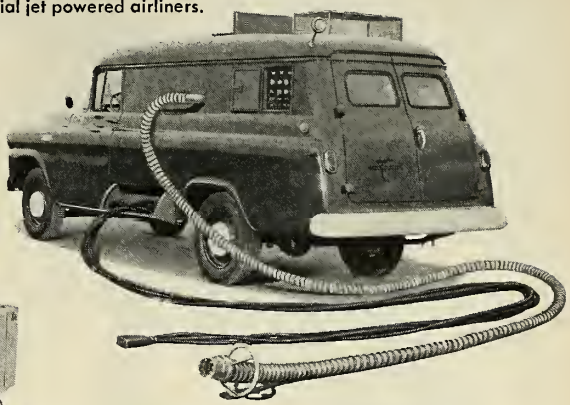
Top Scientists To Meet On Space-Medical Topics

Many of the nation's top space scientists are scheduled to speak at the three-day meeting of the second International Symposium on the Physics and Medicine of the Atmosphere and Space.

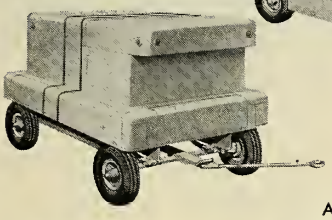
The San Antonio meeting, which will run from November 10-12, will be attended by more than 600 scientists and physicians working in the space field. Chairing the opening session will be Dr. Hugh L. Dryden of NASA.



Truck installations supply pneumatic power for main engine starting, cooling and heating, electrical power for commercial jet powered airliners.

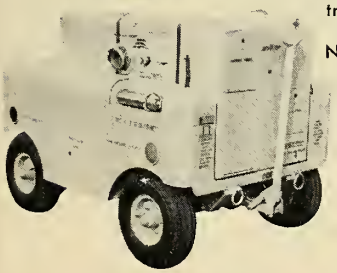


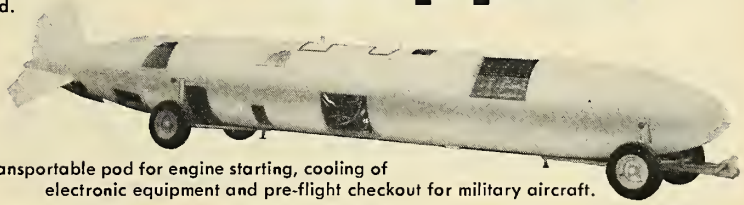
Dual carts for main engine starting, air conditioning and electrical power for military aircraft.



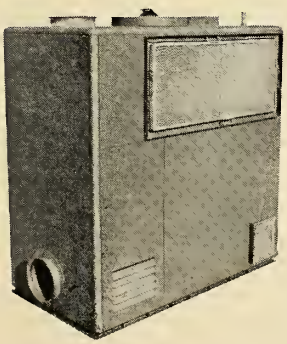
Reliable and versatile ground support

AiResearch MA-1A trailer for starting military aircraft. Nearly 2,500 in the field.





Air transportable pod for engine starting, cooling of electronic equipment and pre-flight checkout for military aircraft.



Lightweight Freon system, usually installed in a van or trailer, for cooling electronic equipment in support of missiles.

AiResearch Aviation Service Company ground support equipment is tailored to meet turbine powered aircraft and tactical missile requirements. Lightweight, compact units can be designed to specific configurations or installed on standard vehicles.

Heart of the lightweight ground support systems are AiResearch gas turbine compressor power units. Capable of delivering both electrical and pneumatic power, nearly 8,000 of these units are operating successfully and dependably in the field.

Support services can include: main engine starting, pressurization and air conditioning of cabins and compartments, missile pre-flight check-out, removal of snow and ice from aircraft and equipment, supply of DC or AC electrical power at any required frequency, and low pressure, high flow air for operation of a variety of actuation systems. The units have push button starting and operate without delay under all weather conditions.

The Garrett Corporation, through its AiResearch divisions, is the world's largest producer of lightweight turbomachinery. The AiResearch Aviation Service Company can package both AiResearch equipment as well as that of other manufacturers to meet your individual ground support requirements. Your inquiries are invited.

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Soviets Cite Progress In Controlled Satellites

The Soviet Union has claimed the solution of various problems in the task of establishing oriented satellites and automatic satellites. According to Radio Moscow, Prof. Dobronravov, a Soviet astrophysicist, has stated that: "Technical and industrial possibilities for the construction of an automatically-controlled satellite capable of speeds of 6.85 miles per second now exist in the USSR." Indications were that this vehicle would be in a moon-earth orbit.

Dobronravov also stated that the necessary equipment for one or two men to take a cosmic trip for ten days could be placed in a vehicle with a weight equal to *Sputnik* III. The Soviet scientist noted that "the achievements of Soviet science, technology, and industry allow the prediction that the trip to the moon will be possible in the near future."

There were no details given with the statements.

There was also strong indication in the Soviet press that work is well underway on a fully-oriented satellite. An automatically-oriented magnetometer was installed in *Sputnik* III, as well as two other measuring transducers which made it possible to determine the satellite's position relative to the Earth's magnetic field and the speed of the satellite's rotation about its own axis.

There was evidence that the Soviet stabilizing system will combine gyroscopes and vernier jets.

SBA Wants Liaison At Contractor's Plants

The Small Business Administration has recommended to the Senate Small Business Committee that SBA liaison officials supplement military representatives at defense plants.

The recommendation was carried in an SBA report to the Senate group and termed the Defense Department system "ineffective." The report was sharply critical of DOD efforts to get small business a larger share of the budget dollar.

Under a Pentagon directive (ASPR 1-707.4), a military representative is supposed to be assigned to plants to determine the "adequacy of the subcontracting program as well as its deficiencies and direct the necessary steps for improvement to be taken." The SBA report said this surveillance was found ineffective and in some instances wholly missing.

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Bendix Canistered Inverters, environment-free and completely sealed, are now in production for the Atlas and Thor missiles. Designed for dependable and efficient operation, Bendix Canistered Inverters are completely sealed against the effects of altitude and can withstand conditions from sea level to outer space.

Cooling techniques employed enable these units to provide full-rated output throughout the flight without external cooling. Both voltage and frequency regulation are accomplished by static, magnetic amplifier-type regulators. Since these regulators have no moving parts, output voltage and frequency are not affected by vibration and shock. The total harmonic content of the output voltage per phase is less than 5%.

Bendix Canistered Inverters are the product of years of development and experience in manufacturing electrical power equipment for aircraft and missiles. They are engineered to meet the strenuous requirements in performance and reliability called for in today's (and tomorrow's) missiles. For more detailed information write TO RED BANK DIVISION OF BENDIX AVIATION CORPORATION, EATONTOWN, NEW JERSEY.

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Bendix AVIATION CORPORATION

astrionics

by Raymond M. Nolan

Despite all the furore about BMEWS and other long-range radar, don't discount other means of missile detection. Many companies are using their own funds in a gamble that effective missile detection will only come from geomagnetic phenomema. One company spokesman said that the frequencies employed will be high audio—which brings the electronics picture full 'round from the currently employed KMC frequencies. The method will reportedly sense disturbances in the ionosphere and will have the dual advantage of being passive and will operate over the horizon at the speed of light.

Soviet activity around the South Pole has caused some concern to a firm retained by the Army to look ahead in the ECM field. Main reason for the disturbance—think how easy it would be to traverse a sensor from Cape Canaveral to Vandenberg Air Force Base if you were sitting on the bottom of the world and distance was no problem.

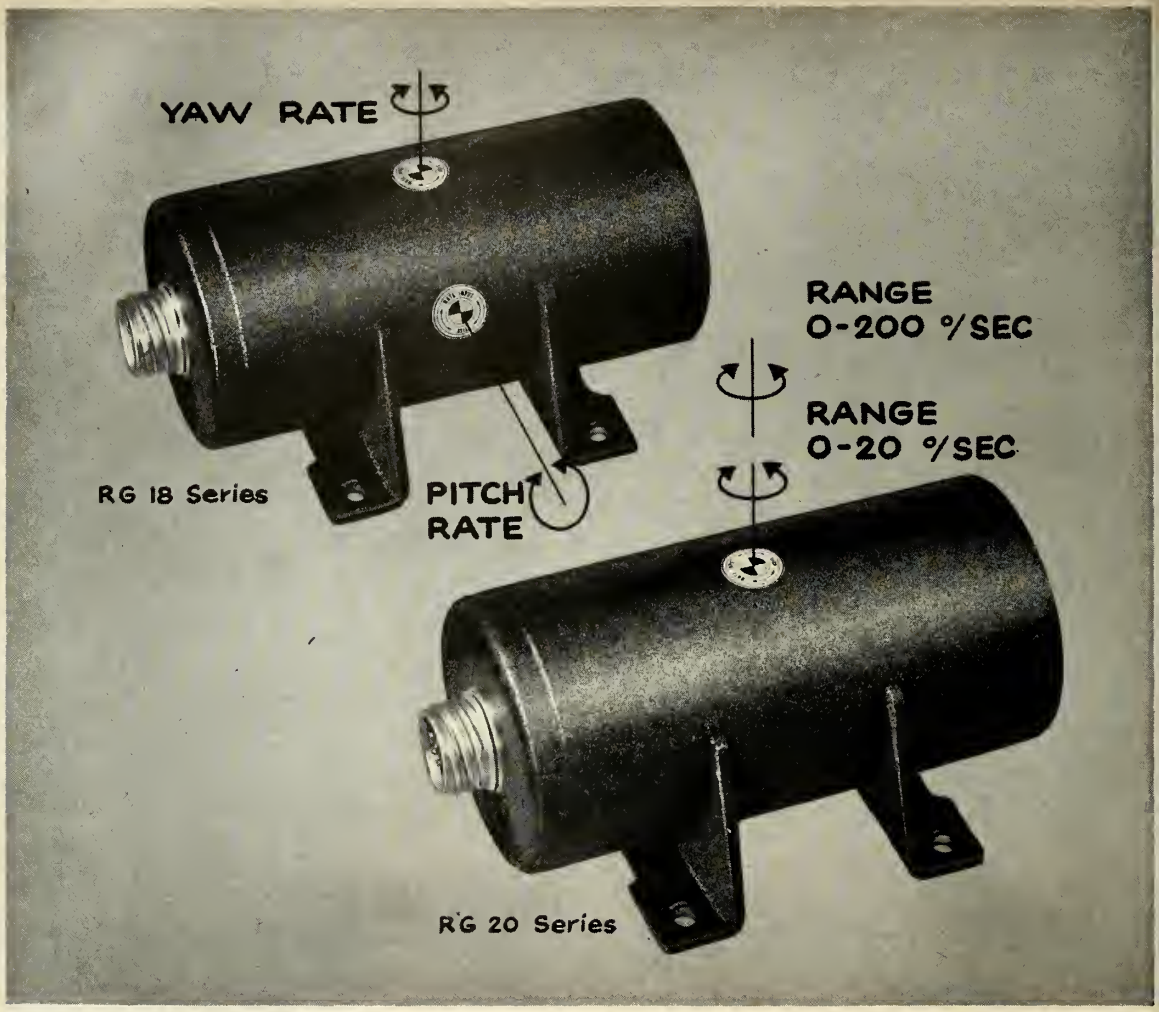
At the recent Association of the U.S. Army meet in Washington, AC Spark Plug had a color picture (but not the hardware) of its miniaturized Achiever stable platform. Used in conjunction with transistorized electronics components, the system will probably weigh about half the present one (estimated at 600 pounds). AC spokesmen said that the miniature units were developed "mostly" with their own money. No buyer has been found yet, but AC people are confident that the lightweight set will provide the answer to "at least" one of the upcoming second generation missiles.

One little-noted fact about the recent lunar probe was that it relayed radio signals between Hawaii and England. Gen. Schreiver reportedly surprised W. W. Kellog, head of the U.S. technical panel for IGY satellites, with his announcement that signals from a transmitter in Hawaii were picked up by the doppler command receiver in the lunar probe, altered somewhat and rebroadcast by the small transmitter in the probe. The signals were then picked up by receivers in Manchester, England and at Cape Canaveral. Signals from Canaveral were also detected at Manchester and Hawaii. Although this was only a test, it was the first time a signal was relayed for such a distance, and it clearly indicates that the many proposals for TV and communications relay satellites are feasible.

A "sun" computer, designed by the Sandia Corporation, is being used for missile tracking. It is said to lessen the loss of projectiles against the bright sun. To operate, trackers set the small computer on a scale map of range, and then position the instrument's base on the specific camera station. If the computer reading shows that the missile will pass between sun and tracking camera at time of shoot, the firing time is changed to one where the condition will not prevail (also shown on the computer).

Another item shown at the AUSA meeting was a "device" recovered with the *Jupiter* nose cone. The so-called "device" was actually the fuzing and arming system for operational nose cones. The unit, developed by Ford Instrument Company and Picatinny Arsenal, is said to operate on inertial principles.

Latest version of the *Falcon* being developed is the GAR 11. Using the Hughes formula of even-numbered GAR's being radar-guided and odd-numbered ones infra-red guided, this means that the latest one is an IR bird. The GAR 11 reportedly has a nuclear warhead. Hughes people are enthused about their latest missile and feel that it will provide the all-weather capability that USAF wants.



New Humphrey dual-rate gyros do the work of two units

Now important reductions in the space required for instrument and control packages can be made with the introduction of a new Humphrey rate gyro that replaces two ordinary gyros. The new design utilizes a single motor to drive two separate wheels in one unit. With this new development, it is possible to measure rates about two different axes with an RG-18 Series Gyro or cover two different rate ranges about the same axis with a single RG-20 Series instrument.

RG-18 gyros should find widespread use for applications now requiring two instruments. For example, one unit could be used to measure both pitch and yaw. The RG-20 Series, with its two different rate ranges, may be applied to instrumentation systems where greater accuracy is required. For example, a single unit can be furnished to cover the rate ranges from 0—20 degrees/second and from 0—200 degrees/second. In effect, you expand the dynamic range of your instrumentation system from 100 to 1 to 500 to 1. This expanded scale gives you far greater accuracy.

The new rate gyros are built with two independent pick-offs—one for each axis or one for each range. They meet tough environmental conditions, such as temperature from −65°F to 180°F while operating, relative humidity 100%, unlimited altitude and excellent resistance to acceleration, vibration and shock. Phone or write today and let the kind of engineering that developed these new dual-rate gyros go to work for you.

Humphrey Inc.

ELECTRO-MECHANICAL INSTRUMENTS

DEPT. M-118, 2805 CANON STREET
SAN DIEGO, CALIFORNIA

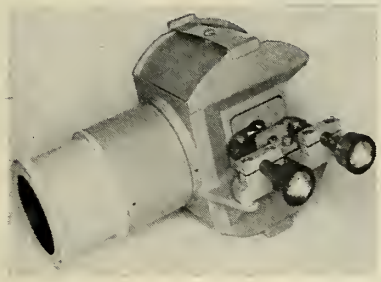
FOR COMPLETE SYSTEMS, SPECIFY HUMPHREY
GYROSCOPES, ACCELEROMETERS, POTENTIOMETERS

Rotating Mirror, Camera Study Speed Events

Two standard laboratory instruments—rotating mirror and rotating drum cameras—have been developed by **Avco Manufacturing Co.** for studies of radiation, explosive compound development, solid fuel ignition and other applications in the missile field.

Displayed for the first time at the recent ISA instrumentation-automation conference in Philadelphia, the cameras were developed and in use for two years in connection with company research in high-temperature gas dynamics and atmospheric reentry problems involved in the Air Force *Titan* ICBM program.

The rotating mirror camera, says the manufacturer, records position vs time relationships, sweeping the image from a hypersonic object source onto fast emulsion film strips.



Part of the machine is a hexagonal, first surface mirror, rotating at 3,000 rps. The drum camera, in addition to making position-time records, also can be used with a densitometer to produce accurate data of hypervelocity phenomena.

Circle No. 292 on Subscriber Service Card.

Transducer System Checks Lox or Fuel Levels

An airborne servo transducer system has been designed for continuous measurement of LOX or fuel head in missiles, and is now on the market.

Wallace O. Leonard, Inc. claims that the unit is based on a unique force-balance servo system that makes it possible to measure the height of a column of liquid within very close tolerances. Typical values for a 22-ft. column are given as: repeatability of

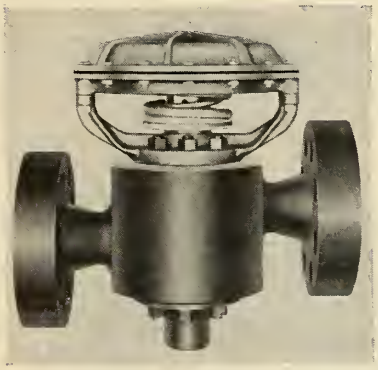
0.040 in., hysterisis 0.080 in.

Additionally, because the transducer senses differential pressure between the bottom and top of the tank, normal LOX boiling will not cause bad readings. Called Leonard model 502400-2, the system has two potentiometer outputs, one fine and the other coarse; and optional outputs include code generators, synchros, potentiometers, or combinations of these devices.

Circle No. 289 on Subscriber Service Card.

New Line of Air Valves for Missile Test Stands

Designed to provide fast response and leak-free operation, **Sinclair-Collins'**



line of 5,000 psi air control valves is now on the market.

The valves are flange-mounted and diaphragm operated, with aluminum bronze billet or alloy steel bodies, and were developed for use on missile test stands, or other applications requiring precise control of ultra high pressure air.

Sleeve-type construction, employing replaceable hardened stainless seat sleeve insert in the valve body, is said to maintain perfect alignment of valve stem and seats at all times. Stellite-faced stem seats are standard. Complete interchangeability of precision-ground lapped stems and seat sleeves simplifies in-service maintenance.

Circle No. 299 on Subscriber Service Card.

Ceramic Resists Extreme Heat-Shock Applications

Pressed ceramic parts which the manufacturer says can withstand thermal changes such as those involved in water quenching from 2,200 deg F, are

now available in production lots.

Named ThermoShock HT-2 ceramic, the new material is a product of **Duramic Products Inc.,** and is the result

NOTE: *For additional information about any product mentioned in this section of Missiles and Rockets use the attached prepaid reply cards. Circle numbers shown on the reply card that correspond with numbers appearing beneath items described. If no circle number accompanies the article or advertisement, give page number (and advertiser's name) on line provided at bottom of the card.*

Your requests for information will be forwarded promptly to the companies concerned.

The Editor

. . . new products

of a two-year development program by the company's engineers. Key to the ability to withstand extremely rapid temperature changes is ThermoShock's zero thermal expansion over a 2,400 deg F temperature range.

Applications include copper brazing locators; projection and spot welding jigs, shielded arc welding jigs.

Circle No. 285 on Subscriber Service Card.

Rocket Thrust Controller Senses Small Errors

Capable of sensing and correcting small errors in thrust chamber pressure in liquid propellant rocket engines is the claim of a new hydromechanical controller now on the market.

The controller corrects errors by producing a rate of change in the actuator position.

The actuator, an integral part of the control, can be used to govern the flow

of propellent to a gas generator by the flow of hot gas from the generator to the turbine, thus controlling the turbine speed and propellent flow to the main rocket trust chamber, according to **Bendix Products Division.**

A two-stage pressure regulator obtains accurate reference, a high-gain pressure error sensing diaphragm and a two-stage hydraulic amplifier comprise major portions of the system. Accuracy and load insensitivity are obtained by well-known servomechanism techniques, such as degenerative actuator velocity feedback.

Circle No. 290 on Subscriber Service Card.

Gasket and Seal Material Withstands Fluid Attack

A Teflon-felt material, said to consist of pure Teflon fibers impregnated with a Teflon resin, is claimed to have a wide temperature range, and to be usable continuously from below minus 100 deg F to plus 400 deg F. Under certain conditions, according to **General Plastics Corp.,** the material has been used up to 600 deg F.

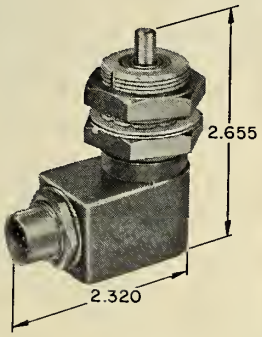
The manufacturer claims that, since the felt is all Teflon, it will withstand attack by strong acids and bases, and is unaffected by water or any common

MICRO SWITCH Precision Switches

Four switches to meet special conditions in airborne and missile launcher applications

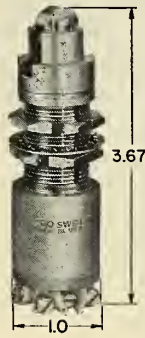
These four special switches are alike in that all are sealed in enclosures filled with inert gas under pressure. Also, in each switch a scraper ring on the actuator shaft prevents jamming or binding even in ice or mud. And all are manufactured with the utmost care and precision.

1EN75R
Has plunger actuator; miniature Deutsch receptacle at bottom.



1EN76R
Has plunger actuator; miniature Deutsch receptacle at side.

12HR1-S
Plunger actuator



22HR1-S
Roller plunger actuator

These new switches withstand high shock . . . meet requirements of MIL-S-901B

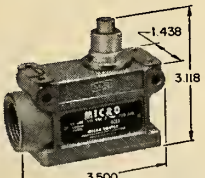
Shock resistant. Meet requirements of MIL-S-901B. Each switch contains two "SM" SPDT basic switches. Operating force 6-12 lbs., release force 4 lbs.; overtravel .250 in. Rating: 28 vdc, 24 amps. inrush; 4 amps. resistive; 3 amps. inductive; 115 vac, 5 amps. Ask for Data Sheet 152.

These switches operate dependably at temperatures up to 600° F.

Hermetically sealed, high temperature DPDT switches for reliable operation to 600° F. Metal-to-metal and glass-to-metal seals in accordance with MIL-E-5272A. Operating force 6-12 lbs.; release force 5 lbs.; overtravel .250 in. Rating: 28 vdc, 5 amps. resistive; 2 amps. inductive. Ask for Data Sheet 122.

Other MICRO SWITCH Precision Switches for aircraft, missile, rocket, and launcher applications include these . . .

A 4-pole DT assembly with four SPDT "SM" basic switches sealed in enclosure only 1½" diameter.



Rugged limit switch for missile shelter, erecting, and launching equipment. SPDT.

Versatile sealed limit switch for launching equipment. Head, arm, and operating direction adjustable. Two-circuit basic switch.

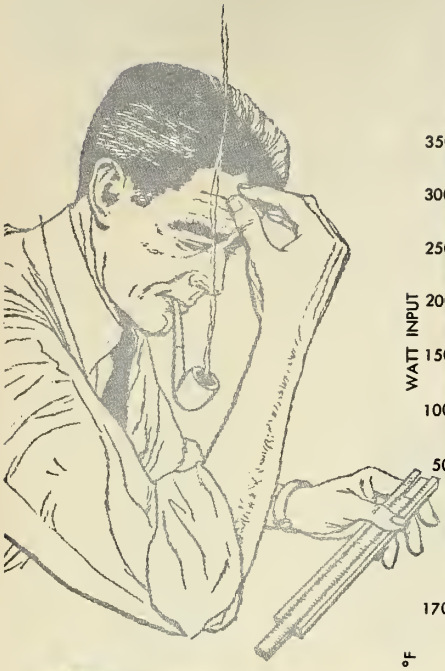
Your request for data sheets covering the switches described above or for information about the switches shown at left will receive prompt action.

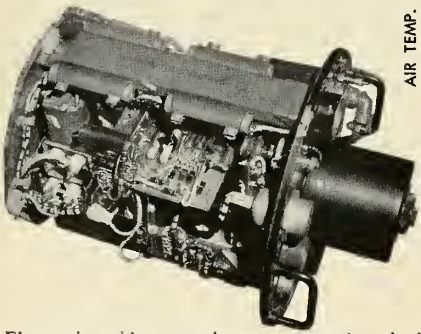
MICRO SWITCH . . . FREEPORT, ILLINOIS
A division of Honeywell
In Canada: Honeywell Controls, Ltd., Toronto 17, Ontario

Look in the Yellow Pages for the name of the branch office and sales engineer nearest you.

Honeywell
MICRO SWITCH PRECISION SWITCHES

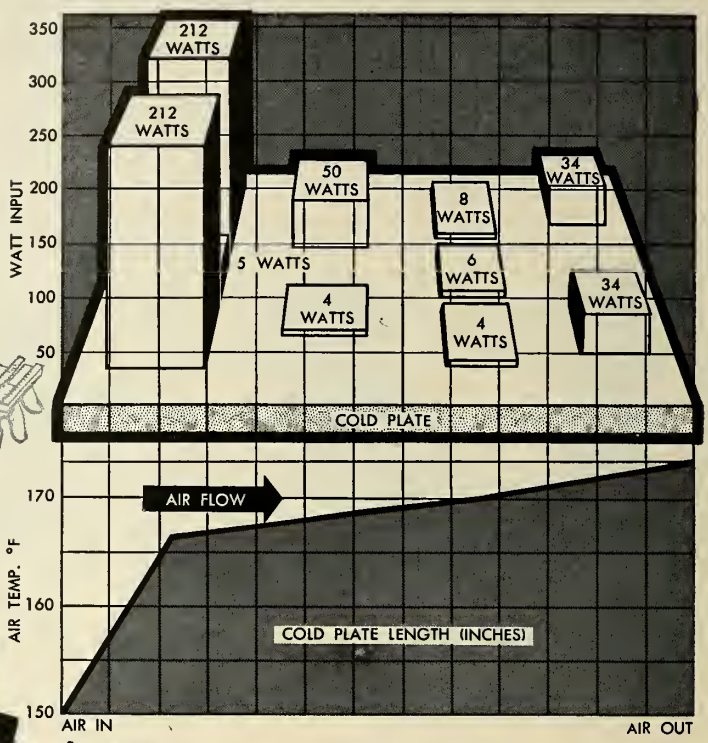
ELECTRONIC COOLING





Electronic guidance equipment mounted to *both* sides of UAP cold plate, contained in UAP pressurized case . . . for control of air-to-air missile.

Requirement: Stay within customer's envelope. Dissipate 569 watts thru 13 x 10 in. cold plate and not exceed a plate temperature of 173°F with cold plate air-in temperature of 150°F. Provide areas for circuits to be mounted to cold plate surface between power units.



Answer: UAP cold plate configuration designed to provide adequate heat transfer from localized high, medium and low heat concentration areas with air-in temperature at 150°F. All requirements met with room to spare.

The hypothetical conditions as stated above are typical of the problems that have come to us since the advent of electronically controlled supersonic missions.

UAP eminence in the heat exchanger field has been firmly established over the years by delivery of systems and components of proved optimum performance and reliability. Our experience covers the engineering and production of devices for application as cold plates, gas-air heat exchangers, air-liquid heat exchangers, and associated controls; mechanical refrigeration systems and expendable refrigeration systems. These can function in the anticipated environmental conditions and utilize one or more of the following heat sinks; ambient air, expanded bleed air, expanded ram air, ram air, expendable refrigerant, or available liquid.

Make your requirements our responsibility. Call . . .

CALIFORNIA.....1101 Chestnut St., Burbonk, Colif., VI 9-4236
NEW YORK.....50 E. 42nd St., New York 17, N.Y., MU 7-1283
OHIO.....1116 Balander Ave., Dayton, Ohio, BA 4-3841
CANADA.....United Aircraft Products, Ltd., 5257 Queen Mary Rood, Montreal, Canodo, Elwood 4131

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UNITED AIRCRAFT PRODUCTS, INC.

1116 BOLANDER AVENUE, DAYTON, OHIO

. . . new products

fuels, lubricants, hydraulic fluids or solvents. Since most materials do not adhere to Teflon, cleaning for re-use is said to be simple.

Gaskets and seals exposed to severe corrosion and elevated temperatures are among the uses forseen for the new material.

Circle No. 288 on Subscribor Service Card.

Ground-based Theodolite Checks Missile Alignment

Now designed and in the process of being fabricated is an optical azimuth alignment electrotheodolite, primarily for use with the *Thor* missile program. The instrument is being built under a $1.7 million subcontract, let by AC Spark Plug to the **Davidson Manufacturing Co.**

The ground-based electrotheodolite is said to be a precision optical device, designed to monitor the azimuth alignment of the missile during pre-launch.

Circle No. 297 on Subscriber Service Card.

Subminiature Amplifier Provides Variable Gain

An AC instrument amplifier, Model 2618, is said to satisfy requirements of missile telemetry, is completely sealed, and will operate continuously in ambients of 250 deg. F.

Endevco Corp. says the amplifier is designed specifically for application with company-made piezoelectric accelerometers, with variable gain of 6 to 20. The unit is completely sealed. Fully compensating feedback is said to reduce harmonic distortion and nonlinearity to less than 1%, with a gain stability of plus or minus 1%.

Circle No. 296 on Subscriber Service Card.

Regulator Diodes Give Circuit Flexibiltiy

Silicon Zener Regulator Diodes that are said to contribute to maximum circuit flexibility are now available from **Motorola's Semiconductor Division.**

Manufactured in both 10 and 50 watt power ratings, with voltage ranges up to 200 volts, the diodes come in several series. The 10MZ series is rated for 10 watts at 55 deg. C, is housed in Jetec, a standard 10-32-stud package. The 50MZ series is housed in the TO-3 package, with either plug-in or solder-in features, as well as series interlock construction for protection against overvoltage on load. Both series are available with either anode or cathode connected to the case.

Circle No. 295 on Subscribor Service Card.

LAST MINUTE AWARDS

CDC Control Services, Inc., automatic control systems specialists of Hatboro, Pa., was recently awarded two contracts of unspecified amounts. The first of the contracts calls for a transonic cascade tunnel control system for the division's Flight Propulsion Laboratory. The second requires CDC to furnish a complete surge control system for five test facility compressors.

A $1-million prime production contract has been awarded to **United Electrodynamics** of Pasadena, Ballastics Missile Center, following an earlier contract under which United designed and developed a transistorized telemetry system for the Air Force *Atlas*, *Titan* and *Thor* Ballistic Missile Programs.

From Boeing Airplane Company—**Telecomputing Corporation,** Los Angeles, has received $115,000 for production of floated rate gyros for the Air Force *Bomarc* missile.

From Army—**Chrysler Corp.,** Detroit, received a $2.1-million contract for the *Jupiter* missile program.

By Guided Missile Division, Chrysler Corp.—A contract with an estimated value of $450,000 has been awarded **Allen B. Du Mont Lab., Inc.**

AIR FORCE

By the National Institute of Health of the U.S. Department of Health, Education and Welfare.

RIAS, a basic research institute supported by the **Martin Co.,** has been awarded grants for two research programs. One, a grant award of $14,160, covers a project to study the "Composition and Metabolism of Chloroplasts." The second is a grant award of $20,540 for a study of the Mechanism of Photosynthetic Reduction of carbon monoxide.

By Headqr., Ogden Air Materiel Area, U.S. Air Force, Hill Air Force Base, Utah:

Boeing Airplane Co., Pilotless Aircraft Div., Seattle, Wash., received $192,360 for technical data for IM-99A missile.

By Patrick AFB, ARDC, U. S. Air Force, Patrick AFB, Fla.:

Westvaco Chlor-Alkali Div. of **Food Machinery** received $37,240 for rocket propellant.

National Co. Inc., Malden, Mass., received $50,000 for standards primary frequency.

By Headquarters, Air Force Flight Test Center, ARDC, Edwards Air Force base, Calif.:

Space Corp., Garland, Tex., received $36,271 for installation of blast instrumentation system.

Electronic Engineering Co., Santa Ana, Calif., received $35,808 for addition of second airborne telemetry monitoring system.

By HQ Cmdr. AMC, Wright-Patterson AFB, Ohio.:

Airborne Instruments Laboratory, Cutler-Hammer, Inc., Mineola, N.Y., received $1 million for composite program of study, planning and recommendation for the electronic reconnaissance system.

Lear, Inc., Grand Rapids, Mich., received $48,720 for indicators, attitude, settable pitch, Model A and B for service test on X-15.

Marquardt Aircraft Co., Van Nuys, Calif., received $1,443,737 for qualification tooling for RJ43-Ma-3 ramjet engine in support of *Bomarc* missile program.

By Headquarters, Warner Robins Air Materiel Area, USAF, Robins Air Force Base, Ga.:

Goodyear Aircraft Corp., Akron, Ohio, received $444,936 for repair/modification of TMO76A weapon system.

ARMY

By Procurement Office, Aberdeen Proving Ground, Md.:

Ampex Corp., Silver Springs, Md., received $67,638 for recording equipment for ARPA satellite tracking complex.

By Headquarters, Redstone Arsenal, U.S. Army Ordnance Missile Command, Redstone Arsenal, Ala.:

Wall Tube & Metals Co., received $28,235 for two items of stainless steel tubing, type 304 round, seamless.

Thiokol Chemical Corp., Trenton, N.J., received $240,017 for continued development of XM20 and XM30 rocket engines.

By Boston Ordnance District, Boston, Mass.:

Raytheon Mfg. Co., Andover, Mass.,

received $497,933 for repair parts and electronic components such as resistors, capacitors, inductances and common hardware.

Olin Mathieson Chemical Corp., New Haven, Conn., received $49,484 for feasibility study of fuels based on solids.

By U.S. Army Signal Corps, Fort Monmouth, N.J.:

The DataTape Division, Consolidated Electrodynamics Corp., has received a $148,000-contract award from the U.S. Army Signal Corps for the development of a new type of narrow-band data-recording system.

By District Engineer, U.S. Army Engineer District, Albuquerque, N. Mex.:

Ramsey-Leftwich, Lubbock, Tex., received $209,475 for *Honest John* facilities, White Sands Missile Range, N.M.

By the Department of the Army:

Chrysler Corp., Detroit, Mich., received a $2.1 million contract for the *Jupiter* missile program.

Dean Construction Co., Inc., Long Island City, New York, received $1.9 million contract for construction of a special weapons building at Picatinny Arsenal, Dover, New Jersey.

By U.S. Army Ordnance District, Philadelphia, Pa.:

Western Electric Co., Inc., New York, N.Y., received $983,739 for *Nike* spare parts & components.

Douglas Aircraft Co., Inc., Charlotte, N.C., received $139,510 for *Nike* spare parts & components.

University of South Carolina, Columbia, S.C., received $11,366 for research on "Temperature Dependence on Properties of Electrolytes in Non-Aqueous Solvents."

Minneapolis-Honeywell Regulator Co., Philadelphia, Pa., received a $10,571 contract for *Nike-Corporal* replenishment spare parts.

Western Electric Co., Inc., New York, N.Y., received $180,056 for *Nike* spare parts & components.

By the U.S. Army Signal Corps:

The Electronic Defense Laboratory of Sylvania's Mountain View Lab. received a $3.6-million contract for the manufacture of prototype equipment on a "quick reaction" basis, field support and service, and research and development.

NAVY

By Office of Naval Research, D.C.:

Stencel Aero Engineering Corp., Asheville, N.C. received $40,047 for research and development of a very fast operating powered parachute system.

Bendix Radio, Baltimore, Md., received $335,680 for services involving operation of minitrack satellite tracking system sites.

Columbia University, New York, N.Y. received $36,886 for research and development in the field of metallurgy.

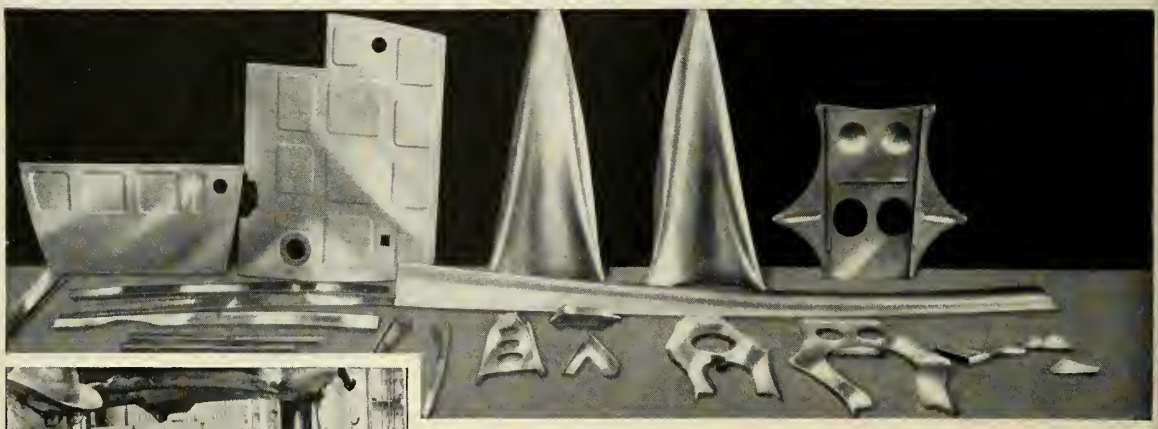
Mellon Institute of Industrial Research, Pittsburgh, Pa., received $70,227 for research on polymer structures and properties.

Purdue Research Foundation, Lafayette, Ind. received $36,000 for research on heat transfer coefficients.

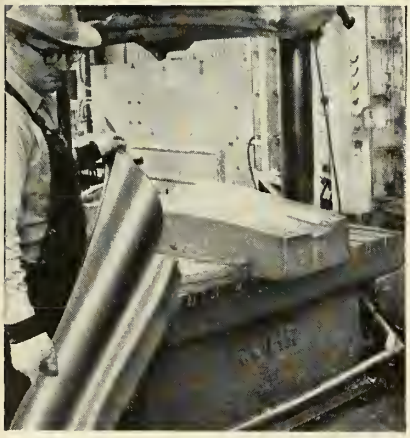
Pennsalt Chemicals Corp., Philadelphia, Pa. received $343,827 for research in the broad field of synthetics and characteristics of inorganic compounds and materials.

ROHR
AIRCRAFT CORPORATION *takes full advantage of*

TITANIUM'S WORKABILITY



Fabricated Parts
Typical titanium parts fabricated by Rohr Aircraft for aircraft applications.



Drop Hammer Forging—*Oven-heated to 1000° F., commercially pure titanium parts are forged on cold drop hammer dies.*

Stretch Forming—*Titanium sheet is stretch-formed on this huge machine, using electrically heated dies, at Rohr's Chula Vista plant.*

Any doubt in your mind as to titanium's versatility and adaptability for forming and fabrication? Then check these examples from Rohr Aircraft Corporation, Chula Vista, California.

Rohr is a major manufacturer of aircraft parts and airframe components. It uses Mallory-Sharon commercially pure titanium and titanium alloys for many of its forged and fabricated parts . . . takes full advantage of the material's workability, as well as its high strength-to-weight ratio, excellent corrosion resistance and high temperature properties.

May we help *you* gain more benefit from titanium's unusual capabilities? Our experienced Service Engineering group is ready to assist you. Or write for new bulletin on *Commercially Pure Titanium.*

MALLORY MS **SHARON**

MALLORY-SHARON METALS CORPORATION · NILES, OHIO

Integrated producer of Titanium • Zirconium • Special Metals

when and where

NOVEMBER

Fifth Institute on Electronics in Management, American University, Washington, D.C., Nov. 3-7.

13th Annual Symposium on Applied Spectroscopy, Hotel New Yorker, New York, Nov. 6-7.

Institute of Radio Engineers, Fifth Annual Meeting Professional Group on Nuclear Science, Villa Hotel, San Mateo, Calif., Nov. 6-7.

National Defense Transportation Association, 13th Annual Convention and Logistics Forum, Sheraton-Jefferson Hotel, St. Louis, Mo., Nov. 9-12.

School of Aviation Medicine, International Conference, Physics and Medicine of the Atmosphere and Space, Hilton Hotel, San Antonio, Texas, Nov. 10-12.

Society for Experimental Stress Analysis, 1958 Annual Meeting, Hotel Sheraton-Ten Eyck, Albany, N.Y., Nov. 12-14.

National Security Industrial Association, Symposium on Molecular Electronics, Washington, D.C., Nov. 13-14.

Conference on Scientific Information, AFOSR/Directorate of Research Communication, NAS, NSF, and the American Documentation Institute, Mayflower Hotel, Washington, D.C., Nov. 16-21.

American Society for Quality Conference, Sixth Annual Aircraft and Missile Division Conference, Biltmore Hotel, Dayton, Ohio, Nov. 17-18.

American Rocket Society, 13th Annual Meeting and Astronautical Exposition, Hotel Statler, New York, Nov. 17-21.

Eighth National Plastics Exposition, International Amphitheatre, and Plastics Conference, Hotel Morrison, Chicago, Nov. 17-21.

Northeast Electronics Research and Engineering Meeting, Mechanics Hall, Boston, Nov. 19-20.

Lockheed Missile Systems Division's Research Laboratory, Third Symposium on Magnetohydrodynamics, Palo Alto, Calif. Attendance by invitation, Nov. 21-22.

The Convertible Aircraft Congress, designing and operating missiles from unprepared sites, Franklin Institute, Philadelphia, Nov. 28.

DECEMBER

Electronic Industries Association Third Conference, Reliable Electrical Connections, Dallas, Dec. 2-4.

Eastern Joint Computer Conference and Exhibit, Bellevue-Stratford Hotel, Philadelphia, Dec. 3-5.

Man-Machine Relationships – A Changing Field for **OPERATIONS RESEARCH SPECIALISTS**

Change is in the very nature of System Development Corporation's work in man-machine relationships. This work involves two major projects:

(1) creating and conducting large-scale training programs in present and planned air defense systems;

(2) operational computer programming for SAGE

In each project, the interaction of men and complex machine systems is of prime importance.

And in each project, any change that affects air defense – a new missile, a revised strategic or tactical concept, an important technical development – requires intensive effort and cooperation by Operations Research Specialists, and an unusual combination of scientists and engineers.

In effect, specialists in many fields at SDC must react technically to all changes that directly or indirectly affect air defense. Their work – whether in Operations Research, Aerodynamics, or any other area–is shaped to a great extent by possible man-machine relationships. In this respect, SDC is unique among companies.

Operations Research Specialists, Engineers, Behavioral Scientists, and Computer Programmers whose aptitude, training and intellectual capacity enable them to work in an environment of change are invited to write. Address: R. W. Frost, 2414 Colorado Avenue Santa Monica, California, or phone collect at EXbrook 3-9411 in Santa Monica.

SDC

SYSTEM DEVELOPMENT CORPORATION
Santa Monica, California

An independent non-profit organization

11-62

. . . but it may be the most significant book you've ever read

There's a whole new way of life for you between the covers of "Opportunities Abound at Bendix Missiles" —and a three-cent stamp will bring it to you by return mail. If you have the qualifications, Bendix can offer you an enviable career in the guided missiles field, working with men who have been responsible for some of the most significant missile engineering advances of recent years.

At Bendix, you will be in a major missile program. Bendix as prime contractor has responsibility for the Talos guided missile, one of our most vital defense weapons. Using the finest equipment, you'll learn fast and grow fast, both professionally and financially. There's opportunity here—opportunity to do important, stimulating work.

You'll like living in the Middle West. The climate is pleasant and Chicago, Lake Michigan and other fine recreational areas are easily accessible. There is also opportunity locally to pursue graduate engineering studies. Mail the coupon below. The book may not be a best seller, but it has been the instrument which started many a talented engineer on a fine career in engineering.

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Road To Space Technology Success

Five months after the launching of *Sputnik* I, the Defense Department established ARPA (Advanced Research Projects Agency), and less than a year after *Sputnik* II Congress established NASA (National Aeronautics and Space Administration)—*two* space agencies.

We've said it before, and we'll say it again: Our space experts, many members of Congress, and representatives from the missile industry have watched with dismay the slow-moving space program in the United States. In view of Russia's energetic missile and rocket programs, it is almost unbelievable that the American public is allowed to remain unaware that we are not in a race with the Russians for space superiority. Perhaps the most incredible aspect of our falling behind the Reds is that we had and still have the necessary know-how and scientists to beat them.

In contrast to the 12-year-old, fully coordinated and massive Red rocket effort, America's interest in rocketry didn't even begin to assume importance until 1952. Since then, it has had more of a chaotic appearance than organization. Only a few years ago advocates of rocketry and space flight were ignored when they attempted to submit their proposals. When the Russians set up their Astronautics Commission, a proposal to do almost the same thing in this country was collecting dust on a Washington office shelf.

Astronautics will not be used solely for peaceful purposes until the world has learned to solve its problems without resort to war. An attempt to "sanitize" space would be a futile procedure and would be fraught with extreme danger for the free world. Military spacecraft offers the possibility for breaking the greatest advantage the Soviet Union possesses: the advantage of secrecy; the advantage that may one day crush the Western world in one overwhelming surprise attack. We must not deliberately blind our new-found eyes. Astronautics must be freed to pursue its own destiny, unfettered by preconceived artificial limitations of personnel, organizations, or scope. It must be headed by enthusiasts and supported with vigor by the government.

In the face of heavy partisan politics by entrenched organizations whose primary interests in space are the preservation of their own hold on the taxpayer's dollar, the end is being subordinated to the means, with disastrous consequences. When first things come last, the result is chaos and waste.

Only a unified effort can put us first in the conquest of space now. We need *one* organization with no other objectives. We didn't create a Manhattan Project to develop atomic bombs and baby buggies. Astronautics, too, is unique. It deserves a unique organization. Singleness of purpose is required. *One organization* to develop *all* space devices (because military and scientific goals must advance hand in hand) is what we must have.

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ATINGS. Impervious coatings that e graphite excellent oxidation resist-e at high temperatures—along with d abrasion resistance and adhesion racteristics—are now available from nesota Mining and Manufacturing

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DULATOR. A new vibrating reed e capacitance modulator is used to vert dc into sinusoidal ac for easy olification by Stevens-Arnold Co. ned Stevens-Arnold Vibrating Ca-itator VC-713/500, it is said to be able of measuring currents as low 10-16 amperes from a very high edance source.

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LDING BLOCKS. New transistorized ital system building blocks for both h and low frequency operation are available from Digital Equipment rp. Each unit occupies 3.25 sq. in. panel space. All types have com-ible signals, thus permitting use of h and low frequency units in one em. As many as 25 plug-in units be mounted in a single 5¼" x chassis.

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ALOG COMPUTER. The Mid-ntury MC-5800 master precision log computer includes circuit logic uired for building-block flexibility, uptability for high speed repetitive eration, bivariable function genera-n, complete automatic problem check.

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SIGNAL COMPARATOR. A precision Signal Comparator that monitors missile "readiness," and which can monitor any required number of signal channels simultaneously has been announced by Avien, Inc. The Comparator, developed by Avien for a still classified USAF weapon system, is designed for use in either airborne or ground checkout applications, and other applications where equipment readiness is indicated by a specified level of signal voltage. In addition, the unit can be readily integrated with larger systems for automated control and sequencing applications.

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CATHODE BULBS. Cathode ray bulbs made of optical quality high temperature alumina-silicate glass are now available from Corning Glass Works. Virtually free of physical imperfections, the bulbs are particularly applicable to high resolution radar surveillance systems. Alumina-silicate glass can be optically melted. Flaws can be held to .001 of an inch or less in size.

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FILTERS. A new line of Model 12680 heavy-duty in-line T filters for ground equipment use is now available from Bendix filter division. The filters are designed to achieve maximum application flexibility at minimum design cost. One basic design with an interchangeable element can be supplied with different flange sizes.

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SOLENOID VALVES. Direct solenoid-operated shear-seal valves for pressures up to 3,000 psi are now available from Barksdale Valves, Inc. Valves operate on 12, 24 or 125 volts, dc.

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COOLING FAN. Rotron's Aximax-3 fan delivers 165 CFM free delivery, when turning at 20,000 rpm, although the fan is only 2.8 in. in diameter, 2.3 in. deep and weighs 14 oz.

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MISSILE LITERATURE

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POTENTIOMETERS. Data sheet 1362 gives details of Helipot Series 5200, a new all-metal, 1-1/16 in. diameter servo-mounting potentiometer. The four-page publication includes complete specification, including environmental.
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FILTERS. ERA Electric Co. has published a new catalog sheet containing descriptive material on its new line of transistor transient filters. These units are connected at the DC input of transistorized inverters-converters, frequency changers and switching circuitry.
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MANUAL. General Electric Co. announces a third edition of its transistor manual, first introduced in 1957 to present to engineers and technicians a handy reference guide on available transistors, and how to use them.
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COMPUTERS. Electronic Associates, Inc., has published a new booklet describing in detail the analog computing equipment installed in the company's three computing centers.
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SCORING. A 28-page pamphlet on missile scoring systems is offered by Traid Corp. It illustrates many pilotless drones and optical scoring systems in action.
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ALLOY FABRICATION. A 30-page booklet entitled "Guide for Purchasing Complex and Unusual Alloy Sheet and Light Plate Fabrication" describes and illustrates the types of products and equipment produced by S. Blickman, Inc. Detailed descriptions and over 80 photographs and sketches of products and fabricating techniques make this booklet a permanent handy reference manual for management; design, development, and process engineers; and purchasing agents.
Circle No. 216 on Subscriber Service Card.

ANTENNA. A radar antenna system designed for ultra-precision tracking of the Talos missile is described in a bulletin published by Special Products Division, I-T-E Circuit Breaker Co. The four-page publication describes details of design, fabrication and testing.
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OSCILLOSCOPES. An illustrated bulle details the Industrial Products Divisi of ITT's most recently developed and 21-in. oscilloscopes built to me ure voltages and currents in the fr quency range from DC to 250 KC. T scopes provide a linearity of better th 1% over a calibrated scale 10 in. 15 in.
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AIR CONDITIONING. Latest designs missile support air conditioning equi ment are illustrated in a four-page br chure issued by C. G. Hokanson C Inc.
Circle No. 207 on Subscriber Service Ca

HOSE FITTINGS. A new catalog on Flexon Aeronautical Synthetic and Flex T hose assembly fittings has been sued by Flexonics Corp. The 15-pa booklet lists product types, and th military parts numbers.
Circle No. 208 on Subscriber Service Ca

TRANSISTORS. Prices, specificatic and design details of three Sperry tra sistor types are included in data shee
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ELECTRONIC CIRCUITS. Free b chures outlining transistorized electron circuits for the engineer and stude are available from Motorola Inc.'s Sen conductor division.
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HARDWARE. A reference manual standard electronic hardware facilitat selection and procurement by equi ment manufacturers. The 75-page boo let, prepared by Amatom Electron Hardware Co., contains photos, di grams, dimensions and sizes of mo than a hundred types of standard pa available directly from stock.
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THERMOCOUPLES. A 36-page catal shows the complete line of therm couple assemblies and pressure seali glands manufactured by Conax Co Also included are new additions, su as Conax Type C bare wire therm couple glands, Conax roll temperatu thermocouples, and other products.
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REFRACTORIES. A report that revie development of high temperature fractories for use in rockets has be released for industry by the Naval O nance Test Station. The material brin together scattered literature on refr tories that has appeared up to 1955.
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