MAY 11, 1959

Missile Flight Simulator Spins "Ball-of-Yarn"

missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS

AN AMERICAN AVIATION PUBLICATION

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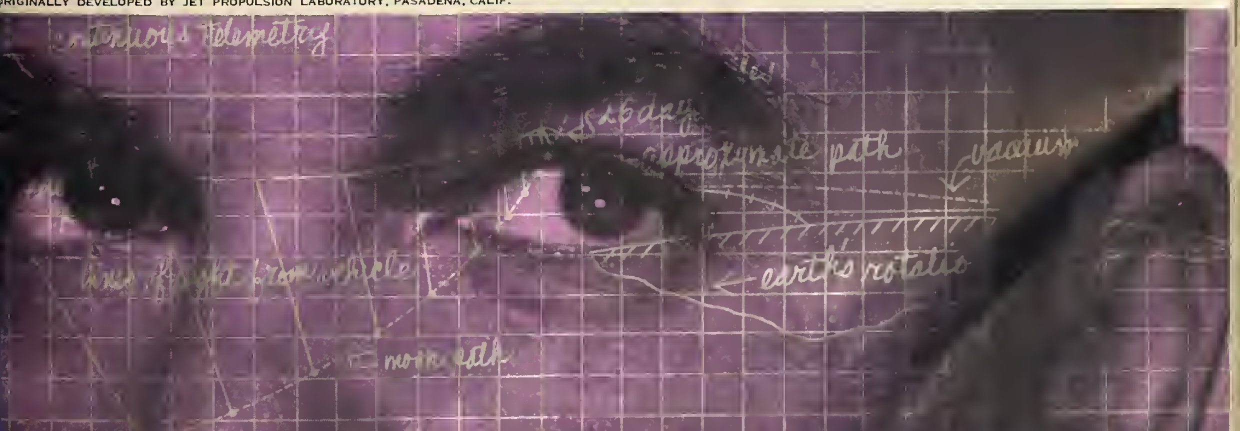

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missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS

MAY 11 HEADLINES

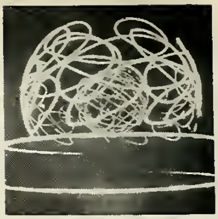
SPECIAL SECTION

ASTRONAUTICS ENGINEERING

MISSILE ELECTRONICS

THE MISSILE WEEK

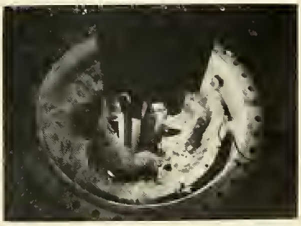
DEPARTMENTS



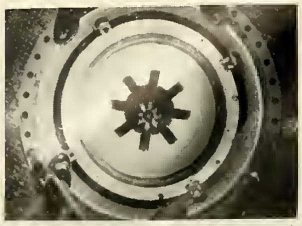
COVER: Gyrations of ballistic missile flight are re-created at Avco in a three axis flight simulator.

AMMONIUM perchlorate aluminized propellant was used in Astrodyne's Project "GO" unit which utilized XM-34 case.

SOME 45,000 pounds of thrust was produced in the 16' x 27" diameter case which had 40 times more propellant than any previous Astrodyne cast motors.



STAR-SHAPED steel mandrel, coated with Teflon to act as lubricant, is inserted in rocket case.



AP aluminized propellant made it possible to pour directly into 13-foot case without benefit of rubber liner.

Concurrency—Prime Need in Pentagon

Lt. Gen. Bernard Schriever took command of the USAF Air Research and Development Command on orders dated April 29 and the same week appeared before the Senate Space Committee and took a few healthy swings at the Defense Department's Advanced Research Projects Agency (ARPA).

Schriever, who is at least as knowledgeable on the subject of missiles and spacecraft as anyone else in the country, told Congress he had always been opposed to establishment of an operating agency on the Secretary of Defense level; that ARPA had not delayed the military space development program as of the present time, but that if ARPA continued to operate in its present fashion a delay would certainly come when the space systems were turned over to the military for operation.

He based his arguments and his logic on the established premise of "concurrency," which he explained thusly:

"A weapon system consists of much more than the hardware which is developed and tested. It also consists of the industrial base required for its production, the operational facilities for its operation and maintenance, the command communications system for its operational control, the supply and transportation system for its support, the training facilities and the instructors, and finally the people organized and trained to operate and maintain the weapon."

Military space systems require the establishment of a complete new operational environment. None of the above-mentioned weapon system elements, for instance, were in existence when work began on the *Atlas* and the *Titan* programs. Under the concept of concurrency, however, each element of the total weapon system was integrated into a single plan. Operational and training bases for both *Atlas* and *Titan* were under construction prior to the test launch of the first missile. So was the training program—and the logistic support program.

The ARPA method of operation pretty well precludes such concurrency. ARPA, conscious that its original mission was to stop the rivalry between the services, divided every military space project between the services. Army may have guidance, Navy tracking and the Air Force propulsion. Then, when the device is properly developed, it will be turned over to the service most needing, best suited, most vocal—or what not.

The trouble with that is that it will then take the service which gets the device two more years to develop the supporting elements required for its usage—the supporting elements which should have been developed concurrently.

General Schriever expressed some doubt that the ARPA system was best for the country. He is not alone in this feeling. The R&D civilian chiefs of all three services share it to a greater or lesser degree. All three of them, incidentally, have recently left or are leaving the Pentagon.

In 1958 A. Blagonravov, a member of the USSR Academy of Sciences, wrote: "It is easy to see that precisely the time element is the decisive factor which should be grasped in the competition with the capitalist countries in the field of technology."

The Rockefeller Report stated: "A nation can achieve a basic advantage if it is able either to develop or to produce weapons more rapidly than its opponents. One of the major weaknesses in our strategic posture has been our inordinately long lead-time."

And, the Von Neumann committee in recommending how to speed up the U.S. missile program said that the *pacing item* in the program would be not technology but organization, management and administrative procedures.

Somewhere in the last few years the Office of the Secretary of Defense has come to have a greater regard for procedures than for action, for form rather than result. There are too many directorates, too many committees, too many offices that exist—Heaven knows why.

Even the Joint Chiefs of Staff have fallen prey to a lethargy of indecision. More and more questions going there result in split decisions—and the matter is referred to a study group.

Maybe it is indecision, maybe it is politics. Whatever or why ever, the result is to drive a lot of good men out of the Pentagon in pure frustration and to impair speed of action when such speed is vital.

Clarke Newlon

washington countdown

IN THE PENTAGON

ARPA scientists hope to install a backstop device in *Discoverer III* to insure that its capsule bearing four black mice is ejected at the right time over the Pacific. A temporary failure of the timing device in *Discoverer II* prevented it from ejecting its mouse-less capsule at the right time last month.

• • •

Discoverer III—scheduled to be launched the end of May—will carry the four mice in the same kind of capsule used in *Discoverer II.* The Air Force also plans to use the same method to attempt recovery—C-119's equipped with trapeze nets.

• • •

This summer will see the greatest shift of Air Force general officers ever. Thirty-five will retire. The Pentagon development office (DSC/D) will be particularly affected by the changes and by the fact that the Directorate of Requirements was transferred from Development to Operations last week.

• • •

Maj. Gen. James Ferguson, who was Director of Requirements and moved with the office, will be transferred soon. Maj. Gen. Leland Stranathan, Director of Development Planning, will also be transferred. Maj. Gen. Donald J. Keirn, assistant C/S Development for Nuclear Systems, will retire. So will Brig. Gen. Don Zimmerman, assistant for Foreign Development. Maj. Gen. Ralph Swofford, assistant deputy C/S Development, is also scheduled for transfer this summer.

ON CAPITOL HILL

House Democrats appear to be adopting a strategy aimed at both eating and having the space program cake. Under the strategy, they'll just about give the Administration what it wants to spend on space—but no more. (This avoids the charge that they're spenders.) Then, if Russia makes a new sensational jump into space and a public howl goes up for action, the Democrats will be in a position to appropriate—and investigate.

• • •

The Senate Military Construction Subcommittee is certain to take up the invitation of Defense Secretary Neil McElroy to help resolve the rivalry between the Boeing *Bomarc* and Western Electric's *Nike-Hercules.* Moreover, the bets are heavy that the subcommittee headed by Sen. John Stennis (D-Miss.) will recommend that *Nike-Hercules* be curtailed in favor of *Bomarc.*

AT NASA

Space program planners are preparing for the not far distant future when the skies will be crowded with satellites. NASA has contracted to install an IBM 709 computer at the IBM-*Vanguard* Computing Center in Washington where a less advanced 704 has been computing the orbits of almost all U.S. satellites. NASA also has contracted for two even more advanced IBM 7090's—probably for use at the NASA Space Center planned for nearby Greenbelt, Md.

• • •

The NASA 704 can handle 42,000 operations a second. It could compute and predict orbits for 10 to 20 satellites simultaneously. The 709 operates three times as fast and could handle about 60 satellites. The 7090 is about five times as fast as the 709.

• • •

The current rumor that NASA Chief T. Keith Glennan will leave his post after his first year and that AF Assistant Secretary for R&D Richard E. Horner is being brought in to replace him apparently is not true. Glennan's friends say he intends to remain until the end of the Eisenhower Administration. Horner is being brought in as general manager, giving NASA the type of organization which Glennan favors and worked with when he was an AEC Commissioner.

• • •

Reason for the Venus probe cancellation was that STL tried to do too much too soon in integrating 13 major experiments into the "paddle wheel" payload of *Thor-Able III.* After *Thor-Able III* is eventually shot into its 30,000-150 mile orbit, the former Venus probes—*Thor-Able IV* and *Atlas-Able IV*—will be shot into deep space. With their improved solar cells, they will be tracked further than any previous payload (M/R April 27).

AROUND TOWN

The British are reported having trouble transporting their liquid *Blue Streak* IRBM to the Australian Woomera Missile Range for testing. Indian Prime Minister Nehru is understood to have refused to allow British planes carrying the missile to land in India on grounds it would affect Indian relations with Russia. Therefore, the British are extending the RAF field at Gan in the Maldive Islands south of India and will use it as the main staging area for missiles being flown to Australia.

industry countdown

STRUCTURES

Douglas Aircraft Company has won an Air Force contract to "design" an ALBM as exclusively reported by M/R last week. No contract figures were released. Under the contract, Douglas is to come up with a design and cost study within six months. Douglas expects to let some subcontracts in the six-month period. The Air Force chose Douglas over nearly two dozen other firms, some of which had conducted experimental test launchings.

• • •

Beef-up of Tactical Air Command is in the works as the result of hush-hush TAC R&D survey showing 17 well-placed Soviet 1-megaton warheads could knock out all NATO missile emplacements in West Germany hardened to less than 5 psi. Contract for design in a hurry of underground sites for Martin's *Mace*, now 1000-mile plus near sonic surface-to-surface nuclear missile being deployed to Germany, is in the hands of Grad, Urbahn & Seelye, A&E firm. *Mace* base concept is expected to permit multiple launching from hillside caves, plus firing from enclosures where acoustics are a primary problem. Hardening of other TAC missile launchers including all presently deployed and expected-to-be-deployed missiles may follow shortly.

• • •

First free-flight of *X-15* is now set for early July. Captive test flights will wind up next month.

• • •

Polaris program is now driving toward two goals: 1.) production of the missile to provide emergency operational capability by 1960 when first subs are ready; 2.) development of the missile for 90% reliability over long pull. Lockheed will provide technical support for assembly at Navy's Charleston, S.C., facility. Next test series for *Polaris* expected this week will be to fire it from "shaker" simulating submarine.

• • •

France now is developing a tactical ballistic missile and a 2000-mile range IRBM. Mach 2 Mirage IV will be last piloted French bomber. Pre-production model expected to use Pratt & Whitney J-75 turbojets is scheduled to fly in 1961.

PROPULSION

Ammonium perchlorate aluminized solid propellant reported to be one of the most advanced in the industry has been successfully test-fired by Astrodyne from XM-34 rocket 16 feet long and 27 inches in diameter. I_{sp} is classified, but in-house developed unit produced 45,000 pounds of thrust and contained 40 times more propellant than any previous cast motor fired by the company.

ELECTRONICS

Look for an AF announcement soon that one of the largest (about $40 million) prime R&D contracts will go to Airborne Instruments Laboratory, a division of Cuttler-Hammer. Contract will be to develop airborne recon for B-52 and future aircraft with integration into a multi-weapon system. Subs are: Aerojet-General for IR; Filtron Co. for RF; Haller, Raymond and Brown Inc. for human engineering; Raytheon for semi-automatic receiver equipment; Sperry Gyroscope for tactical support and training; Sylvania for data processing; and Temco for weapons systems integration and flight test. Winning proposal, one of four presented on team basis, covered 1400 pages and cost $500,000 to prepare.

• • •

Pointing the way for practical ion propulsion of space vehicles is Republic Aviation's operating (for more than six months) magnetic pinch plasma engine producing a significant amount of measurable thrust which observers say reaches several thousand pounds for a micro-second. Prototype engine proves out Republic's "curved nozzle" theory.

• • •

Brand new field of semiconductor materials may be opened by high-temperature, high-pressure effects research at Army Signal Corp's R&D laboratory. Although process resembles making synthetic diamonds, emphasis is on changing electrical properties of materials rather than producing new ones. So far researchers have succeeded, in producing momentary super-pressure of several million psi, believed to be the highest pressure yet achieved.

SPACE MEDICINE

In nuclear-propelled space flight, Douglas Aircraft bio-astronautic scientists propose shielding occupants from radiation with three to six feet of liquid hydrogen around control compartment. The H_2 is part of the payload, being ultimately used as a reactor after-coolant following propulsion termination.

• • •

No space suits? Dr. Hubertus Strughold believes if space ships land in the "lowlands" of Mars—3,000 to 5,000 feet below the general surface of the planet—man could survive for short periods using only a pressure-breathing oxygen mask.

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Air Force wants $343 million in FY '60 alone to harden Atlas and Titan bases . . . advent of Minuteman will swell outlay which could add up to . . .

Billions for ICBM Launching Facilities

by William E. Howard

WASHINGTON—Challenging American industry today is a completely new dimension in defense installations—the ICBM launching base.

Only a few months old, the program to arm the United States with *Atlas* and *Titan* missile complexes from which to fire a knock-out retaliatory blow at Russia already is assuming vast proportions. The scope may be far greater when the solid-fueled *Minuteman*—with its projected 2600 launch silos—comes along in two or three years.

By the end of the current fiscal year on June 30, the Air Force says it will have committed $900 million for the construction of test, training and operational phases of the ballistic missile program. For the 1960 fiscal year, the Air Force is asking $343 million to go almost exclusively into the building of "hardened" *Atlas* and *Titan* launching sites.

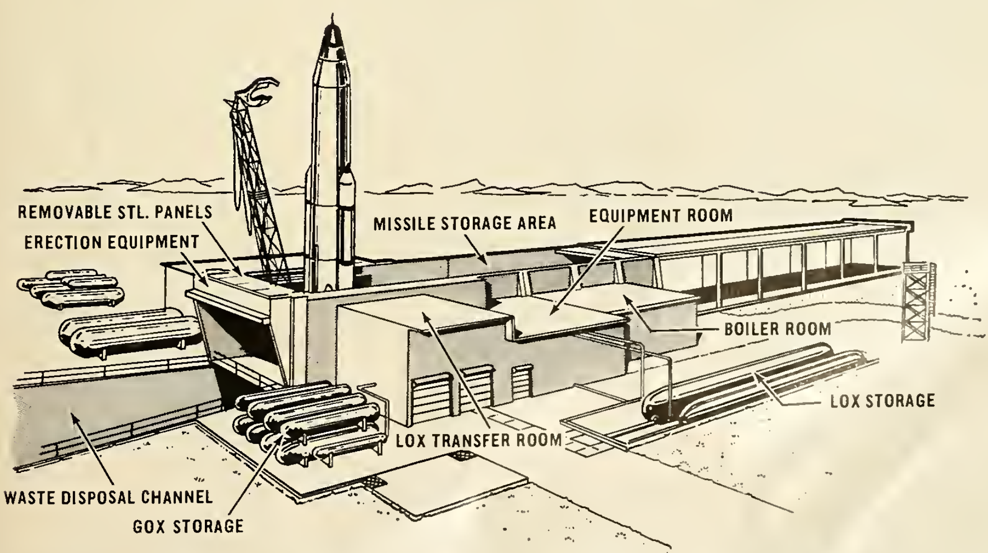
First of a Series on MISSILE SUPPORT

Future spending on facilities—which require 80% of the total investment of a missile system—is hard to project. Today's plans may be changed tomorrow by new strategic, technological or political developments. But Pentagon planners have made it plain that the ICBM is to be the backbone of the defense system and they could spend billions on facilities alone in the next few years.

As of the present, there is no apparent "master plan" for ICBM installations. As one military engineer puts it: "The program is going ahead all at once, and it's a real can of worms."

• **Comparative costs**—The overriding consideration is money, of course. With underground *Titan* bases costing about $40 million apiece, and *Atlas* about the same, defense officials are looking to *Minuteman* as a cheaper answer. Once in production the Boeing *Minuteman* is expected to cost much less than the liquid-propelled *Atlas* and *Titan*.

And, although it will have only a one-megaton warhead, *Minuteman* will



ANNEX "A" at Warren AFB, Wyo., will include six missile launch and service buildings like this one. This and three additional, similar sites in the Cheyenne area will cost a total of over $27 million.

not require a large launching complex and manpower. It is designed to be left alone in a reinforced concrete silo far from population centers and available for instant use. One of its problems, however, is development of a reliable ground environment system—which may turn out to be expensive.

There has been considerable talk among missile experts of wide dispersion of any future *Atlas* and *Titan* launching sites, which also would run up ground support costs. Another complicating factor is that Convair's *Atlas* will be operational this summer, according to former BMD commander Lt. Gen. Bernard A. Schriever. But many Air Force officials feel the Martin *Titan* will be a better missile when it is ready later next year.

Is there a possibility of adapting *Atlas* to *Titan* bases? The Air Force says it's possible, perhaps, but impractical now—though future missile modification might make it feasible.

• **Present and future**—Construction of ICBM complexes is under way now at 11 Air Force bases in the U.S. A total of 20 ICBM squadrons are programmed—11 *Titan* and 9 *Atlas*. These squadrons will have a combined capability of firing approximately 180 ICBM's in a one-shot salvo. Present construction plans do not call for reloading the launchers, which will be used only in event of nuclear war.

Conceivably, military strategists will see the need for many more to hit targets out of reach of the 1500-mile *Thor*, and *Jupiter* IRBM line in NATO countries and *Polaris*. Russia is known to be readying huge underground civil defense shelters and presumably is also digging in much of its industrial and military establishment. To knock out these targets would require bigger warheads, such as the 7-megaton wallop packed by *Titan* and 4-megaton by *Atlas*, than are carried by IRBM's.

Whatever number will be needed eventually, top officials of many of the nation's biggest companies are betting it will be large. And they are already moving or preparing to move in a big way into supplying the huge amounts of steel and concrete and the multitude of fabricated parts, electronic equipment, heavy machinery and other items which go into ICBM ground support.

Ahead of industry are some monumental engineering and development problems. Much of the present construction calls for completely underground installation—and a new breed of military personnel, "molemen," to operate it.

• **Design complications**—Each ICBM launching site must be tailored to fit the weapon it is designed for, and human occupancy as well. And complicating it all is a design requirement of the missile silo, control section, personnel quarters, power facilities, communications and computer-guidance equipment to withstand the overpressures, ground shock and radiation from a nuclear attack. For the bases are being built for up to 100 psi hardness under the concept that this country will be hit first before it strikes back.

A high Pentagon official told M/R that a key problem is "shock spectra criteria." Not enough is known about blast effects on a 90-foot missile like the *Titan*, which is put together with extremely close tolerances, or to extremely delicate electronic ground support components.

Suspension of nuclear tests, moreover, is preventing design engineers from obtaining the data. As a result, many experts feel that presently planned ICBM bases may be overdesigned. Nuclear tests last year, one official said, enabled them to cut back somewhat on the specifications for *Titan* bases. But they believe more could be done at a considerable saving in money.

Being built into bases now for personnel safety are free-floating floors and rubber mountings to absorb ground shock and complicated air filtration systems to protect "molemen" from radiation.

The Air Force Ballistic Missile Division, which is running the entire base construction program from its Los Angeles headquarters, has initiated environmental studies to obtain much-needed experience with people subjected to long periods of underground living.

The Air Force expects to utilize many off-the-shelf items developed by the Navy for submarines and ships to outfit the underground missile nests.

• **Lowry bases**—The first fully-operational *Titan* base is being constructed at Lowry AFB near Denver. Bids on a second Lowry facility will be opened May 27. Each will house one squadron of *Titans*—with nine launching silos.

Roughly comparable to putting a 10-story building underground, the first Lowry facility—composed of three complexes, each with three missile silos—will cost about $40.6 million without sensitive instrumentation equipment. The silos are dome-shaped, 163 feet deep and 40 feet in diameter.

Each complex will include a 73 x 27 foot storage silo for spare missiles; a spherically-shaped domed control center with a 39-foot ceiling and a 51-foot radius; spherical powerhouse measuring 46-feet high and having a 62-foot radius; propellant storage silo 47 x 37 feet; equipment storage silo 62 x 40 feet and two guidance antenna silos each 27 feet in diameter and 68 feet deep.

Connecting steel tunnels are provided. These include a nine-foot six-inch diameter personnel tunnel, a similar sized utility tunnel, a 12-foot diameter fuel and lox tunnel connected with six-foot six-inch diameter offset tunnels to each missile silo and nine-foot six-inch diameter exhaust tunnel structures as well as a five-foot diameter ventilation tunnel to blast locks.

The bird will be assembled on the silo elevator, motors first. At instrumentation sections there will be openings in the silos for test and checkout. To fire, *Titan* will be raised to the surface, and doors will close automatically over the silo opening. Simultaneously, the six antennas will also be elevated to the surface.

Design and fabrication of the silo elevator and missile handling equipment is by American Machine and Foundry under BMD contracts totalling $43 million. Western Electric, which has the guidance contract for *Titan*, and Aerojet-General, the powerplant, are overseeing the design of their own antenna and fuel installations.

The architectural design and engineering of *Titan* bases is divided between two firms—Daniel, Mann, Johnson & Mendenhall and Ralph M. Parsons Co. These firms are also doing the A&E for *Minuteman* bases.

• **Vandenberg specs**—A conception of the overall materiel requirements is contained in contract specifications issued by the Army Corps of Engineers for building three training silos at Vandenberg AFB. They call for excavation and subgrade preparation of 80,000 cubic yards of earth; 475 tons of steel ring beams and rods for bracing and shoring shaft excavations; 1691 feet of 10-foot steel tubing for tunnels nearly 4000 feet of steel waterline for the fire water-control system; another 2000 feet of galvanized steel pipe for the domestic water supply; 2084 feet of sewer pipe; 3534 feet of perimeter fencing, and a number of valves, complete electrical control and distribution systems, blast locks and manholes.

Requirements for paving include 8530 square yards of various types of concrete and 797 tons of bituminous and asphalt topping and cement.

Cost of this work alone will run to nearly $7 million and it is expected to take 540 days to complete. Ground was broken in March.

Other *Titan* installations are being built at Ellsworth, S.D., and Mountain Home, Idaho.

The first operational *Atlas* will be deployed at Vandenberg AFB.

Construction is starting this spring on *Atlas* bases at Offutt AFB, Neb., which is SAC headquarters, and Fairchild AFB, Wash. Digging will begin this summer at Forbes AFB, Kan

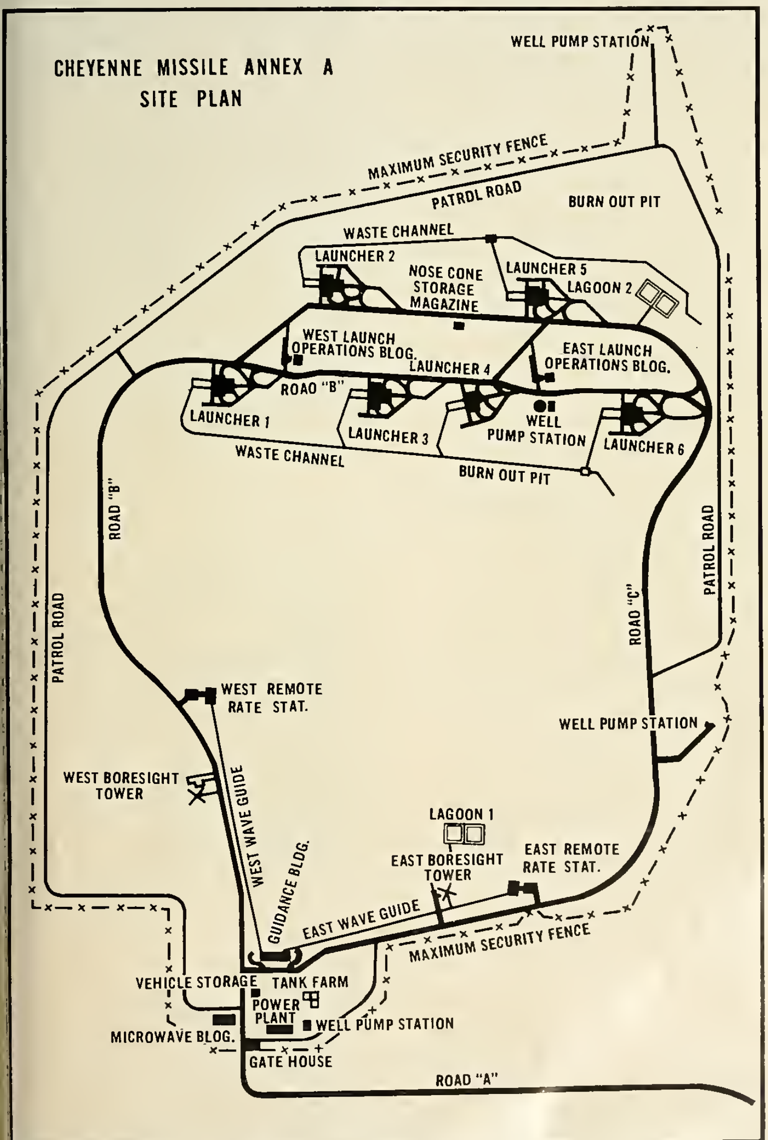
Other *Atlas* installations are planned at Schilling AFB, Kan., and Lincoln, Neb.

The two at Fairchild and Forbes will be "hard" bases.

• **A "soft" base**—Construction is nearly complete at the first "soft" *Atlas* site at Warren AFB, Wyo. Here there are four launching "annexes" located at an 18-mile radius from the four corners of Cheyenne. Annex "A"—to be ready this fall—has six launchers; the other three annexes will each have three launchers. Total cost: over $27 million.

Although above ground, the Warren facilities are being constructed of reinforced concrete and steel, enabling them to withstand considerable overpressure. The missile is housed and serviced in a horizontal "coffin" type structure, which has a mobile roof to allow the missile to be erected on a launch pad for firing.

Annex "A" is comprised of six missile launch and service buildings, each 103 x 133 feet, two blockhouse operations buildings measuring each 73 x 78 feet and a 75 x 212 foot guidance building. Pre-stressed concrete panels up to 36½ feet long go into the roof and part of the floor of the guidance building. Included in this facility are two boresight towers and two remote rate stations situated about 1300 feet east and north of the building. They are connected to the facility by wave-guide enclosures.



FIRST "SOFT" ***Atlas*** **site will actually be built with heavy amounts of reinforced concrete and steel. Some pre-stressed concrete panels will be 36½ feet long.**

Design of the three other annexes is almost the same, with each site having half the amount of facilities of Annex "A".

The Corps of Engineers gives this rundown on materiel employed to build Annex "A": structural steel—1140 tons; reinforcing steel—1950 tons; mechanical steel items—8040 tons; electrical—1430 tons; concrete blocks and pre-stressed members—4350 tons; cement—6300 tons; concrete aggregate—37,460 tons; road aggregate—66,120 tons; asphalt—800 tons; miscellaneous wire, lumber, nails etc.—1260 tons. Total—128,850 tons.

Tanks to store oxygen, nitrogen and helium are located outside the building and above ground. In all there are 192 tanks in sizes up to 28,000 gallons. Fueling system has pressure capacity up to 15,000 psi and is of heavy stainless steel.

A&E for *Atlas* sites is under contract to Bechtel Corp., Stearns and Rogers, Holmes and Narver and Black and Beatch. Bechtel has the design for installations at Forbes, Fairchild and Lincoln. Stearns and Rogers has Schilling and Lincoln; Holmes and Narver—Warren and Black and Beatch—Offutt.

• **Jurisdiction**—All of the responsibility for design and construction of ICBM base facilities comes under the installations section of the BMD. This section establishes the technical criteria for the A&E firms and monitors their work.

The Corps of Engineers takes over as the constructing agency. At Warren AFB, for example, the work comes under the jurisdiction of the Omaha District Engineer and the Missouri River Division. Competitive bid prime construction contracts are let by the district engineer for major facilities, on authority issued by the Los Angeles District Corps of Engineers, which is working directly with BMD. Supervision of construction and coordination of the paperwork falls on the Cheyenne area engineer. BMD also maintains an on-site field office. On completion, the base is handed over to SAC.

Heading up the operational end is the 1st Missile Division. Last January the 706th Strategic Missile Wing (*Atlas*) and the 703rd Strategic Missile Wing were integrated with the 15th Air Force. The 706th SMW will have two squadrons at Warren, and the 703rd SMW is at Lowry.

Training of missilemen is underway at Vandenberg by the 704th SMW, and the 704th Instrumentation Squadron, the 394th Missile Training Squadron and the 576th Strategic Missile Squadron.

Also under construction is a missile targeting center at SAC's Offutt AFB.

This will be operated by SAC's directorate of intelligence. The Air Force says the center will supply all SAC missile bases with trajectory data. Systems to be used include paper tapes with pre-cut targets, enabling base crews to feed guidance information into the missile system "in a matter of minutes."

• **No lagging**—Historically, facilities have frequently lagged behind the development of weapon systems. The ICBM program has been a marked departure. Gen. Schriever, commenting recently on the lead-time requirement of 18 months to construct an ICBM base, said "we haven't the time to perfect the missile and then build. We have had to do it simultaneously."

So far the base-building program appears to meeting the missile development deadline. But the picture could change, quickly, with a sudden menacing move by Russia.

If top planners abruptly decide many more ICBM's are needed, construction will have to be shoved onto a "crash" basis. A high official in the Corps of Engineers told M/R that it might be possible to build bases within six months "going all-out." The present program is taking up only 3% of the construction industry's capability; thus there is a large untapped potential.

Congress is still up in the air as to how much more funds it wants to pump into the ICBM program, over and above the amount requested in President Eisenhower's budget. It is almost a sure bet, however, that lawmakers will increase the figure substantially.

• **More questions**—Aside from money uncertainties, there are other headaches confronting missile base builders. What is the ceiling on destructive capacity? Will the present and programmed nuclear capability of the U.S. be so great when exploded with Russia's in a war that the globe would become uninhabitable afterward? At what point does building more hydrogen weapons become academic?

Air Force officials, too, are conceding in private that public relations problems are looming in connection with ICBM locations. Every new site becomes another Soviet target—and with it the surrounding civilians.

This has inspired some studies on the feasibility of dispersing the launchers over much wider areas. And in the case of *Minuteman* thought is being given to making their launching equipment mobile. They could, for example, be moved from place to place on barges towed along rivers or be fired from railroad flat cars.

Next week: Requirements for Establishing an Equatorial Launch Site

RCA Demonstrates Solar Cell Using Gallium Arsenide

Company also shows new 'tunnel' diode and rectifier, calls development of vital importance

PRINCETON, N.J.—A new match-size solar cell which uses a high-temperature compound called gallium arsenide to transform light into heat has been developed by RCA scientists, who say it holds great promise for use in space vehicles.

A solar battery built around the novel cell, and a radio system using a new high-temperature diode of the same material, were demonstrated for the first time last week by the RCA Semiconductor and Materials Division at the National Aeronautical Electronics Conference in Dayton, Ohio.

The battery was shown powering a miniature radio transmitter of a model satellite which uses a gallium arsenide "tunnel" diode.

The RCA exhibit at the conference was assembled to show military personnel and engineers the progress made by the firm's investigation of new compound semiconductor materials which can operate at high temperatures up to 750°F, without appreciable loss in operating efficiency.

Beside the solar battery and radio system, the exhibit included new gallium arsenide rectifier diodes—the first high-temperature devices, according to RCA scientists, which compete electrically with diodes made from conventional semiconductors such as germanium or silicon.

The research leading to the new units was performed at RCA's David Sarnoff Research Center at Princeton. The gallium arsenide devices shipped to the Dayton conference were developed by Paul Rappaport, Joseph Loferski and Dietrich Jenny, members of the RCA Laboratories technical staff.

The solar battery was developed under sponsorship of the U.S. Army Signal Corps. The high-temperature diodes were developed at the laboratories under sponsorship of U.S. Air Force Electronic Components Laboratory, Wright Air Development Center, Dayton. The rectifier diodes are the result of a contract with the Air Force's Manufacturing Methods Division of the Air Materiel Command.

• **Potential**—According to RCA scientists the match-size solar cell, the basic element of the solar battery, promises to be extremely useful in powering electronic equipment in satellites, missiles, high-speed jet aircraft and other space vehicles. It is expected that gallium arsenide solar cells will give higher efficiency than the silicon solar cells now aloft in a number of America's satellites.

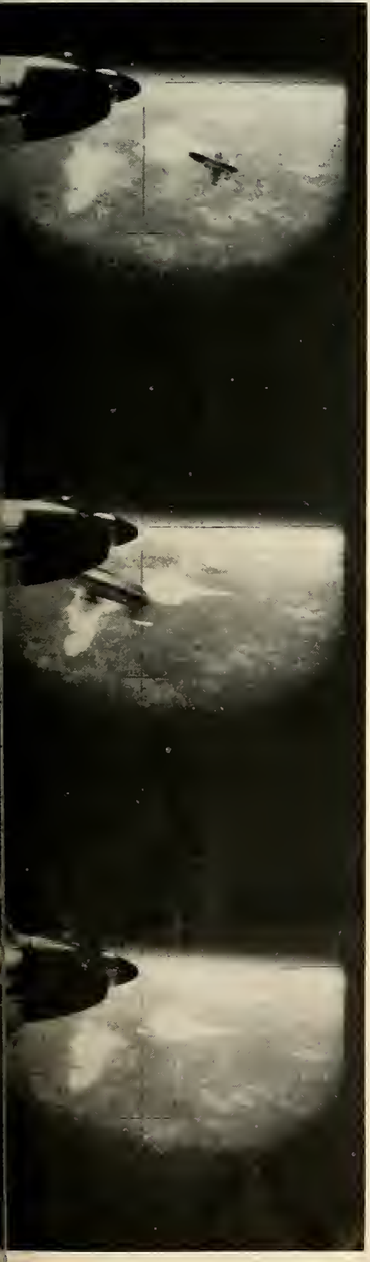
When light is focused on the surfaces of the solar cells, electricity is generated and fed to the transmitter. The transmitter consists of a coil, a capacitor and a new electron device, the "tunnel" diode, which is also made of gallium arsenide. Signals from the transmitter within the model satellite are picked up on a nearby radio receiver in the display.

The development of gallium arsenide devices is of vital importance to the electronics industry, according to Dr. Alan M. Glover, Vice President and General Manager, RCA Semiconductor and Materials Division.

"The new solar cell promises higher efficiency over a wider temperature range than present cells using other materials now available," he said. "The voltage output of the gallium arsenide cell matches the voltage requirements of the newly-developed 'tunnel' diode which operates the transmitter in the model satellite.

"The 'tunnel' diode is itself the industry's first gallium arsenide device to generate high-frequency radio signals. It promises great simplicity in circuit design, high reliability, high frequency operation and operation over a very wide temperature range. Furthermore, the diode's bi-stable characteristic makes it particularly suitable for use in electronic computers."

- ***Progress on 24-channel time multiplex system***
- ***No decision yet on a British spaceflight programme***
- ***Blue Steel readied for test at Woomera***



by **G. V. E. Thompson**

LONDON—The British Institute of Radio Engineers recently held a one-day symposium on radio telemetry. Most of the papers dealt with the 24-channel time multiplex system, in which up to 24 signals are selected in turn and transmitted over the radio link. This system has been chosen for missile work, in preference to frequency multiplexing or pulse systems, by the Royal Aircraft Establishment (responsible for guided weapons R&D of the U.K. Ministry of Supply).

The missile-borne telemetry equipment must withstand temperature ranges of –40°C to +85°C, pressures of the order of 35 mm mercury, vibration levels of 50g in the frequency spectrum 10 cps to 7 kc/sec and 50g shock loads. It must be immune to fungus and salt spray. To meet these requirements, various modifications had to be made to the prototype after environmental testing. A transmitter is now in production by E.M.I. Electronics Ltd.

A series of 24-channel receiving and recording systems have been commissioned from electronic firms by the RAE. The most recent—manufactured by McMichael Radio—is compact, incorporates improvements to facilitate operational use, and is completely mobile.

The Guided Weapons Engineering Department of the Bristol Aircraft Co. have developed a frequency multiplex f.m./a.m. system which transmits six channels of bandwidths such that frequencies in the range 10 cps to 10kc/-sec can be telemetered simultaneously. With commutated reference levels, the frequency coverage can be extended to include the band 0-10 cps. There have been only four failures in several years' firing of pilotless test vehicles, involving 600 units—a performance attributed to the fact that only a few components in the main transmitter are common to all channels.

DIRECT HIT is scored by a Bristol/-Ferranti *Bloodhound* launched in trial at Woomera Range. The surface-to-air bird is already in RAF service.

In addition to recorders and test sets for the 24-channel time multiplex system, the firm J. Langham Thompson has produced a 20-channel, 600 mc/sec-pulse telemetry system. Using pulse position modulation, it is designed to handle information containing transients of the order of 1 msec from guidance equipment.

• **Still no programme**—No decision has yet been reached by the government on whether to establish a British spaceflight programme. Such a programme would be welcomed by the aircraft industry, which faces lean times as a result of changes in defense policy and the pattern of civil aviation.

It is estimated that two years from now the number of people engaged in the U.K. aviation and missiles industries will be 100,000 less (a reduction of 40%). A spaceflight programme would help to prevent this. However, economists and politicians are doubtful whether national resources are sufficient to support such a programme in addition to the other large technical projects in hand.

At a conference organized by the Institution of Production Engineers, Peter G. Masefield, Managing Director of Bristol Aircraft and President-Elect of the Royal Aeronautical Society, said: "Regrettably, perhaps, the financial ticket is the passport to success or failure. The millions which are being poured into aeronautics and astronautics by the United States and the U.S.S.R. cannot be matched except by adequate funds to compete in *selected* fields. How limited these fields should be is the biggest policy issue of all."

• *Blue Steel* **air-to-ground missile**—First full-scale firing of the Avro *Blue Steel* aerial torpedo is expected to take place soon on the Woomera rocket range in Australia. Details of the design of the missile are still secret but it is known that it is intended to be launched from bombers flying at around 60,000 ft at a distance of over 100 miles from the target.

Successful stage separation of *Titan* was reported by the AF in May 4 firing. Second stage was freed by ignition of two small solid-fueled rockets. Test was prelude to second stage ignition test of the 90-foot vehicle.

Slow contract negotiations, say West Coast missile makers, are making conduct of business with DOD tougher all the time. Example: in the past negotiations took 60 days for continuing development contracts; last year they ran to 11 weeks and this year they are starting later, probably in July, and are expected to last 15 weeks. This runs up overhead costs.

In Paris, France's rocket-making M.A.T.R.A. Co. is reported exporting 10% to 12% of its 511 air-to-air missiles to countries like India and Israel which use French-made fighter planes.

Missile-borne MASER amplifier is now under development at the Army Signal Corps R&D laboratory at Fort Monmouth. Feasibility has been proved, but future development may be limited by present state-of-the-art. Need is to eliminate pumps, among other problems. One MASER, greatly reduced in size, has operated continuously for days.

National Bureau of Standards analysis shows last summer's nighttime high-altitude nuclear bomb explosions ionized the upper atmosphere to near daytime intensity. The resulting electric current flows temporarily altered the earth's magnetic field. Significance of the observations is that man may some day control the ionsphere and radio communications—a vital factor in wartime.

AIA in its new edition of "Aviation Facts and Figures" reports the earnings of the 12 major aircraft and missile manufacturers decreased during 1958, despite record sales. Dollar volume for the 12 totalled $7.2 billion—up 5% from 1957. Aggregate earnings after a tax bite of $153 million were $142 million, or 2%. The 1957 earnings were 2.4%. AIA points out that the average earning rate for all other industries is about 6%.

Mergers & Expansions: Radiation Inc. of Melbourne, Fla., has merged with Levinthal Electronic Products Inc. of Palo Alto, Calif. Another cross-country combination is the Laboratory for Electronics at Boston and Servomechanisms Inc. of Los Angeles. Fansteel Metallurgical Corp. is building a 20,000-square foot plant at North Chicago with a daily capacity of 30,000 silicon rectifiers. A new 50,000-square foot facility is going up at Moorestown, N.J., for Philadelphia Insulated Wire Co. In the Boston area, Clevite Corp. of Cleveland is erecting a $3 million transistor and diode manufacturing plant. Space Electronics Corp. of Glendale has formed an exploratory development department—to develop advanced concepts for technical proposals and R&D in areas of applied physics.

Products: Latrobe Steel Co. has a new vacuum arc melting furnace to produce highly refined tool steels and superalloys. Improved version of its transonic jet-drone *Q-2C Firebee,* Ryan Aeronautical reports, recently hit a new altitude of 59,000 feet. Maximum speed was Mach .95.

Contract for *Pogo-Hi* II E3C Target Missile system has been received by Aeronca Mfg. Corp. for delivery by June 27 to the AOMC White Sands Missile Range. *Pogo-Hi* has Thiokol solid motor and is used to test *Nike-Hercules, Talos, Sidewinder* and *Falcon* at altitudes up to 80,000 feet.

Urgent need for miniaturized electronic equipment to obtain physiological data in early stages of *Mercury* man-in-space program will be underlined at a Franklin Institute, Philadelphia, symposium May 18. Discussions will center around transducer and television applications of bioastronautics.

Boeing Airplane Co., in an effort to expand dealings with small business, now has a policy instructing its buyers to indicate with each order the reason for placing it. If it is not a small firm, buyers must say why.

Anaconda Wire & Cable Co. has purchased Sequoia Wire and Cable from Mandrel Industries Inc. New subsidiary will make small wires for use in missiles, aircraft and electronic controls.

Britain's Royal Air Force is ordering an improved version of the ground-to-air *Bloodhound* produced by Bristol/-Ferranti. New system is reported to have "substantially" increased operating range and altitude over earlier models.

Financial notes: Texas Instruments President Patrick E. Haggerty expects company sales to hit between $185 million and $200 million in 1959 with earnings of about $13 million—more than double the 1958 figure. On the downside, Chance Vought Aircraft reports first quarter sales of $66 million and net of $1.5 million compared to the same quarter in 1958 when sales were $78 million and the net $2.3 million. C-V's backlog as of March 31 was $330 million. On the same date a year ago unfilled orders totaled $595 million. First quarter earnings of the Martin Co. of $3 million are up from the $1.6 million net of a year ago. Sales during the period were $122 million—an increase of 27% over the $96 million in sales of the like 1958 period.

A $6 million LOX, liquid nitrogen and liquid argon plant is being built by Air Products Inc. at Glassmere, Pa. First production is scheduled this fall.

First *Vega* contract for $33.5 million has been awarded by NASA to Convair. Test flights of the three-stage vehicle (*Atlas, Vanguard* booster and new JPL rocket) are scheduled late next year. NASA, which ultimately may spend $76 million on *Vega,* plans to use it to put a manned satellite into orbit and to make instrumented lunar and planetary probes.

Seven firms are in the competition for subcontracting elements of the Boeing *Minuteman* airborne telemetry test equipment. They include Consolidated Electrodynamics, Texas Instruments and Radiation Inc. Selection of the subcontractor will be made late in the summer.

SAC troops successfully fired a second *Snark* May 5 from Cape Canaveral 5000 miles down the Atlantic test range. Flight time was 8 hours and 45 minutes.

Pursuing its diversification program, Lockheed Aircraft discloses it is exploring a possible merger with Lear Inc.

AUNCH of Type 422 GAM missile.

Air-to-Air and Ground-to-Air Missiles

The M.A.T.R.A. Company, a French firm which specializes in the manufacture of rocket launchers and missiles, employs about 1200 in five plants. Two are in Paris (one is for airframes and another plant is for prototypes). Others are Boulogne-sur-Seine, a suburb of Paris (laboratories, tests, mechanics), Salbris (production line of rocket launchers) and Courbevoie, near Paris (laboratories, wind tunnel).

The main production of M.A.T.R.A. now consists of rocket launchers, but the type *422* ground-to-air and the *511* air-to-air missile (shown in these photographs) seem assured of a good future. They are being ordered in quantities to equip the next generation of French fighters. Ten to 12 percent of the M.A.T.R.A. production is now exported, particularly in such countries as India or Israel which use French-made fighters.

THE Vautour weapon system includes this massive array of rocketry.

YPE 422 missile on semi-trailer.

TYPE 511 slung under wing of Canberra.

ARCON and *ARCAS* Renew Interest In End-Burning Rockets

Descendants of earlier JATO's offer high-burning rates and flexibility and may provide cheap rockets for weathermen

by Michael Lorenzo*

WASHINGTON—The state of the art of solid propellant rocketry has been enhanced by recently-released novel design information on end-burning *ARCON* and *ARCAS* type rocket motors—a concept which could be likened to a burning cigarette.

These are technological derivatives of earlier vintage end-burning asphalt composite JATO's. They utilize conventional solid propellants in much the same way as do the familiar star and other hollow grain configurations.

Since all of the volume in the rocket case is used to house propellant and inhibitor, the resulting propellant mass fraction can be made high—taking advantage of the natural log function of the structural efficiency parameter of the ballistic missile range equation. Specific impulse and characteristic velocity figures obtained in development thus far are comparable to other members of the SPR family.

The comparatively smaller diameter of an equivalent mass end-burner design helps to facilitate aircraft installation in the case of JATO applications and lessens bulk in missiles. This smaller cross-sectional SPR design should create less drag in most applications—an airborne installation being more sensitive than a ballistic vehicle.

• **High burning rates**—An approximate value of 52.5 inches can be derived for the *ARCAS* rocket-motor length by differences in the accompanying table of design characteristics. The length of the grain can be estimated at 47 inches. Similarly, the *ARCON* rocket-motor and grain lengths are estimated to be 102.6 and 96 inches, respectively.

These end-burning grain lengths when considered with their burning times give corresponding values of 1.9 and 2.9 inches per second as burning rates. These values are considerably higher than those encountered in hollow grain solid propellants and, if correctly deduced, would obviously represent the basis for the current renewed interest in end-burning rockets.

• **Flexibility**—Paradoxically, published textbooks on rocket propulsion describe solid-charge end-burners as *restricted* burning types and hollow charges as *unrestricted* burning types. After taking note of the aforementioned burning rates of the *ARCAS* and *ARCON* motors, the nomenclature *restricted* probably should be changed to *adjustable* or *flexible.*

The end-burning design is innately flexible in that adjustments to achieve specific burning times, corresponding altitudes and/or ranges can be accomplished by simply cutting the length of a standard motor to a required size.

• **Development**—The *ARCAS* meteorological rocket is being devel oped for the Geophysics Branch of th Office of Naval Research by the Atlar tic Research Corporation, Alexandria Va. The Aerology Division of th Navy Bureau of Aeronautics and th Air Force Cambridge Research Cente also are supporting this project whic is headed up by Lt. Cmdr. "Sam Houston of the Office of Naval Re search.

On Jan. 27, the Army's Signal Mis sile Support Agency successfully fire this rocket to an altitude of 179,20 feet at White Sands, N.M. Col. Joh McGovern, commanding officer of th Agency, announced that this low-cos meteorological rocket system can b completely assembled and launched b a two-man crew within two hours. Th closed-breech launcher consists of fiv major parts weighing a total of 39 pounds. It stands 11 feet 8 inches hig and imparts a 100 fps exit velocity.

ARCAS (All-purpose Rocket fc Collecting Atmospheric Soundings eventually will be made of finely-spu glass fibers so that it may be fired b meteorological personnel over popu lated areas and exploded to fragmen after it has gathered needed data.

ARCAS now joins a family of a mospheric data-collecting rockets ii cluding *Loki, Nike-Cajun,* and *Aer bee-Hawk.* It will be developed to carr payload weights of approximately 12. pounds (rocket total weight is 7 pounds) as high as 206,000 feet. Th *Iris,* designed to carry 100 pounds 20 miles high, is in advanced developmen at Atlantic Research and completio is anticipated early next year.

Rocket vehicles used by meteorolo gists in the past have been expensiv heavy, bulky and complicated affair converted from military missiles wit high acceleration rates which damage the data-seeking instrumentation. Cos

DESIGN CHARACTERISTICS

	ARCAS	ARCON
Overall length	92.3 in.	133.8 in.
Diameter	4.45 in.	......
Instrument section (nose cone) length	18.1 in.	31.2 in.
Parachute section length	13.4 in.	......
Separation device length	2.7 in. (approx.)	......
Payload	12.5 lbs.	......
Gross weight	77 lbs.	......
Burnout weight	36 lbs.	......
Thrust	390 lbs.	......
Burning time	25 sec.	......
Propellant	ARCITE 373	......

* *Contributing Editor to M/R and Advisor to Air Force on Propulsion*

-bade routine us of them for gather- ; weather data.

ARCAS, developed from the draw- ; board as a pure meteorological :ket, seems to be an answer. It can fired almost as easily as a mortar ell, provided close supervision is car- d out by personnel experienced in :ket trajectory calculations.

These *ARCASes* fired by SMSA iy be forerunners of inexpensive istic rockets that meteorologists will : daily to provide much needed :urate weather forecasts.

The prima facie pros and cons of id-propellant end-burning grains ap- ar as follows:

• **Advantages**—1. The entire rocket se volume, with the exception of a ripheral volume occupied by insula- n and inhibitor, is utilized for pro- llant loading.

2. Problems of burning in a cavity, ., resonance and erosive burning, are eliminated.

3. Desirable aerodynamic shapes, i.e., high length-to-diameter ratios, may be achieved in long-duration applications. The length of an existing standard rocket can be readily adjusted to attain desired total burning time and resulting range and/or altitude.

4. In sounding-rocket applications, increased burning times permit conservation of fuel during low-altitude operation for more effective use in the thinner air above.

5. The simple geometrical shape of thc grain reduces processing problems, relieves the demand for excellence of physical proprties which may conflict with the attainment of high performance, and gives rugged, shock-resistant grains.

• **Disadvantages**—1. Insulation is usually required to protect the motor case from the combustion gases as the burning surface recedes; however, insulation can be tapered toward the head end, and the relative volume occupied by insulation decreases with increasing motor diameter.

2. The center of gravity of the rocket shifts during burning; although the net shift is the same for end-burning and internal-burning grains, the mean location of the center of gravity of an end burner is forward of the mean center of gravity in a central-perforated system.

Some "imagineer" undoubtedly will see another seemingly innate advantage of end-burner designs by adopting an autophagia (from the Greek word "autophagos" meaning self-devouring) combustion principle. This certainly should enhance the state of the art of increasing the propellant mass fraction and resulting performance. After all, the chemist is well on the way to reaching the physical limit of releasing chemical molecular bond energy.

GHTNESS and ease of handling for *:as*, 72-pound research rocket is design uirement.

O' TAKE-OFF from Wallops Island, d-burning *Arcon* has high acceleration.

New Theory Advanced for Hydraulic Failures

WASHINGTON—The failure of missile hydraulic and liquid fuel systems may be caused by the same sort of stress which causes strokes in humans, according to a theory advanced at the American Physical Society meeting.

The theory was described in a paper presented by Harry Lobel, an electrical engineer who has done extensive private investigation into the application of electrical analogs to fluid flow and the human circulatory system.

Lobel has applied his studies to the design of hydraulic fittings patterned after arterial bifurcations which compensate for surges and stresses which may lead to failure.

Ideally, such junction fittings would be designed to change configuration automatically in response to varying stress conditions caused by turbulence, vibration, and cavitation. Lobel feels, however, that a non-variable fitting could be developed to compensate for a relatively wide range of variations.

Free-rotor Gyroscope Developed by Autonetics

LOS ANGELES—Inertial guidance platforms may be considerably simplified and made more stable by the use of a "free-rotor" gyroscope developed by North American's Autonetics Division.

Only two of these gyros are needed to stabilize an inertial reference platform whereas at least three conventional single-axis gyros are now used. In addition, a simple second-order type servo system will suffice, with inherently more stable characteristics and less complicated electronic circuitry.

The rotor is supported and turns in a spherical gas-lubricated bearing—with practically no friction and wear. The overall mechanical assembly is less complex and reportedly there is no need for gimbaling and liquid flotation of the rotor assembly.

The spherical bearing must be manufactured to extremely close tolerances. However, the minimum number of parts and the long life predicted for the gas bearing should lead to a considerable gain in reliability. A prototype bearing has been operating continuously at Autonetics for seven years.

Telemetering Conference

"Investigation of Space" will be the theme of this year's National Telemetering Conference at Denver, May 25-27. Papers and panels of telemetry experts from over the nation will discuss progress of telemetry and its important role in space exploration.

The conference, jointly sponsored by ARS, AIEE, IAS, and ISA, will be chaired by Max Lowy of Data Control Systems, Inc. Alan P. Gruer, of Sandia, is program chairman.

Some sessions scheduled and their respective chairmen, include:

Critique and Comparison of Various Telemetry Systems for Space Instrumentation, John Eckhart, Sandia Corp; Telemetry System Integrity, W. M. Koellish, Martin-Denver;

Miniaturization and Transistorization Progress, C. E. Ruckstuhl, Bendix;

Ground Stations - Techniques and New Components, K. A. Hall, STL;

Space Medicine Problems Probed by AMA

by Frank G. McGuire

Los Angeles—The 30th annual meeting of the Aerospace Medical Association here opened a Pandora's Box of radiation, weightlessness, psychological disturbances, physiological hazards and inter-agency bickering to be faced by the first astronauts.

Along with these, it brought out some interesting solutions to several problems, including hibernation to ease extremely long, boring space flights; severing of certain nerves in the inner ear to avoid motion sickness in space; and assuming a fetal position to present a smaller target for intense radiation. No simple solution for the inter-agency fights was forthcoming.

Some highlights of the conference:

• Dr. Hubertus Strughold, Air Force space medicine chief who is also an M/R contributing editor, said man may be able to operate in the Martian lowlands with no more elaborate equipment than an oxygen mask, and that man may be unable to survive the 100°C heat on Venus.

• The possibility that man may be able to venture into deep space for only three years out of every eleven was voiced by Dr. Hermann J. Schaefer of the Navy's School of Aviation Medicine at Pensacola.

• The technique of spinning a satellite to provide an artificial gravity for the occupants may give rise to a motion sickness so severe that the astronauts might be much happier in a weightless state, according to Dr. Ashton Graybiel, also of the Navy's School of Aviation Medicine.

• A lone man on a protracted mission into space might soon find himself completely detached from his own personality and convinced that he can't possibly be that silly fool sitting in a space ship and going nowhere. Lt. Col. Jerrold L. Wheaton, USAF neuropsychiatrist, added, however, that a properly selected individual might be trained enough to circumvent this situation.

• The problem of weightlessness compounds, according to Dr. Harald von Beckh of Holloman AFB, when the subject suddenly awakens and finds himself in this state, contrasted to the ease with which he adapts to it when fully expecting it.

• **Space-suit-less?**—Dr. Strughold told a press conference at the meeting that Mars has certain lowlands with an atmospheric pressure equivalent to 45,000 feet in the earth's atmosphere. This would allow, he said, the wearing of heavy clothing and an oxygen mask. The climate there is about like that of the Pamir Plateau in the USSR. Other areas of the Red Planet, with higher elevations, have pressures equivalent to about 55,000 feet, and will probably require a pressure suit.

On Venus, Strughold said, there is a great amount of CO_2 in the atmosphere, resulting in a high heat-absorption that makes a "greenhouse effect." The surface temperature of the planet may thus be as high as 100°C, preventing manned exploration.

• **Radiation**—The data obtained from *Pioneer III* was not borne out by *Pioneer IV*, said Dr. Hermann J. Schaefer, and it now appears that the radiation intensities near earth are as much as ten times that predicted by van Allen. The inner belt particles have much higher penetrating power, he said, and the shielding problem here may be hopeless.

There is a possibility, however, that the situation as shown by *Pioneer IV* is only a temporary one resulting from a solar flare that occurred a few days before the launching. In this case, it is likely that a manned space ship caught in a burst of radiation from a solar flare would be doomed. The radiation intensity could easily increase one-thousand-fold in fifteen minutes with no warning.

The use of polar exits from the earth's vicinity could solve the problem, he said, but there is reluctance to use this method because of the greatly complicated navigation problem. If the worst indications of *Pioneer IV* data are confirmed by future findings, it may be possible for man to leave the earth's vicinity beyond 1000 km for only the three inactive years of the eleven-year solar cycle.

• **Motion sickness**—The astronaut riding in a rotating satellite in orbit may be content to let weightlessness take its course rather than suffer the miseries of motion sickness under artificial gravity. This opinion from Dr. Ashton Graybiel came after experiments had shown that persons who do not keep their heads perfectly fixed while rotating become violently sick.

Head movement during rotation causes angular acceleration in the semicircular canal of the inner ear in a different plane than that being maintained by the rotating satellite. While it is possible to use drugs to offset this condition, it is more desirable to cut the nerves leading to the semicircular canal. Severence of these nerves is not difficult, he said, and it does not impair the hearing.

• **Extreme boredom**—Behaviora and emotional problems in space ar not easy to predict accurately, becaus of the difficulty in reproducing cond tions there. Any subject undergoin psychological tests in an isolatio chamber, etc., is fully aware that a though he may be isolated, he is sti on the ground and safe.

However, extreme boredom take over and an astronaut may find hin self daydreaming and dozing off. Whe awakening to find himself still in cramped and lonely space ship, he wi become irritable and restless. After while, his thoughts turn to fantasy ar he becomes detached from himself.

"After a length of time dependir on the type of person he is, he will n know who he is, but he'll be sure he not that silly fool sitting all alone in space ship going nowhere," reporte Col. Wheaton. But a carefully selecte and mature individual might g through a lengthy trip with no mo than mild irritation, he said.

• **Hibernation**—Defining hibern tion as "a periodic physiologic state which the body temperature falls to low level approximating that of tl ambient temperature, and heart ra metabolic rate, and all other functio fall to correspondingly minimal levels Raymond J. Hock, USAF Arctic Aer medical Laboratory, said the theo has great advantages for space fligl but is not immediately feasible.

Periodic arousal from hibernati is highly desirable, to allow certain a tivity essential to the mission. To p mit man to hibernate, scientists mu first solve at least four problems: lo ering the body temperature to 10 or below, without the occurrence ventricular fibrillation; ability to mai tain these low temperatures for lo periods, rather than the present lin in animals of a few hours; understar ing of the energy turnover that w allow this condition to be maintaine and ability to arouse man to a norn condition periodically.

• **Weightlessness**—Unless cont consoles are properly designed, ported Dr. Harald von Beckh, an c erator under conditions of weightle ness may reach for a button witho looking for it, and find he has t wrong one. This was pointed out citing the importance of vision in c entation. Even this, however, is not great a problem as the disorientati experienced by an astronaut who aw ens suddenly to find himself weightle where there was no weightlessness fore.

NAA's Novel Approach to Stainless Steel Honeycomb Panels

Company sees "new era" in vehicle construction; process includes original heat-treating cycle

by Frank G. McGuire

LOS ANGELES—North American Aviation, Inc. has developed a new process for producing stainless steel honeycomb sandwich panels for aircraft and potential missile construction. NAA devised its own heat-treating cycle, changed the method of building retorts for fabricating panel sections, and developed a new "roller-skate" device for heliarc welding the edges of the retort.

The new panel is designed to operate in a temperature range of 460°F to 640°F (see Fig. 1), and is constructed with a view toward its use in fabrication of integral fuel tanks. Simultaneous heat-treating and brazing is done in a unique gas-fired porous-brick furnace with eight separate heat-control zones.

• **Special cycle**—The stainless steel alloy used is PH 15-7 Mo CRESS (precipitation-hardening, 15-7 Mo corrosion-resistant stainless steel) with a heat-treating cycle (see Fig. 2) determined by NAA engineers, in preference to that recommended by the supplier. The cycle involves fast uniform heating rates to brazing temperature of 1625°F, where it is maintained for about 18 minutes. Fast uniform cooling is then applied until the temperature reaches 1000°F in about 45 minutes, after which the panel is subjected to −110°F for three hours, then to 900°F for eight hours to the end of the cycle.

According to NAA, the "most critical phase" of the cycle is the rapid cooling from 1625°F to 1000°F in a 45-minute period. "If this rate of tem-

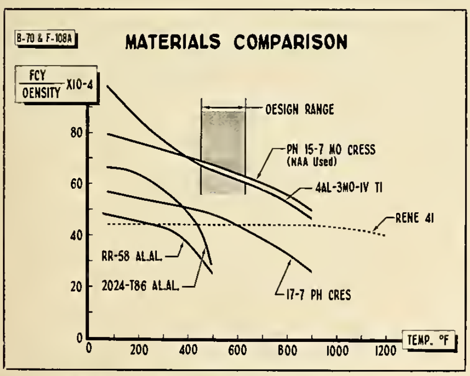


FIG. 1—Superior performance of PH 15-7 Mo CRESS.

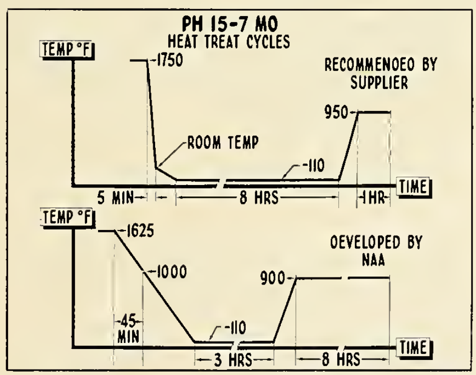


FIG. 2—NAA devised its own heat-treating cycle.

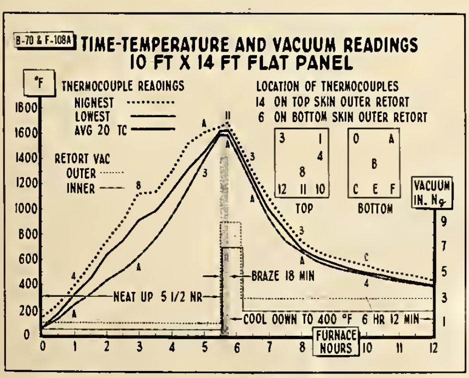


FIG. 3—Big panel exceeded strength requirements.

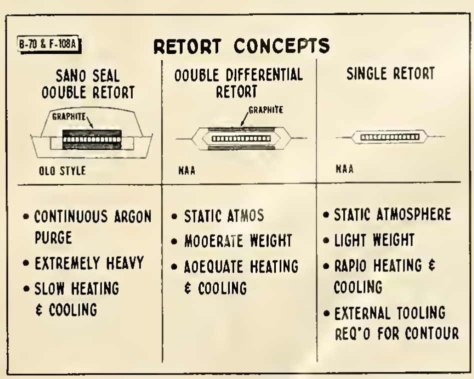


FIG. 4—Graphite removal precluded contamination.

perature descent is not exactly controlled, the panel probably won't be worth much," a company official said. The cooling is accomplished through the use of cold air pumped through the furnace after heat-treating and brazing.

The general operation of this furnace is as follows: a mixture of gas and air is pumped into a plenum chamber between the steel shell of the furnace and the brick internal surface. The gaseous mixture flows through the porous brick and is ignited upon reaching the internal surface. The flow is such that it cools the brick, and although the inside surface temperature of the brick is above 1600°F, this temperature has dropped to 300°F two inches from the inside surface.

To promote cooling at the end of the cycle, the operator cuts off the flow of gas, which terminates ignition, and allows the cool air to continue flowing into the furnace, substantially reducing the temperature. The eight control zones which allow the operator to govern the elevated temperature over any portion of the panel also allow closely controlled cooling during the critical phase.

• **Brazing alloy**—Brazing is accomplished through use of a sterling silver (92½%), copper (7³⁄₁₀%) and lithium (²⁄₁₀%) alloy which is compatible with the base metal, stainless steel. The copper acts as a temperature gradient equalizer, assuring equal temperature throughout the surface of the panel. The copper used must be phosphorized, or oxygen-free, to prevent blistering of the finished panel.

Before NAA discovered the use of copper in December, 1958, the largest panel which could be made was about six feet square. After oxygen content in copper ruined a $28,000 ten-by-fourteen-foot panel, the company switched to the oxygen-free type. Copper is also used in the inner retort when attached members must be welded to the facing plate of the panel in the retort.

In constructing its largest panel, 10 x 14 feet (see Fig. 3), NAA was required to achieve a minimum yield strength of 200,000 psi (it achieved 227,000 psi), a minimum tensile strength of 225,000 psi (it achieved 242,000 psi), and a minimum elongation of 4% (it achieved 4 to 6½%). X-ray examination of this large panel disclosed 99% brazed bonding between the core material and the facing plates of the panel.

Thermal conductance of the bonding alloy was lowered in order to reduce heat transfer to fuel supplies when structural designs call for using the panel in integral fuel tanks, as in the B-70 bomber and the F-108A interceptor. The brazing temperature was lowered from 1750°F to 1625°F in order to make it more compatible with the brazing alloy's optimum brazing temperature.

• **Graphite is eliminated**—North American also devised a method of eliminating graphite from the tooling needed within the retort, and thereby removed the possibility of contamination (see Fig. 4). In the single-retort method used, the weight of the panel being fabricated is greater than the weight of the retort. This method also provides rapid heating and cooling, a static argon atmosphere (compared with continuous argon flow formerly needed) and simplicity of design.

Edges of the retort are automatically fusion-welded by use of a "roller-skate" device which replaces the hand-operated method. The roller skate mounts a heliarc welding torch and traverses the edge of the retort, fusion-welding it in a short time. This method allows use of the retort a number of times, since it is unnecessary to grind away a great portion of the flange in order to open the retort. The roller skate was conceived and designed by NAA engineers.

• **Ultrasonic inspection**—Inspection of finished panels is done by use of ultrasonics (see Fig. 5). The method was adopted when the company was seeking to reduce the amount of time and money required by X-ray inspection. It previously took one hour for X-ray inspection of one square foot of panel and the cost of inspecting this square foot was $16. The present method handles 14 square feet per hour and costs $1 per square foot (one side only). NAA plans to use multiple inspecting heads on its ultrasonic equipment to greatly increase the inspection rate.

The ultrasonic scanner operates at 18 inches per second, on a width of 1/32". A strip chart recorder reproduces the interior image of the panel on a 1:1 ratio. Defects found are analyzed by a fluoroscope installation, because the ultrasonic scanner can find defects, but not the cause for them. The fluoroscope presents a 3D image enabling the company to determine if salvage or repair of the panel is possible, and if so, how.

Present average size of the panel in production is 6 x 12 feet, but sizes up to 10 x 14 feet have been fabricated. The B-70 bomber will utilize about 20,000 square feet of the panel and the F-108A interceptor will use about 35[illegible] square feet. The B-58 Hustler reportedly uses about 1200 square feet of honeycomb sandwich panel.

North American feels that the three most significant advances in state-of-the-art methods inherent in their new system are: removal of graphite from within the retort; use of a static argon atmosphere instead of a continuous flow; and use of copper in the brazing alloy, thus allowing fabrication of large-size panels.

North American foresees the use of the panel in many future high-speed aero/space vehicles. The process, according to company officials, ushers in a "new era" in vehicle construction.

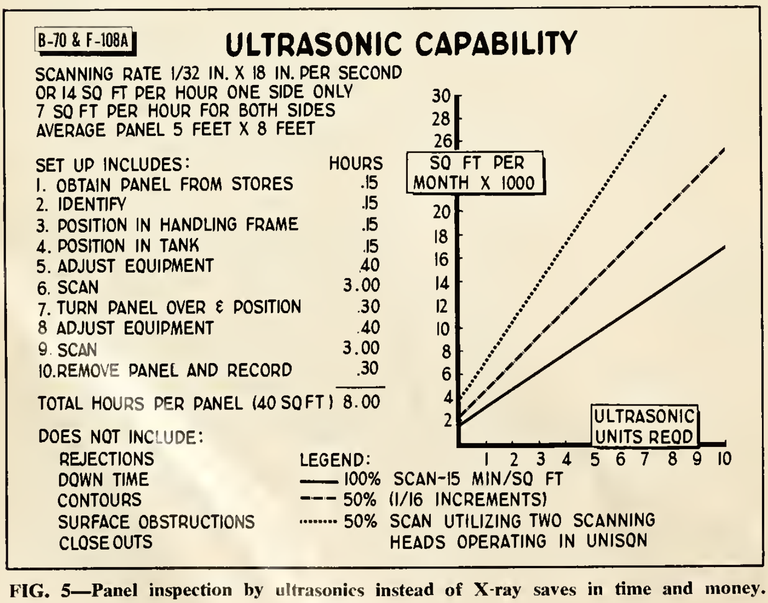


FIG. 5—Panel inspection by ultrasonics instead of X-ray saves in time and money.

reviews

ATERIALS FOR ROCKETS AND MISSILES. ;obert G. Frank and William F. Zimerman, 124 pp., $4.50, The Macmillan 'ompany, New York, N.Y.

The new lightweight, high-temperature aterials now available for use in missiles nd rockets have appeared with such apidity on the market during the last ear that attempts to index and catalogue nem have run far behind. This book conisely fills the need of many engineers in ne industry to know what present engieering data is on existing metal and eramic materials, and what materials can e expected to become available during ne next few years.

Because of the technical advances in ne missile material field and the difficulty nat engineers not directly concerned with ne development of these materials have 1 understanding these advances, the book lso gives brief descriptions of new eramic and high-temperature metallurgy chniques.

The book attempts to give a broad ross-section of all the materials availble for specific applications, and then commend the best materials for each se. Conclusion: A handy handbook on aterials and metals and a valuable addion to the missile industry library.

ETALS FOR SUPERSONIC AIRCRAFT ND MISSILES. D. W. Grobecker (Ed.), 23 pp., American Society for Metals, leveland, O.

A compilation of technical papers prented at the Conference "Heat Tolerant etals for Aerodynamic Applications," at lbuquerque, N.M., in January, 1957, uner the joint sponsorship of the Albuerque and Los Alamos Chapters of the merican Society for Metals, and the niversity of New Mexico.

Eleven papers are included on the rious techniques and problems conrned with the metals and ceramics apications to missile development.

Chapter 12 is a summary and evaluan of the papers by J. R. Townsend, eviously of the Sandia Corp., and prestly a Special Assistant to the Assistant cretary of Defense for Research and ngineering.

IE UPPER ATMOSPHERE. H. S. W. Mas n and R. L. F. Boyd. 326 pp., $17.50, w York Philosophical Library, New rk, N.Y.

An account of the experiments concted and knowledge gained about the per atmosphere during the International ophysical Year for students, scientists other fields, and those technically inested in space travel.

This book has one very unique asset d one distinct liability.

Its authors have been able to explain re of the technical details about both experiments and the results of the Y upper atmosphere tests in lay guage than any publication to date. ey treat mathematical exposition as if were taboo, and explain in language

(continued on page 29)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reviews

not requiring advanced knowledge the instruments and vehicles used and the information obtained.

The book has the liability of having been printed at a time when our knowledge about the upper atmosphere was ever-increasing. It was printed before Van Allen discovered the two belts of charged particles, which is the most significant piece of information produced about the earth's atmosphere in centuries. The authors did point out, however, that one urgent problem to be solved was the amount of "concentration of meteoric and micrometeoritic particles in space and in the upper atmosphere."

The book describes the techniques and vehicles used in the investigation of space, such as balloons, spectroscopic devices, sound and radio waves, searchlights, rockets and artificial satellites. Methods used in finding the positions and speeds of rockets and satellites, and of interpreting their coded signals, are explained. Detailed attention is also given to the phenomena of radio fadeout, radio absorption, night airglow, aurorae, meteors, cosmic rays, and currents responsible for magnetic variations.

POWER UNLIMITED! and TOMORROW THE MOON, both by Abraham and Rebecca B. Marcus, both $3.50, both approximately 150 pp., Prentice-Hall Inc., Englewood, N.Y.

Space primers by a husband and wife team which give adequate coverage of the fields in easy to read terms and diagrams. *Power Unlimited!* covers the field of propulsion from jets to ion rockets. *Tomorrow The Moon* starts with the ancient Greeks and projects us out into space by way of Peenemunde, White Sands, and Cape Canaveral.

These are not books for missile and rocket technicians and engineers. They are good books to recommend for friends who would like to know more about the industry and space technology, and for the children and wives of people in the missile and rocket industry who would like to know more about what daddy and husband are doing.

* * *

The National Bureau of Standards *Journal of Research* will be published in four separate sections beginning July 1:

Section A—Physics and Chemistry

Section B—Mathematics and Mathematical Physics

Section C—Engineering and Instrumentation

Section D—Radio Propagation

According to the Bureau, the change is being made to permit better distribution and to better meet the specialized needs of the scientists, engineers, and mathematicians who subscribe. The change will also allow the editorial scope of the *Journal* to be broadened to better cover the Bureau's technical program.

Printing schedules and subscription costs vary among the various sections. Subscriptions may be ordered from the Government Printing Office.

Special Problems of the Monkey-in-Space

by Dr. Earl T. Carter
Ohio State University

COLUMBUS, Ohio—Space medicine scientists are hard at work on the problems involved in placing experimental animals in orbit and returning them safely to earth.

They have found that monkeys—in some respects—present greater difficulties than men.

• **Science of balance**—Maintaining the health and normal functions of an animal under sealed environmental conditions involves the science of Ecology, dealing with the process of keeping an energy balance between an animal and its environment.

To achieve such a state of balance it is necessary to know the exact metabolic requirements of an animal—the exact amount of oxygen, water, and food he consumes, as well as the amount of heat he adds to the environment and how this amount compares with the heat input from all possible external sources.

For many years, data has been accumulated concerning metabolic functions of animals such as the monkey. But there is a scarcity of data applicable to the special conditions of space flight. Accordingly, researchers have had to create laboratory capsules in which space flight conditions can be simulated as closely as possible.

Studies of this type are being conducted in laboratories of the Department of Physiology-Biophysics at the USAF School of Aviation Medicine. Here Drs. Hans Clamann and Richard Bancroft are making careful studies of the behavior and metabolic requirements of the spider monkey in experimental sealed capsules. Many unexpected problems have arisen.

• **Drinking problem**—First, there was the key problem of providing liquid to an animal in the weightless state, since drinking in this condition is impossible without special mechanical means. This was solved by development of a special gelatin mixture which is 80% water and is packed with nutritious materials such as peanuts, oatmeal and vitamins. This semi-solid gelatin is contained in small trench-like recesses along the inner walls of the capsule. The monkey can handle and chew it even in the weightless state.

• **Dark confusion**—Another problem unique to such a system is prolonged darkness. A monkey, like a human, is used to sleeping in the dark and eating in the daylight. Prolonge darkness tends to alter many of hi habits and even his basic physiologica functions. Whether such effects migh have deleterious results will be deter mined by further testing.

• **Overindulgence**—The monke himself has provided several prob lems because of his peculiar personality In early experiments it was found tha he tended to eat his entire food suppl in one sitting. To overcome this glut tony, a special food dispensing devic was designed with a timing mechanisr to insure that only a single day's suppl of food was delivered at the beginnin of each day.

• **Little menaces**—Furthermore, was found that monkeys are like hu man children—destructive. In prelim inary experiments, they were bore in the sealed capsule and amused them selves by taking everything apart. Ven tilation systems were unscrewed an dismounted, power supply cables wer chewed through, and measuring de vices were otherwise put out of orde

To handle this problem, a seale system was designed in which no loos object, sensing device, motor, or othe control mechanisms could be reache by the busy-fingered simians.

THE U.S. TREASURY SALUTES THE AIRCRAFT INDUSTRY

—and its thousands of employees who help strengthen America's Peace Power by buying U.S. Savings Bonds

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L. A. MARTIN, skilled aircraft mechanic, is typical of the thousands of valued employees in this field who are buying U.S. Savings Bonds regularly. Mr. Martin, through his company Payroll Savings Plan, is making a personal contribution to the Peace Power of his country.

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COVER STORY

$23 MILLION research center ready.

BIRTH OF A *TITAN* NOSE CONE

The story in pictures of previously secret data on nose cone technology conducted by Avco which is opening new R&D center

WILMINGTON, MASS.—One of the most complete and advanced Space Age research centers in the world will be dedicated here on May 14. Completion of the $23-million center—Headquarters of Avco's Research and Advanced Development (RAD) Division—marks the end of one phase of a phenomenal success story. Less than five years ago the company's research effort on the critical ICBM re-entry problem was begun with only a handful of scientists. Today it has grown to a staff of more than 2500 scientists, engineers, and supporting personnel.

The center will be devoted to basic and applied research and development. One of its most important functions will be continuing work on the ICBM program—primarily, atmospheric re-entry. Avco holds contracts for nose cone work on both the *Titan* and *Minuteman* long-range missiles. The division is also doing significant work in related fields of high-temperature gas dynamics, magnetohydrodynamics, metallurgy, materials research, and environmental test methods. Division scientists began research during the last year on the anti-ICBM problem.

The decision to put Avco into Space Age work was made by Victor Emanuel, chairman of the board, in 1955. Since that time the Research Division has become the company's "greatest instrument of growth." While its primary work is concerned with missile programs, it also provides a pool of talent and facilities for other Avco divisions. It aims for the kind of scientific breakthroughs upon which totally new products, and sometimes new industries, are built.

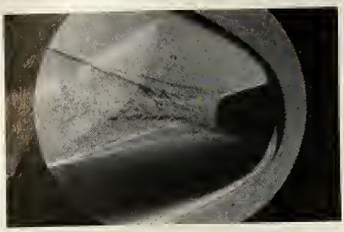
Corporate funds support research in many fields. Work is under way in propulsion, radar, guidance, gas dynamics, nuclear energy, navigation, communication, fire control, and electronic computers.

The president of RAD is James Kerr. He helped form the new group when the decision was made to bring the company into the space business. At that time he was head of Avco's Office of Defense Planning.

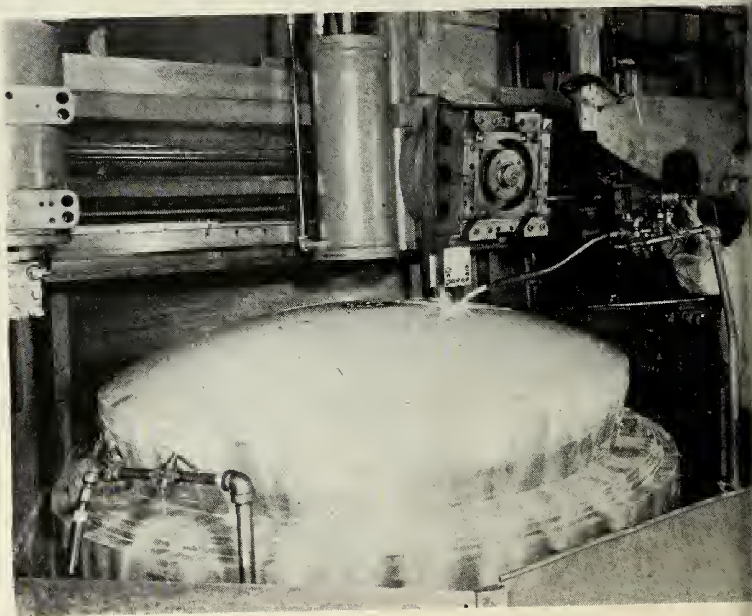
A vice-president of Avco and director of the Research Laboratory since its founding, Dr. Arthur Kantrowitz, has had the responsibility of gaining experimental data on Mach 25 flight—a prerequisite to solving the problem of atmospheric re-entry.

Project director of the *Titan* nose cone program is Dr. Jack A. Kyger. He was once the top scientist in the Navy group that rushed the nuclear-powered Nautilus to successful completion.

The following pages show some of the division's work on the re-entry nose cone—how it is made and tested and some of the vital components that go into the final system. Many of the just-released photographs show details never before published.

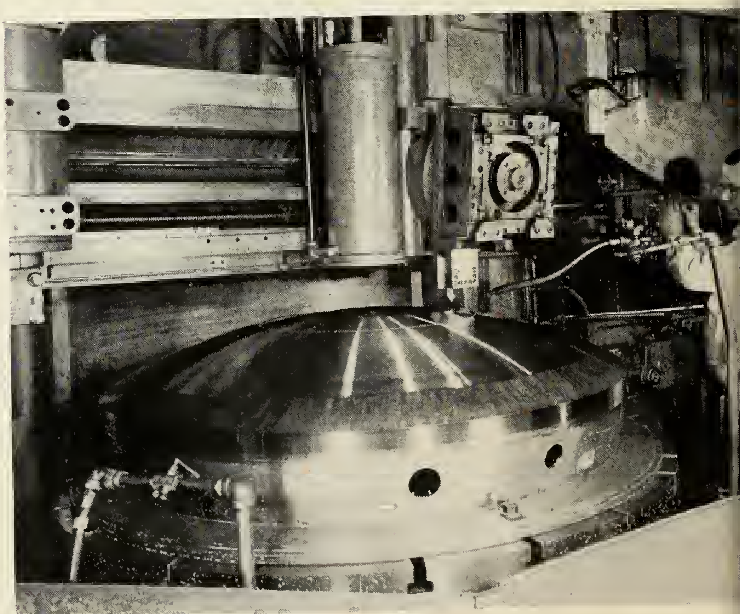


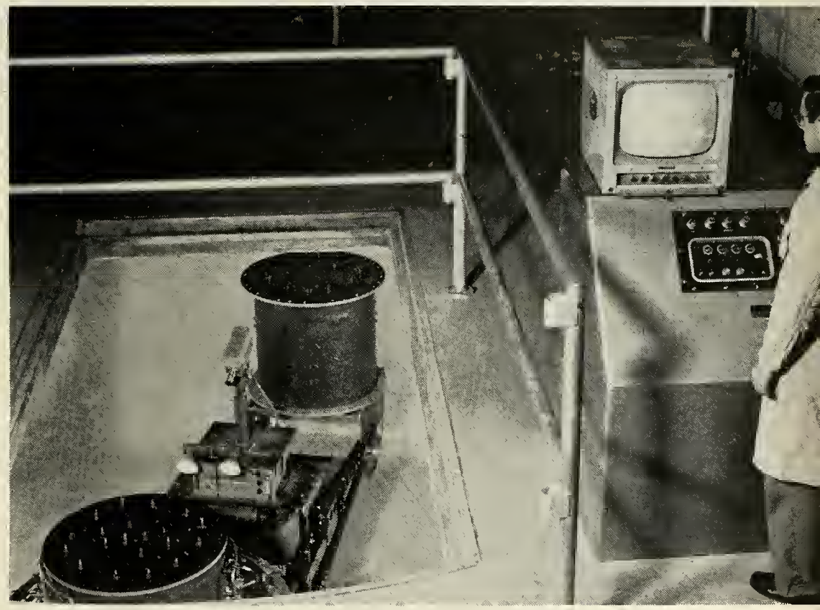
PRELIMINARY WORK on the *Titan* nose cone begins with schlieren studies of stock wave and wake turbulence of actual cone shape test model.



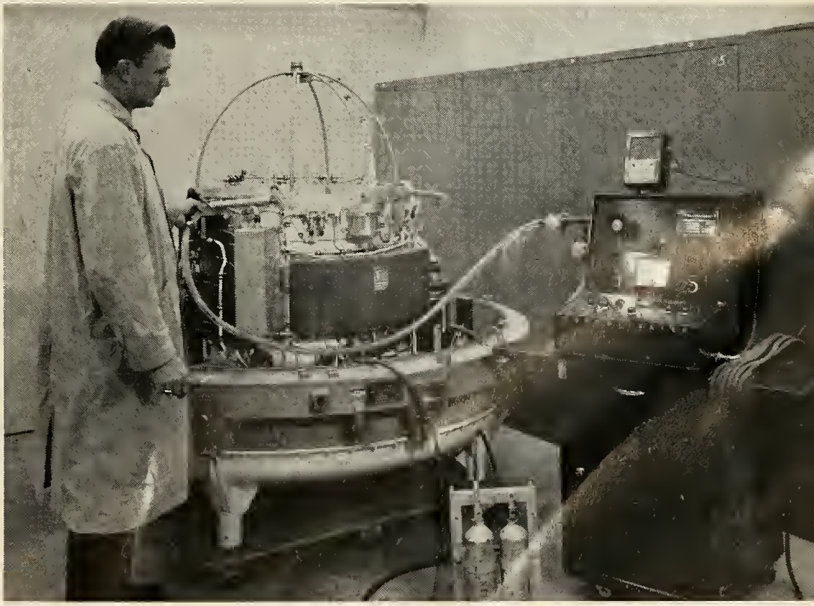
THE FACE of the heat-sink nose cone is milled to the extreme tolerances required for successful re-entry.

. . . and nickel-plated and finished to mirror smoothness to minimize atmospheric friction.

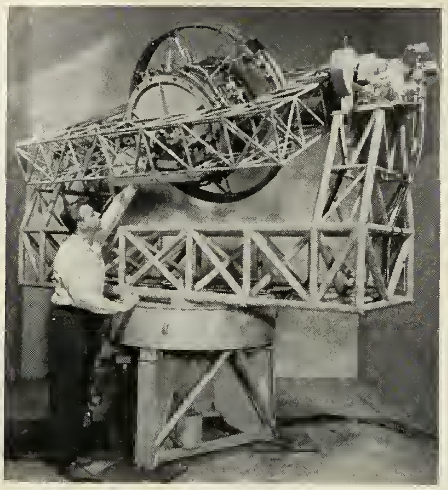




COMPONENTS ARE SUBJECTED to 100g acceleration tests and watched by closed-circuit television for signs of failure.

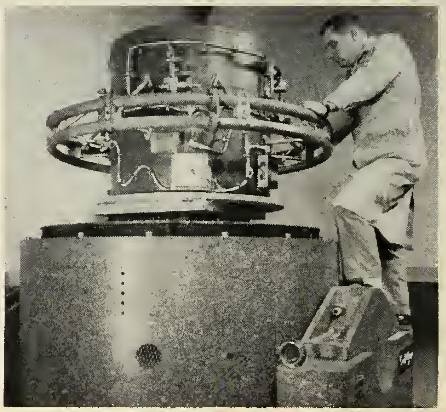


THE INTERNAL SYSTEMS receive final pressure check before final assembly.



THE AVCO DARAC—which aligns the nose cone to the proper attitude to re-enter the atmosphere —is tested on the three-axis flight simulator

. . . and on the shake table which simulates rocket-engine vibration



. . . and subjected to the extreme cold of outer space.

The men who guide Avco research . . .

James R. KERR
Vice-president, Avco Corp.
President, Lycoming Div.
President, Res. & Adv. Dev. Div.

Dr. Arthur R. KANTROWITZ
Vice-president, Avco Corp.
Dir., Avco Res. Lab.

Dr. Jack A. KYGER
Vice-president & Tech. Dir., RAI
Proj. Dir., *Titan* nose cone

AT THE END OF THE LINE the completed vehicle receives a final vibration check before shipment to a *Titan* test site to make its contribution to space technology . . .

Communications Satellites:

A Largely Neglected Force for Peace

Long-proposed space relay system, now technically and economically feasible, still gets little non-military attention

by Hal Gettings

WASHINGTON—Satellite communication relay stations—the first practical application of space research to non-military pursuits—could be close to reality. Several significant problems still stand in the way—notably, satellite life and reliability. But according to D. M. Culler of ITT Laboratories, the system could be implemented in the very near future.

Actually, such a system was proposed 14 years ago by English scientist A. C. Clarke, who has stated that "the TV satellite is mightier than the ICBM. It may well determine whether Russian or English is the main language of the future." Dr. Louis G. Dunn, president of Space Technology Laboratories, has predicted that communications satellites "will have more direct effect on the man in the street than any other development in space technology."

The first step in such a project has been made with the *Atlas* SCORE, which successfully received and retransmitted voice messages back to earth. But what is being done to further the program?

Nothing, actually, so far as a non-military system is concerned. Althou the first sentence of the Space A declares ". . . it is the policy of t United States that activities in spa should be devoted to peaceful pu poses for the benefit of all mankin only a military system is being work on at present.

The military program (which d not include TV is going forward joint effort of ARPA and NASA. low-altitude *Courier* is scheduled 1960 and a higher-altitude satellite 1962. These are delayed-repeater s tems, however, and will handle only channels of teletypewriter code inf mation. Within 5-6 years they hope have a 24-hour system in orbit. T system will have an increased co munication capacity of up to 144 vo channels.

No budget figures are available approximately $50-60 million per y is being scheduled for "communi tions." Although the problems are qu different and the military system complex than the "commercial" sion, knowledge gained by the milit should contribute to success of a pea ful project.

• **System concept**—The system p posed by Culler consists of three re stations mounted in satellites each a 24-hour orbit so as to remain fi over a specific spot on earth. Prop maintained in these locations, the tions would allow line-of-sight c munications with 98% of the ear surface. Culler says the cost of suc system would be competitive with p sent transoceanic cable systems, wh incidentally, are not adequate to han the wide bandwidth required by t vision.

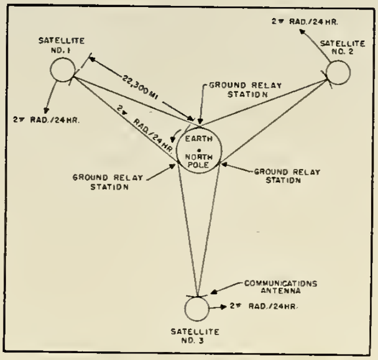
The satellites, with active repeat would orbit in the equatorial plan

TABLE I: MAJOR SYSTEM DESIGN PROBLEMS

PARAMETER	LIMITATIONS	SYSTEM REQUIREMENTS
1. LIFE	Component State-of-the-Art Control Propellant Supply	1-2 Years Minimum
2. RELIABILITY	No Satellite Maintenance	No Satellite Failure Redundancy
3. COMMUNICATION SUBSYSTEM		
a. Coverage	Line-of-Sight 3 Satellites—98%	Depend Upon Application
b. Frequency	Ionosphere Effects Atmosphere Effects	1000—10,000 mc
c. Capacity	Weight Bandwidth Power Modulation	Voice, Teletype, TV
d. Satellite Transmitter Power	Weight Electrical Power Supply	Directional Antenna High Power Efficiency
e. Ground Receiver Sensitivity	Noise S/N Ratio Modulation Technique	High Antenna Gain Parametric Amplifiers
4. VEHICLE SUBSYSTEM		
a. Payload	Rocketry State-of-Art	V = 10,070 ft/sec h = 22,300 mi
b. Ascent Guidance and Control	Multiple Orbits Planar Transfer Guidance Blackout	Δ V = ±5 ft/sec Δ a = ±0.1°
c. Orbit Guidance and Control	Moon-Sun Gravitation Light Pressure Dumbbell Effect Internal Moments Antenna Beamwidth	±0.1° Latitude and Longitude ±4° Attitude Control
5. ELECTRICAL POWER SUBSYSTEM	Weight Surface Area Solar Collector State-of-Art	Maximum Energy Conversion Efficiency

ı altitude of 22,300 miles, as shown ı the illustration. By stationing one f the three satellites every 120 de-·ees about the orbit, it is possible to rovide almost complete global cover-ȝe with line-of-sight communications ırough the addition of the three indi-ıted ground relay stations in the line-f-sight overlap areas. All but 2% of ıe earth's surface is covered by such system. Only limited areas about the orth and south poles are below the ıes-of-sight horizon with respect to ıe satellites in the equatorial plane.

The angle subtended by the two ıngents to the earth's circumference rom the satellite is approximately 17 egrees; thus, the coverage indicated ill require a satellite antenna beam-idth of at least 17 degrees.



ORBIT location of 24-hour satellites.

With only two satellites, one over ıe Atlantic and the other over the acific, most of the free world can be overed by microwave broad band ommunication capable of handling ıany channels of telephone, teletype, ıd television transmission. With three ıtellites located as indicated, and the ıree ground stations at, for example, thens, Tokyo, and Houston, complete orld-wide coverage is obtained except ır minor polar regions. With appro-riate ground networks it would be ossible to establish a world-wide dial lephone system as one application of e satellite repeaters.

• **Problems**—Two of the biggest oblem areas are life and reliability. ı order for this communications sys-m to be economically feasible the tellite must operate continuously for minimum of one to two years, plac-g a tremendous burden upon com-onent life. Actually, the functional life the satellite is primarily dependent on two factors: 1) life capability alizable within the component state the art, primarily electronic com-onents; and 2) the supply of control opellants that can be carried to main-in the satellite on station and in oper attitude.

In reliability, the major limitation that there is no opportunity for main-nance of equipment—it must exhibit overall failure during its life. This ıviously places a strong requirement ı component reliability and the need r redundancy.

Three development problems re-ıire particular consideration. But none of these necessitates any major break-through; they need only extension and refinement of existing equipment and techniques.

1) Reliable satellite-borne equip-ment with sufficient power supply to operate high-power transmitting and receiving equipment.

2) Guidance and control systems to place and maintain the satellite in proper orbit and attitude.

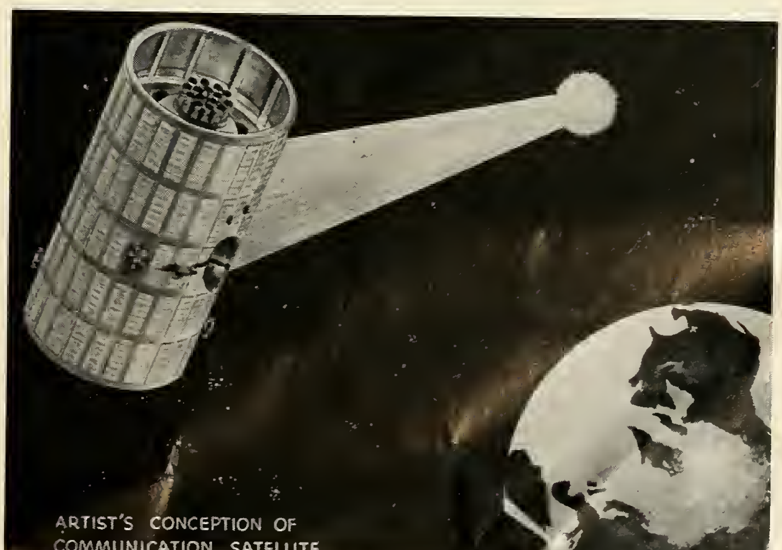
3) Increased satellite payload ca-pacity.

• **Communication subsystem**—In the design of the communications sub-systems two parameters are most in-fluential: ground receiver sensitivity and satellite transmitter power output. Cur-rent rocketry imposes a low limit on the payload that can be put into a 24-hour orbit. Therefore, it is desirable to maximize the capability of reception on the ground in order to minimize the satellite transmitter power output.

With parametric amplifiers, receiver noise figures of 0.5 to 1.5 db are pos-sible. Also, recent improvements in modulation techniques allow efficient utilization of these noise figures at high channel signal-to-noise ratios to make possible both high sensitivity and signal quality in the ground receiver within the present state of the art.

The satellite transmitter power out-put requirement is a function of the path loss and the ground station sensi-tivity. Since the satellite transmitter power is limited by payload weight and electrical power supply, the maximum communications capacity of the system is a function of the minimum power level detectable by the ground station (maximum sensitivity) and the maxi-mum power output of the satellite transmitter.

The other link of the communica-tion path from the ground to the satel-lite is not a limiting factor, since the ground transmitter power has consider-



AT LEAST five communication satellites—two within polar orbits—are needed for world-wide communications.

able latitude under present capability.

• **Satellite position and attitude**—Once the satellite is in its appropriate orbit, it must be maintained on station and in proper attitude. Here a limitation is the satellite antenna, which must be directional and of minimum beamwidth to cover the necessary area. The vehicle must be referenced to the earth's vertical as closely as possible.

The vehicle is constantly subject to such perturbating forces and torques as the moon-sun gravitational field, light pressure, dumb-bell effect, and internal moments. Considering the moon-sun gravitation, light pressure, and residual drift rate, the position of a satellite can be controlled within approximately one-tenth degree latitude and longitude. Considering best estimates of torques due to light pressure, residual magnetism, induced currents, and the dumb-bell effect, attitude can be held to within ±4 degrees of nominal about all three axes.

At present, very little data is available to accurately define the forces and torques that will cause these perturbations. It therefore cannot be overemphasized that the guidance and control during both ascent and orbit phases is a very significant problem.

• **Power system**—The electrical power system is limited in capability by the weight and surface area available in the satellite payload and the efficiency of the solar collectors. In the immediate future the primary source of energy for the satellite will be solar energy with batteries used for energy when the satellite is in the earth's shadow. In the long term, nuclear and other energy sources will be used in space vehicles for electrical power.

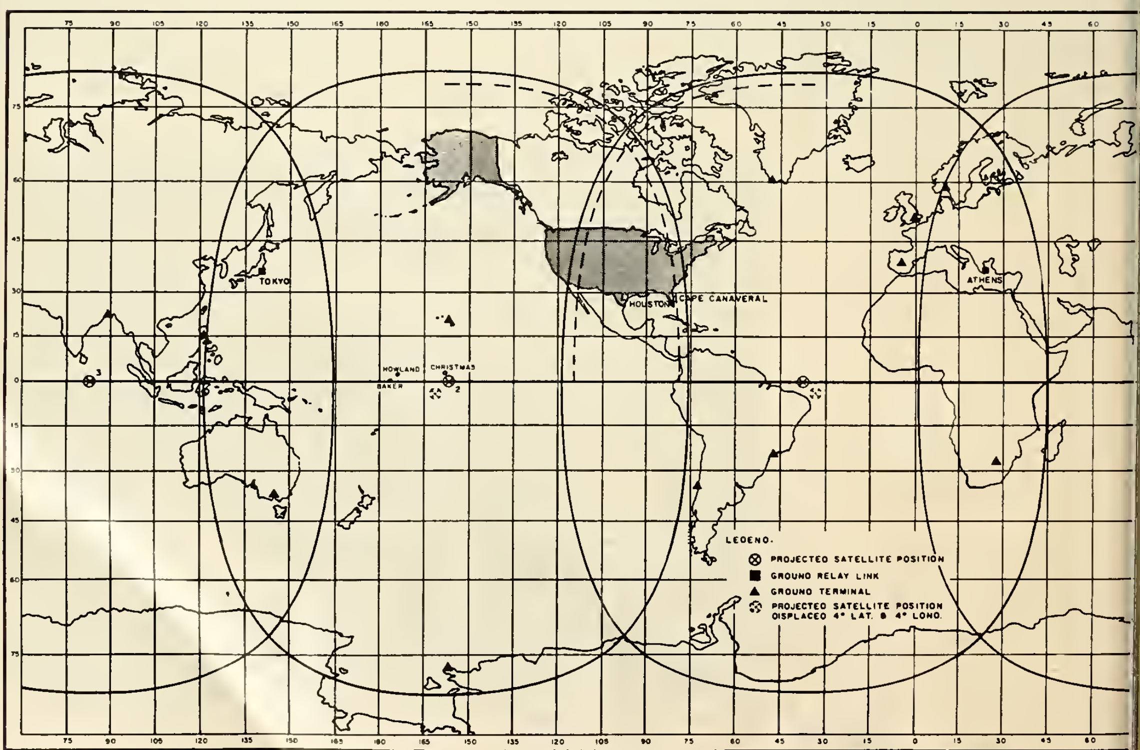
The recent development of the "plasma thermocouple," for example, offers significant promise for a space power source. Furthermore considerable improvement of the solar collectors can be expected in the future.

• **Economic considerations**—From an economic point of view, it is interesting to note that the communication satellite system is rapidly becoming quite competitive with the cost of transoceanic cable systems. For example, current transatlantic cable costs are approximately $200 per voice channel mile. A 96-voice channel satellite repeater system feasible within the immediate future for Atlantic Ocean coverage only would cost approximately $300 per voice channel mile even compensating for a 2-year life for the satellite as compared to a 20-year life for the cable.

Furthermore, present cable systems are incapable of handling conventional television transmission due to the 4.5 mc bandwidth requirement.

Estimates indicate that a complete global 24-hour active satellite communication system would cost, under present state of the art, approximately $100-300 million. Thus, the system ap pears economically feasible for the in mediate future. On the longer term, is quite probable that it will be th most economical means of long-rang broadband transmission. Anticipate improvement in payload and reliabilit of rocket systems leads to a very opt mistic viewpoint on future system cost For example, while only two years ag it cost approximately $1-million fo every pound of payload in low-altituc orbit, it is expected that by 1960 th will have been reduced to $1000 ar by 1964 to $100 per pound. Althoug these figures refer to low-altitude orb conditions, they do reflect the rate improvement in rocketry costs to b expected in the future.

• **Conclusions**—Cruller's argumen provide strong support for the 24-hou satellite as a major breakthrough long-range broad bandwidth commun cation capability as a time when com munication channels are rapidly reac ing capacity. Through increased worl wide communication—particularly tel vision—made possible by such a syste the interests and social customs of th various countries of the world will closer bound together and the univers brotherhood of man brought neare Thus it is very possible that the com munication satellite will be the fr world's best instrument for peace. T day's technology can bring it about the very near future.



R Analyzers Monitor Giant Wind Tunnel

TULLAHOMA, TENN.—To monitor ınd control explosive gases and fumes n the U.S. Air Force's giant transonic ınd propulsion wind tunnel at Arnold Engineering Development Center here, ı system of 16 infrared analyzers is ısed.

Built by the Perkin-Elmer Corp., he analyzers are located at critical points around the tunnel with a sample-collecting line running from each unit nto these areas. Recorders and indicating dials for each unit are centrally ocated on one panel in a test control building.

In operation, the analyzers continuously monitor conditions in their area. When an explosive concentration eaches 25% of the lower explosive imit, an alarm is set off. If the concentration reaches 50% of the lower xplosive limit, the instrument automatically initiates shut-down of fuel nd reduction of power input to the unnel compressor. It also activates quipment that fills the tunnel with itrogen.

Unlike the more common open-end vind tunnels, the AEDC tunnel is a ompletely closed system. Fuel can ollect in several ways during testing f jet and rocket engines, and this uild-up, if it went unchecked, could ecome a serious danger to personnel nd to the expensive structure itself.

• **Critical areas**—Fuel is pumped nto engines under test at rates up to 25 gallons per minute. At this rate, ven a small leak can result in a sizeble build-up of fumes. There is usully a small amount of fuel spillage rom engines, and, since they are tested p to stall, some fuel is not burned.

To handle the great quantity of uel needed in tests, a special test-fuel uilding serves as a storage area. Here certain fraction of leakage is to be xpected. Fumes also collect in the elow-ground foundation of the main est area.

A serious leak or fume collection ı any one of several of these areas ould lead to a damaging explosion. he infrared analyzers guard against ıch a situation.

• **Operation**—The analyzer instruments are sensitized to analyze a number of different fuel elements: JP fuels , 2, 3 and 4; kerosene; alcohol; methne; aviation gasolines and rocket uels. The analyzers can detect the ower explosive limit for the most explosive member with an accuracy of ±5%. The instruments indicate the unnel contents with a response time of six seconds.

The instruments are designed to operate with a high degree of accuracy and with as fast a response time as possible under the unusual conditions found in the wind tunnel. The instruments analyze vapors which can exist under widely different environmental conditions: temperatures ranging from −10° to 230°F, velocities varying from 0 to 200 feet per second, and altitude pressures ranging from sea level to more than 100,000 feet.

To achieve reliable operation under such conditions required unique design, especially in the sample handling, according to Perkin-Elmer. The fast response time called for an unusually large sampling capacity. Despite the wide range of pressures, the pressure in the instrument's sample cell is held constant within 5%.

• **The development center**—The Arnold Engineering Development Center was established for the development and evaluation of aircraft, propulsion systems and guided missiles.

The wind tunnels and test cells of AEDC, by simulating the conditions of actual flight, provide a precise, safe and economical means for determining effects of speed, temperature, pressure and altitude on engines, aircraft and missiles. The facilities of the AEDC can test the largest engines under development or on the drawing boards, as well as scale model and full-size aircraft and missiles.

Ionosphere Reported Bigger Than Supposed

COLUMBUS, O.—According to T. Gordon Hame, scientist at the Antenna Laboratory of Ohio State University, the ionosphere extends thousands of miles further out into space than was previously supposed. Previously it was thought that the ionosphere, which begins about 50 miles above sea-level, extended upward to about 300 miles.

Hame said the electrons in the ionosphere reach their greatest density at a point about 300 miles above the earth, and from there outward the electron density tapers off gradually.

He said that at an altitude of some 200 miles, the density is about 10^{12} electrons per cubic meter. At 1000 miles out in space, the density has dropped only to 2×10^{11} electrons per cubic meter.

He said this probably means that kinetic temperatures in the exosphere (which is considered to encircle the earth above an altitude of some 625 miles) are much higher than previously was thought. It also means that the ionosphere extends outward into what has been called the exosphere.

These conclusions were based in part on data obtained by Hame while working on a research project sponsored by the Wave Propagation Branch of the Wright Air Development Center's Aerial Reconnaissance Laboratory at Wright-Patterson Air Force Base, Dayton, Ohio.

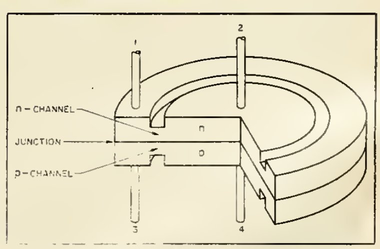
The Ohio State engineer said that beyond an altitude of 200 miles, real kinetic temperatures would increase five times within 700 miles on an outward space journey.

Hame, who is assisted by three graduate students, has described some of his findings in a report to be published in the Institute of Radio Engineers Proceedings. The research team has been listening to *Sputnik III* since last July on a radio frequency of 20.005 mc. (This Russian satellite was chosen because its orbit is farthest from the equator.) Since January, he also has been listening to the Soviet satellite's second harmonic on 40.01 mc. This, he said, cut down the margin of error in measuring the electron density to about 2%.

Hame said when the satellite's radio signals pass through the ionosphere, the effect of the earth's magnetic field and the electrons polarize the signal. By measuring the time difference between the polarized peaks on recording graphs, he and his associates are able to work out mathematically the electron density in space.

The researchers tune in on the satellite's beeps some five hours each day, and collect more than 25 feet of recorded data daily.

Bell Tetrode



A FOUR-TERMINAL semiconductor device—a field-effect tetrode—has been invented by Bell scientists. The device is unlike tubes or previous transistors and will act as either a transformer or a gyrator—functions normally available only with extensive circuitry. The cutaway shows construction of the unit, an etched disk of semiconductor with a diffused junction.

Fluorine Engines May Arrive Within Five Years

Dramatic increase in rocket capability will come when compatible materials are developed. Fuel supply considered more than adequate

by Paul Means

WASHINGTON—Time and money are the only two factors needed to produce a rocket engine using elemental liquid fluorine as its oxidizer—the ultimate chemical propulsion system for space vehicles.

Chemists need time to find materials, compatible with fluorine under operational conditions, to be used for such a rocket's gaskets, joints, seals and lines.

And many of the nation's chemists and rocket makers think that more of the second factor—money—would cut down on the time it takes to find the compatible materials.

The technology needed to produce a fluorine engine is here. This was demonstrated as long ago as 1949 when the NACA Lewis Research Center at Cleveland operated a small engine with it. It was dramatically demonstrated recently when the Bell Aircraft Corp. field-tested a large fluorine engine.

Fluorine engine research is presently being carried on at Bell, Lewis, JPL, and the Rocketdyne Division of the North American Aviation Corp. Lewis has a new $2.5-million facility designed to handle fluorine rocket engines up to 26,000 pounds thrust, and received more money in the Fiscal '60 budget to carry on fluorine engine development.

Bell recently received a $1,070,000 contract from NASA to carry on its fluorine engine development program originally funded by the Air Force in 1956. NASA has asked Bell to determine "feasibility of a high-energy fluorine-liquid hydrogen rocket engine."

If the problems of handling fluorine and finding materials compatible with it are solved, a high-energy upper-stage fluorine engine could be produced within very few years.

• **Pioneer**—And the company most likely to solve many of these problems is not in the rocket engine business at all. The General Chemical Division of the Allied Chemical Corp. is a pioneer in production and handling of fluorine, the major producer of fluorine, and the only producer selling elemental fluorine to the missile and rocket industry.

It was not practical to produce great quantities of elemental fluorine, or to consider it as a likely oxidizer for a rocket engine, until General Chemical found a way to economically transport large quantities in 1957. (M/R, Sept., 1957.)

Prior to that time, ICC regulations restricted shipment of the gas to six pounds of fluorine in a 200-pound cylinder under 400 pounds of pressure.

Now, General Chemical's tanks can transport 5000 lbs. of elemental liquid fluorine at a time.

In order to eliminate the problem of fluorine burn, the seamless tanks are first cleaned to remove all impurities, and then filled with gaseous fluorine. The oxidation of the fluorine with the metal forms a coating of iron fluoride. Then the liquid fluorine i very slowly bled into the tank until i displaces the gaseous fluorine.

With the shipping tank and carefu handling, General Chemical has ha good success in transporting larg amounts of fluorine from its Metropolis Ill., and Baton Rouge, La., plants wit a negligible number of accidents.

• **The big problem**—The grea problem in handling fluorine, in pro duction, transportation, or rocket de velopment, is that it is the most powe ful oxidizing agent known, reactin with practically all organic and in organic substances. The few exceptior are the inert gases, metal fluorides, an a few pure completely fluorinate organic compounds.

And the problem becomes formid able when the rocket experiments ar taken out of the static conditions of th laboratory into the field.

Bell's engine uses no gaskets ar as few joints as possible. Joints cann be welded with such smooth consis

FEASIBILITY of transport of large quantities of highly-toxic liquid fluorine has be demonstrated by Allied Chemical.

ency that nodules do not form, leaving imperfections that cannot be protected so easily by a fluoride.

Gasketing in fluorine rocket engines with present materials is risky. General Chemical, when it must use gaskets in production and transportation of fluorine, uses pure soft aluminum, which has the necessary give.

Fluorocarbons, though satisfactory with gaseous fluorine, break down when used with liquid fluorine under operation friction or pressure. The eventual gasket materials for fluorine engines, however, will probably be improved fluorocarbons and/or silicons.

Another problem which must be overcome is the finding of lubricants compatible with fluorine.

General Chemical says it has had success in handling fluorine at room temperature with nickel, monel, steel, stainless steel, brass, copper, aluminum and magnesium. At elevated temperatures, the use of nickel and its alloys and stainless steel is preferable. For all-around applications at low and high temperatures, General Chemical likes monel.

General Chemical has also used tetrafluoroethylene polymer for valve packing.

• **Potentials**—When chemists solve the last major problem impeding the progress of fluorine engines—that of finding compatible materials—rocket manufacturers can look forward to developing engines that can lift payloads 70% heavier than any space vehicle now on the drawing board.

A fluorine-hydrogen engine will give a specific impulse of 463, and yield 5,800 B.T.U.'s per pound.

Such a rocket, according to John L. Sloop, Chief of the Rocket Engine Branch at Lewis, could lift into space a 20,000 lb. manned satellite with half the booster weight and half the thrust of current propellants. On a trip to the moon and return, according to Sloop, the fluorine-hydrogen rocket could increase the ratio of payload weight to take-off weight eightfold over what can be done with today's propellants.

• **Ample fuel sources**—Because of the facilities of General Chemical and other manufacturers producing fluorine, and General Chemical's ability to transport the oxidizer, the advent of fluorine engines in large-scale production will find the fuel waiting for them.

General Chemical began producing large quantities of elemental fluorine for conversion into uranium hexafluoride, which the AEC buys for nuclear work. The U.S., Canada and Mexico have ample reserves of fluorspar which could more than take care of any expanding need for fluorine.

• **Cost justified**—In comparison with present fuels, the cost of fluorine is high. Present prices start as $3.75 a pound and range down to $2.65 a pound f.o.b. in lots of 100 tons per year. General Chemical believes that use of liquid fluorine in operational missiles in the future would bring the price down to $1.00 a pound in large quantities. Liquid oxygen, by comparison, costs only 10 cents a pound.

But the reduction of cost effected by the increased thrust and lower weight of a fluorine rocket would more than make up for the more expensive oxidizer, making the entire rocket less expensive to build.

• **Fluorine bases**—As the fluorine engine approaches operational status, missile and rocket men will have to solve the final problem: How do you fire a fluorine rocket safely?

Missile experts say a fluorine engine cannot be fired from any of the present missile bases or any now on the drawing board.

In case of a misfire or a topple in which fluorine spills out of the rocket, the resulting reactions could endanger not only the crew but surrounding installations.

It is felt that the safety precautions and materials developed in the construction of a fluorine engine would solve many of the problems connected with firing the rocket. Launching pads would probably have to be widely dispersed and automatic controls refined in order to handle the powerful oxidizer.

Judging by the rapid improvement in the techniques of handling present-day liquid engines, the problem of handling a fluorine engine does not seem to be insurmountable. *Thors, Redstones* and *Jupiters* are now handled operationally by troops in the field only a few years after the first experimental firings of large-thrust liquid rockets.

Such high-energy engines would probably be used for scientific exploration of space rather than for military missiles, reducing the need for mass firing techniques.

• **How soon?**—How far away is a fluorine rocket? The best guess is five years. But more research on materials compatible with fluorine could cut the time considerably.

And development of such a rocket would provide the nation with a rocket powerful enough to meet all needs until nuclear and even more exotic forms of propulsion are developed.

Austenite Lowers Steel Fatigue Strength

WASHINGTON—Austenite in amounts up to 10% lowers the fatigue strength of high tensile steel, research by the National Bureau of Standards has demonstrated.

Experiments also showed that retained austenite in the matrix is transformed by fatigue stressing into untempered martensite. NBS said this "probably accounts for the deleterious effect," which may find use in the processing of steel for missile casings.

Four different low-alloy steels, SAE 4340, Tool Steel No. 1, Tool Steel No. 2 and SAE 52100, with carbon content ranging from 0.44% to 1.06%, were investigated.

For each steel, the NBS said, adjusted fatigue strengths decreased as the amount of retained austenite increased. However, for the three higher-carbon steels there appeared to be a "limiting value of approximately 10% beyond which no further decrease in strength occurred."

Specimens refrigerated before tempering had greater fatigue strengths, indicating that refrigeration tends to cut the amount of retained austenite.

FIRST LARGE-SCALE test of rocket using liquid fluorine has been accomplished by Bell Aircraft Corp.

Two scientists from the senior staff of Hughes Aircraft Co.'s research and development laboratories in Culver City, Calif., have been named to sit on National Aeronautics and Space Administration advisory committees. **Dr. Allen E. Puckett,** Hughes vice president and director of the company's systems development laboratories, has been appointed to NASA's committee on control, guidance and navigation. Dr. Puckett, an authority on aerodynamics and guided missiles, was chief of the wind tunnel section of the Jet Propulsion Laboratories at CalTech. **Dr. Leo Stoolman,** manager of Hughes' aerodynamics department, will join the NASA committee on structural loads. He is a former senior staff engineer of the Jet Propulsion Lab and author of technical papers on aerodynamics.

PUCKETT

Two top executives and a director were elected at a board of directors meeting of Kearfott Company, Inc., subsidiary of General Precision Equipment Corp. **Donald W. Smith** is the new chairman of the board, **Fred D. Herbert, Jr.,** is president and **Robert N. Brown** was elected director. Smith, who has been Kearfott's president since 1955, was recently elected president of General Precision Equipment. Herbert, son of the late founder and first president of Kearfott, has been associated with the company since 1932, when he helped develop the first successful automatic radio direction finder. He is also a vice president and director of General Precision Equipment. Brown, who joined Kearfott in 1946, is vice president and assistant general manager, and manager of the company's newly-established Avionics Operations group.

The Gabriel Co. has announced plans for immediate construction of a solid fuel manufacturing plant at Mesa, Ariz., and appointment of **Charles E. Bartley,** former founder and president of Grand Central Rocket Co., to head Rocket Power, Inc., a wholly-owned subsidiary organized to operate the new plant. In 1954 Bartley founded Grand Rocket Co., which was sold to Tennessee Gas Transmission Co. in 1958 in a reported $6,000,000 transaction. Earlier, he was chief engineer of the solid rocket division of CalTech's Jet Propulsion Laboratory.

BARTLEY

George Ustin fills the newly-created post of vice president in charge of engineering at Buchanan Electrical Products Corp., subsidiary of the Elastic Stop Nut Corp. of America. New products currently in the planning or development stage have brought the company into the space and aviation fields. Ustin was formerly with Continental Copper and Steel Industries and holds a number of patents on electrical components and devices.

USTIN

The Daven Co. announces appointment of **Emil Kohler** as project engineer in charge of development on transistorized power supplies and equipment. Kohler formerly worked for the Bogue Electric Manufacturing Co., where he was responsible for electro-mechanical, ultrasonic, and semiconductor development. He also was installation and service supervisor for the RCA Service Co. and supervisor of the prototype section of the ESC Corporation.

contract awards

WASHINGTON—The Convair Division of General Dynamics Corp. has been given the $33.5 million NASA prime contract for *Vega*, a two or three stage rocket with *Atlas* as its booster due for test flights by mid-1960.

The 295,000 pound *Vega*, capable of putting 5000 pounds into an earth orbit, will consist of an *Atlas* first stage, a modified *Vanguard* booster as the second stage, and a 6000-pound-thrust encapsulated nitrogen tetroxide and hydrazine engine as its third stage. The General Electric Company has the second stage contract, and JPL is responsible for the third stage, technical supervision, and payload planning.

Convair will have the responsibility for design, construction, tests and launching of the vehicle. The contract does not include the cost of the *Atlas* boosters.

NASA

$1,992,848—Doyle and Russell, Norfolk, Va. for two launching pads.

MISCELLANEOUS

$4,340,000—Sylvania Electric Products, Inc., New York for production on new communications system; fourth "significant" recent multi-million-dollar award—details not available because of security classifications.

$1,500,000—Aeronutronic Systems, Inc., Allied Research Associates, University of Chicago, Convair Div. General Dynamics Corp., General Electric Co., General Mills, Inc., Hughes Aircraft Co., Industrial Research Associates, Ramo Wooldridge Corp., RCA, Republic Aviation Corp., Technical Operations, Inc., for research and study of *Project Defender*.

NAVY

761,751—Aerojet General Corp. for *Jato* rocket motors and 17 spare igniters.

239,785—AL-CO Co., Inc. for construction of communication transmission feeders at Naval Missile Facility, Point Arguello.

3,718—Walker Electrical Co., Inc., Atlanta for switchboards.

50,400—Standard Electric Contracting, Inc., for construction of a KDA facility at Naval Auxiliary Air Station, Brown Field, Chula Vista.

29,250—National Lead Co., Research Laboratories, Brooklyn, N.Y. for dihydroxy benzoate.

ARMY

Aeronca Manufacturing Corp., Middletown, Ohio, for production of the *Pogo-Hi II* E3C target missile system for the White Sands Missile Range, N.M. Amount not disclosed.

40,668,034—Morrison-Knudsen Co., Inc., F. E. Young Co., Johnson, Drake & Piper, Inc., Olson Construction Co. for construction of WS-107A-2 technical facilities, Lowry Air Force Base, Denver.

20,384,003—Western Electric Co., New York for *Nike-Hercules* repair parts. (two contracts).

13,266,720—California Institute of Technology, Pasadena, for research and development. (four contracts).

11,900,165—Thiokol Chemical Corp. for production of rocket motors and plant maintenance at Longhorn Ordnance Works, Marshall, Texas.

8,000,000—Westinghouse Electric Corp. for advanced shipboard radar systems.

7,623,416—Chrysler Corp., Detroit, for repair parts and tools for the *Redstone* missile program.

2,153,375—Sylvania Electronics Corp., Needham, Mass., for electronic equipment.

1,851,000—Davidson Construction Co., Inc., Manchester, N.H. for construction of tracking and data acquisition station at New Boston.

1,190,767—Douglas Aircraft Co., Inc. for missile launching items.

689,000—Charles Ramsey & Co. for *Nike-Zeus* LAR receiving building, White Sands, N.M.

581,654—Northrop Corp. for target missile research and development.

$514,845—Western Electric Co., N.Y. for *Nike* spare parts and components. (seven contracts)

$406,000—Poorvu Construction Co., Inc., Wellesley Hills, Mass. for construction of Boston CONAD facilities, Fort Heath and Fort Banks.

$400,000—Telemeter Magnetics, Inc., Los Angeles for development of high speed computer drums.

$310,204—Rheem Manufacturing Co., Downey, Calif. for classified material.

$247,743—J. I. Lark Construction Co. for construction of drone target facilities at Tyndall Air Force Base, Fla.

$234,403—Electronic Engineering Co. of California, Santa Ana for ballistic camera synchronization system.

$200,415—Rheem Manufacturing Co., Downey, Calif. for warhead fuzing system.

$206,578—Western Electric Co., Inc. for *Nike* spare parts and components. (four contracts)

$187,483—North American Aviation, Inc., Autonetics Div. for computers.

$169,512—Telecomputing Corp., Data Instrument Div. for research and development of a fixed camera reader.

$104,610—Gilfillan Brothers, Inc., Los Angeles for *Corporal* missile repair parts.

$100,000—California Institute of Technology, Pasadena, for research and development work at the Jet Propulsion Laboratory, Pasadena.

$78,000—North American Aviation for design and development.

$70,000—Maurice H. Connell & Associates, Inc. for architect-engineer services with criteria for IRBM launch complex at Island "J."

$63,413—Douglas Aircraft Co., Inc. for *Blue Streak* and emergency spare parts. (three contracts)

$57,750—North American Aviation, Inc. Canoga Park. Classified.

$52,699—Norris-Thermador Corporation, Vernon, Calif. for rocket parts.

$46,651—Hufford Corporation, El Segundo for research and development.

$46,651—Librascope, Inc., Glendale, Calif. for a tape cartridge memory system.

$45,957—Telemetering Corp. of America for telemetry system.

$45,000—The Firestone Tire & Rubber Co., Los Angeles for modification of guided missiles.

$43,492—A. P. Wyman, Inc. for construction of water supply for missile facility, Bangor, Me.

$31,200—Firestone Tire & Rubber Co. for repair of guided missiles.

$30,000—University of Utah, Salt Lake City Utah for research and development.

AIR FORCE

$18,715,141—Philco Corp., for extension modifications of AF AIRCOM technical control intersite and multiplex point to point facilities, including spares, special test equipment and data.

$17,000,000—General Electric Co. for production of high-power search radar.

$11,408,009—I.T.T. Federal Division, Clifton N.J. for transmitting sets, electric guidance signals.

$1,155,480—Union Carbide Corp., Linde Co Div., N.Y. for liquid oxygen and semi trailers.

$923,200—Lewyt Manufacturing Corp., Long Island, N.Y. for coordinate data.

$598,360—Cook Electric Co., Chicago for design, construction and test of a positive ion accelerator.

$250,000—National Co., Inc., Malden, Mass Frequency standard, missile borne with synthesizer to be employed for missile application used in service test program

$130,000—AVCO Manufacturing Corp., Crosley Div., Cincinnati for radio receiving sets and modulators for missiles.

$112,686—Melpar, Inc., Falls Church, Va. for design, development and construction of a voice data processing system.

$100,960—Eitel-McCullough Inc., San Carlo for tubes.

propulsion engineering

Propulsion by upper atmosphere chemicals is impractical for nost purposes, and impossible for all but low-speed craft, a UCLA engineering professor contends. A. F. Charwat, who is also consultant to Aeronutronic Systems, says the performance of an engine operating on recombination of atomic oxygen in the so-called chemosphere (about 50 miles up) would be a function of the flight Mach number. Some people have suggested that when our knowledge of the chemosphere increases this condition may be changed, but Charwat says the speculations are not justified.

Chemospheric propulsion depends on the established kinetics of the oxygen recombination reaction. Looking at the reaction, as Charwat does in the American Rocket Society Journal, shows that an oxygen recombination engine would be operable over only a very limited range—in the "low supersonic flight Mach numbers; flight at near orbital speeds is proved not to be possible." Even in this limited range, Charwat says, the engine's performance will be marginal. He says nobody has completely disproved such an engine's usefulness or feasibility, but he doubts that a successful one can be built.

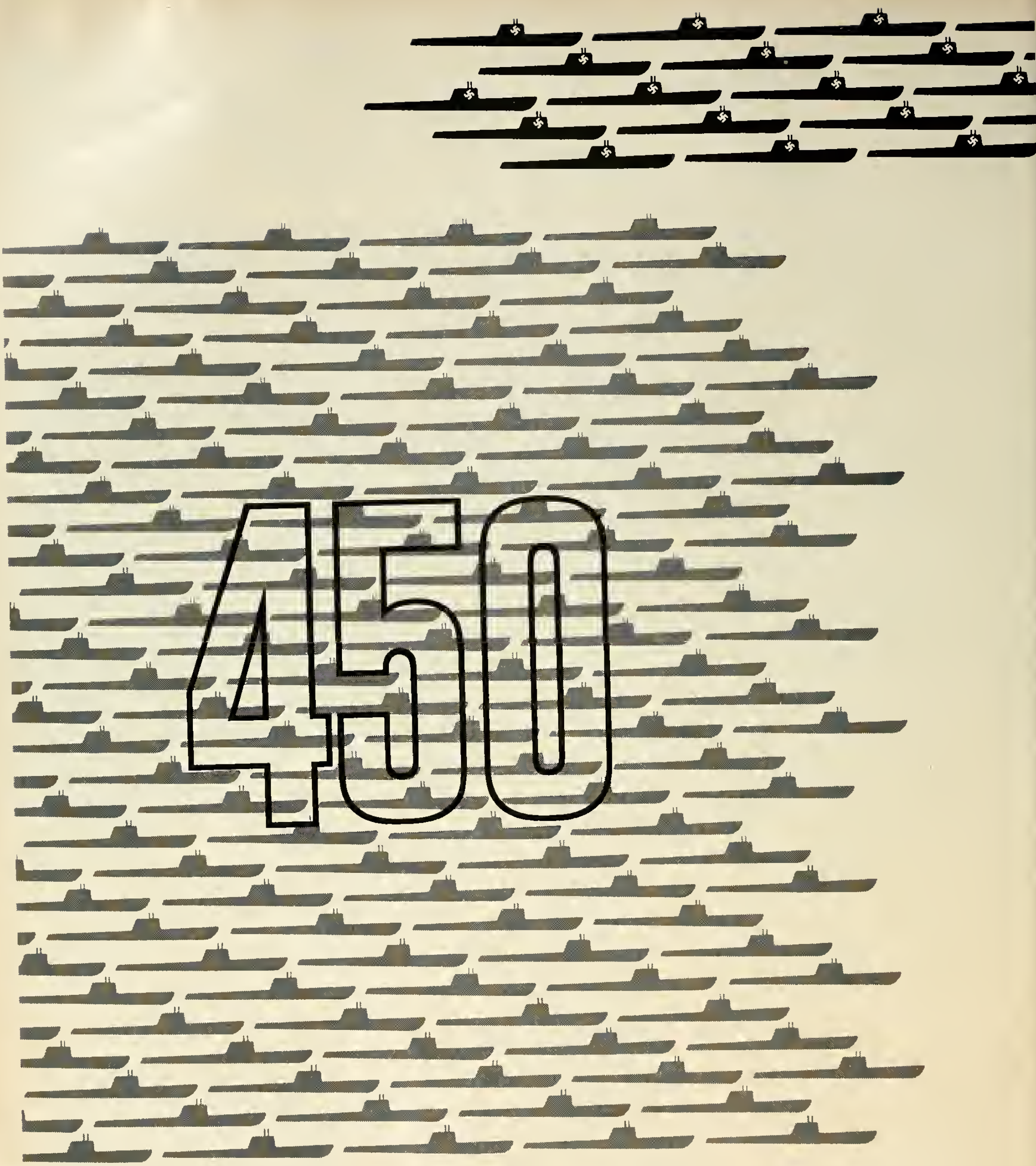
New catalysts will have to be found if an upper atmosphere engine is to be built even for marginal operation, Charwat says. The oxygen recombination reaction, although capable of releasing large amounts of energy, does not proceed satisfactorily under natural conditions. Although catalysts cannot shift the reaction equilibrium, they can accelerate reaction time. However, thermodynamically, even at a near-ideal reaction rate, there is no net thrust except in the low supersonic range. This means operation below Mach 4, with an optimum operating speed of about Mach 2.

Only very large and extremely light oxygen recombination ramjets can sustain flight at all, and then the payload is practically nothing, further Charwat calculations show. The practical problems of launching the engine and then boosting it to operational speed—besides the job of "unfolding" the engine at 50 miles—will be tough to solve. Charwat says popular statements that such an engine will be ready to fly in about two years "appear to be somewhat premature."

Linde's new super insulation (Propulsion Engineering, April 6) makes possible unvented liquid hydrogen storage tanks with a loss rate of only 9% per year, not 0.9% as mentioned. There apparently is some mix-up in the nomenclature for the insulations and super insulations. Linde reports the "super insulation" which will make low-loss liquid hydrogen storage possible is SI-4, not an offshoot resulting from the work done in developing that insulation. The April 1 article referred to the new insulation as a "powder," but the company will not confirm whether it is or is not a powder.

Hard-boiled eggs show why accelerated aging of propellants at elevated temperatures is not a true test of how a propellant responds to nonrefrigerated storage for long periods. Carl Boyars, head of the chemical physics division, Naval Propellant Plant, Indian Head, Md., says BuOrd uses accelerated cycling aging—even though there are many valid criticisms—because some short-term testing procedure has to be available to supplement long-term testing. Look at the egg, he says, and you'll see why the results of rapid aging by elevated temperatures are not necessarily valid. A chicken egg aged for just a few minutes at a little above 200°F becomes hard-boiled. However, that same egg, aged naturally at a more moderate temperature, might have produced a baby chick!

Accelerated aging, however, is a necessity in order to forecast—even with narrow limitations—the probable future behavior of a rocket. The test has its value: Certain phenomena have been spotted prior to increases in malfunction frequency. The accelerated aging program, Boyars says, also can bring to light, more rapidly than can be done by normal storage, unforeseen chemical changes.



EIGHT TIMES GREATER THAN THE U-BOAT THREAT

Fifty-seven submarines came close to strangling world commerce and knocking the Allies out of World War II. This was Hitler's U-boat strength at the start of the war. Today it's the sobering fact behind estimates of what 450 subs might do. For this is the threat the U. S. now faces. Today's sub is far more powerful than before . . . a more deadly menace to American overseas commerce, 99.85% of which still come and goes by ship. And today there's the additional menace o sub-launched nuclear missiles, which open our inland citie to possible devastation. If the Free World is to survive, th submarine threat must be solved. Primary fighters in thi urgent contest are the men and ships of the Navy.

ADVANCED WEAPONS | ASTRONAUTICS | ASW | ELECTRONICS | MISSILES AIRCRAFT | G | RANGE SYSTEMS

CHANCE VOUGHT
DALLAS, TEXAS

missile business

by William E. Howard

Dollarwise, what's the future of the space market? In 1965 will the United States be spending closer to $10 million or $10 billion on space missions? How important is a manned expedition to the moon? Will the day come when a probe to Mars is scratched in favor of an irrigation project in the Sahara?

An evaluation of the broad problems ahead of industry and the nation has been made by E. B. Doll, vice president of Space Technology Laboratories. His conclusion, in brief: right now we are long on technical know-how, but too short on basic wisdom.

"The technical developments in this field have come so rapidly, and pose such complex questions," say Doll, "that there has not been time for the general public, our national leadership, or even our scientific community to evolve a sufficiently deep and broad-based set of values, principles and objectives concerning space projects to permit these projects to be viewed in proper perspective."

Moreover, Doll contends, "as a nation, we are not yet prepared philosophically to judge the importance of space technology as compared with other segments of science and engineering. There is no reservoir of common understanding of the military or economic or scientific values of accomplishing space missions. There is no general agreement on which particular projects will contribute the most to our military strength and national security, to scientific progress, or to the preservation of individual liberty and health and happiness."

Foresight being a hard-to-come-by commodity anytime, Doll proposes that in view of the nation's "limited" economic and intellectual resources, much concentration should be given to distinguishing between what is possible—and what is needed; what can be done—and what should be done.

What is the immediate space market outlook? Doll, whose firm is a chief consultant to the Air Force BMD, sees space missions bound closely "for many years to come" to military requirements and, chiefly, ICBM development. "It is unlikely that the development of manned stations on the moon or like projects will be pursued in the foreseeable future under the forced draft of military necessity," he says. Emphasis will be on improving ICBM's, advanced aircraft systems or other advanced, but earth-tied, military projects.

Does this mean that space missions are out? Not necessarily. But, here is where the question comes in of determining what should be done. Doll notes that there are commercial as well as military applications for communications satellites, intercontinental rocket flight, and possibly, control of the earth's weather from a satellite system. With global television, he concedes there may be problems. "Nevertheless, I suspect that an international public which has learned to withstand the pressures of TV commercials would be less likely to succumb to misleading political propaganda."

Money spent now on instrumented and manned space probes, Doll feels, must be weighed against earthly requirements, such as the conquest of cancer. But he thinks that perhaps in 50 years the economy may expand to where paying $1 billion for a "synthetic planet-type" space vehicle holding several thousand people would be a "trivial" expenditure.

However, Doll says "major new scientific discoveries" are needed first before manned flights to Mars and Venus and creation of a manned lunar station become possible. This requires extensive research. Therefore, he says, "advanced research and development activity is a most important future space market."

Another important requirement: there must be widespread public understanding of basic technical and non-technical facts associated with both missiles and space programs. The reason, says Doll, so U.S. citizens may "properly arrive at some of the difficult national decisions which lie ahead of us."

CLASSIFIED

when and where

MAY

The Atomic Energy Commission, Technical Information Meeting on Test Reactors, National Reactor Testing Station, Idaho Falls, Idaho, May 13-15.

Society of Aircraft Materials and Processing Engineering-Eastern Div., Spring Meeting, Hotel Statler, New York City, May 15.

American Institute of Chemical Engineers, Symposium, Hotel Muehlebach, Kansas City, Mo., May 17-20.

Space Medicine Electronics Symposium, Franklin Institute, Philadelphia, May 18.

Society of Aeronautical Weight Engineers, 18th Annual National Conference, Hotel Henry Grady, Atlanta, May 18-24.

American Institute of Electrical Engineers, Middle Eastern District, Satellite Tracking Session, Lord Baltimore Hotel, Baltimore, May 19-21.

The Society for Experimental Stress Analysis, 1959 National Spring Meeting, Sheraton Park Hotel, Washington, D.C., May 20-22.

Instrument Society of America, 1959 Ohio Valley Instrument and Automation Exhibit and Symposium, Cincinnati Section, Music Hall, Cincinnati, May 21-22.

Institution of Electrical Engineers, The Radio and Telecommunication Section, International Transistor Exhibition and Convention, Earl's Court, London, May 21-27.

Federation Aeronautique Internationale, Annual Meeting, Moscow, May 24-June 5.

National Missile Industry Conference, sponsored by The National Rocket Club in cooperation with the Electronic Industries Association, Sheraton Park Hotel, Washington, D.C., May 25-27.

American Rocket Society, Institute of the Aeronautical Sciences, American Institute of Electrical Engineers and the Instrument Society of America, "Investigation of Space" Conference, Brown Palace and Cosmopolitan Hotel, Denver, May 25-27.

American Society for Quality Control, All-Industry Production and Quality Control Exposition and Convention, Cleveland Public Hall and Hotel Sheraton, Cleveland, May 25-27.

American Society of Mechanical Engineers, Design Engineering Show and Conference, Convention Hall, Philadelphia, May 25-28.

The Institute of the Aeronautical Sciences, San Diego Section, Regional Meeting on Supersonic Transports, San Diego, May 26-28.

JUNE

Institute of Radio Engineers' Professional Group on Microwave Theory & Techniques, National Symposium, Harvard University, Cambridge, Mass., June 1-3.

Institute of Radio Engineers' Professional Group on Production Techniques, Third National Conference, Villa Hotel, San Mateo, Calif., June 4-5.

The Pennsylvania State University's Missiles Systems Engineering Seminar, University Park, June 7-13.

Aero Club of Michigan, Industry Missile and Space Conference, Sheraton-Cadillac Hotel, Detroit, June 8-9.

American Rocket Society, Semiannual Meeting, El Cortez Hotel, San Diego, June 8-11.

United Nations Educational, Scientific and Cultural Organization, Paris, June 15-20.

Cornell University Industry Engineering Seminars, Cornell University, Ithaca, N.Y., June 16-19.

Institute of the Aeronautical Sciences, National Summer Meeting, Ambassador Hotel, Los Angeles, June 16-19.

Institute for Practical Research on Operations, Chief of Research and Development, U.S. Army, the University of Connecticut, Storrs, June 21-July 3.

American Institute of Electrical Engineers, Air Transportation Conference, Olympic Hotel, Seattle, June 24-26.

JULY

Tenth Annual Basic Statistical Quality Institute, Chief of Research and Development, U.S. Army, University of Connecticut, Storrs, July 12-24.

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