April 4, 1960

missiles and rockets

THE MISSILE/SPACE WEEKLY

Avco's RVX-4 Nose Cone Rides on *Atlas*

AN AMERICAN AVIATION PUBLICATION

Avco "primes" America's newest peacemaker — Newest weapon in America's atomic defense is the Navy's submarine-launched missile, Polaris. The critical job of making sure the Polaris detonates on time and on target was handled by Avco's Crosley Division. Arming and fuzing for the Polaris—like the recent development of the Air Force's Titan nose cone—is typical of Avco's role in U. S. missilery.

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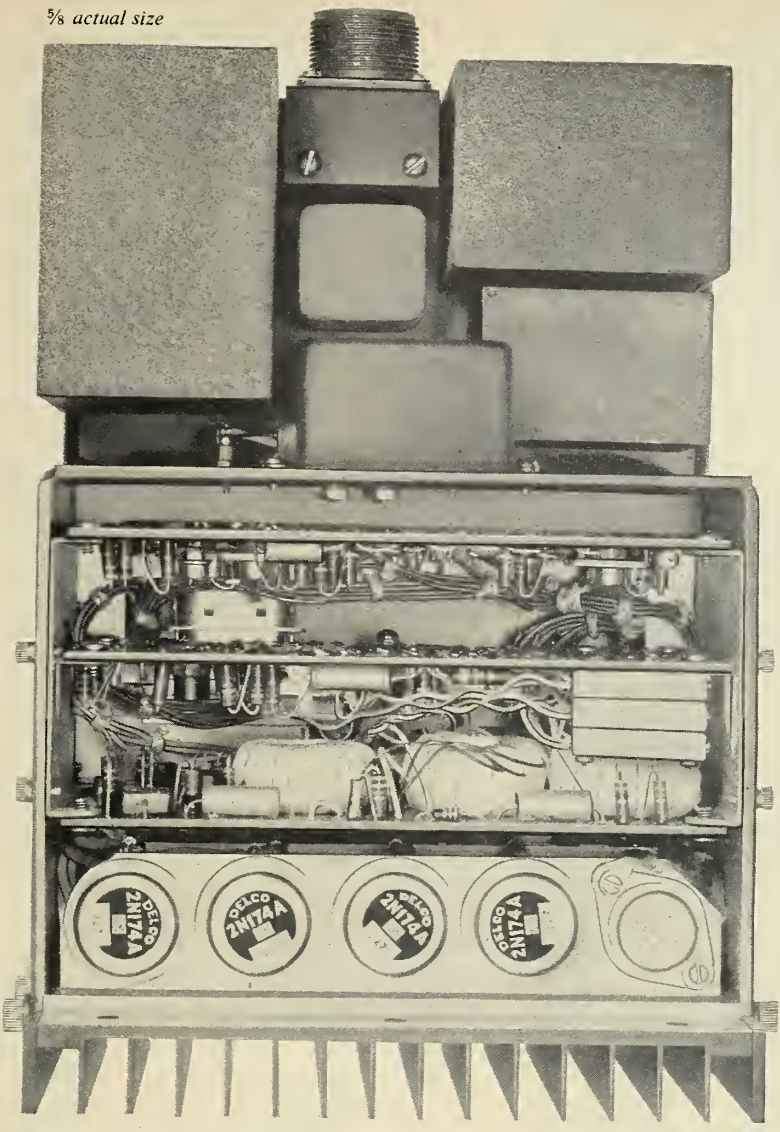

FROM DELCO RADIO NEW IDEAS FOR DEFENSE

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Delco Radio's high capacity Static Inverters and Converters fill a critical need in missile guidance and control—offering extremely reliable, very highly regulated power of precise frequency. The Static Inverters use direct crystal-frequency control and digital logic circuits to produce accurate, single or polyphase power output. They have no moving parts. There is nothing that can get out of adjustment. Electrical characteristics are: High Capacity—150 to 4,000 volt-amperes. High Efficiency—65 to 90% depending on power and control (precision and regulation) required. Accurate Phase Angle Control—to 0.5 degree. Precise Frequency Control—up to 6 parts per million maximum variation under all load and environmental conditions. Voltage Amplitude Control—to ±1% no load to full load. Low Distortion—typically 2% total harmonic distortion. Delco Radio has developed and produced power supplies for missiles such as the Air Force's Ballistic Intermediate Range Thor, Intercontinental Titan, and the pilotless aircraft Mace. For further information on military electronics, write to our Sales Department. *Physicists and electronics engineers: Join Delco Radio's search for new and better products through Solid State Physics.*

PIONEERING PRECISION PRODUCTS THROUGH SOLID STATE PHYSICS

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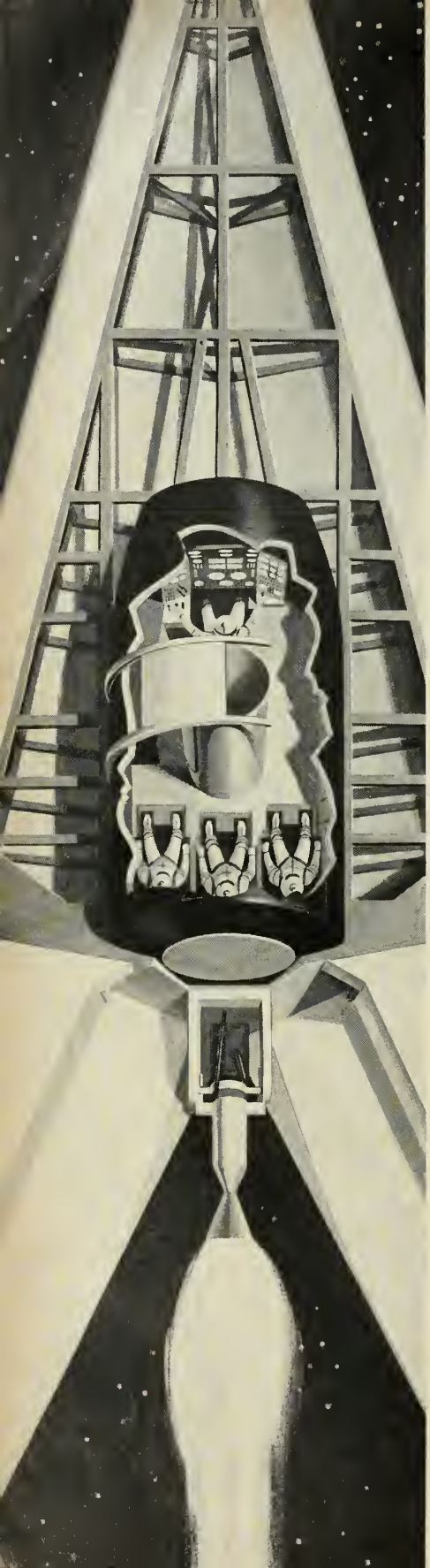

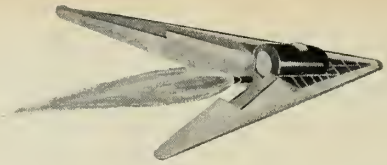

FUTURE PROJECTS LOOM LARGE AT LOCKHEED

There has never been a time in the long and distinguished career of Lockheed when it has not looked to the future; when it has not considered how best to use its store of engineering and scientific knowledge and the capabilities of its personnel. This is more true today. Lockheed's advanced thinking in the transportation and communications complex is twofold:
1) To advance the state of the art in space/age applications.
2) To improve standards of living.

Pictured here are examples of Lockheed's project-plans in advanced areas: The strike reconnaissance concept as a counter weapon to mobile missile launching; providing our foot soldiers with safety and air mobility; revolutionizing automobile transportation with an automatic destination system; transmitting telemetered motor instructions from a human operator to a machine; advanced infrared navigational methods for space applications; family-sized air vehicles utilizing lift augmentation; studying all physical aspects of living in a space environment and correspondent instrumentation and telemetry; flight vehicles for safe, fast, economical, atmospheric and space travel.

High-caliber scientists and engineers are invited to explore Lockheed's long-range plans—future projects that offer great rewards for men of great promise. Openings are available in: Aero-thermodynamics; electronics—research, systems; flight test instrumentation; servosystems and flight controls; experimental physics; astro-physics; bio-physics. Please address your inquiry to: Mr. E. W. Des Lauriers, Manager Professional Placement Staff, Dept. 1704, 2404 N. Hollywood Way, Burbank, California.

LOCKHEED / CALIFORNIA DIVISION

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THE MISSILE / SPACE WEEKLY

missiles and rockets

April 4, 1960 Volume 6 No. 13

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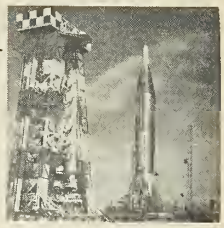
THE COVER

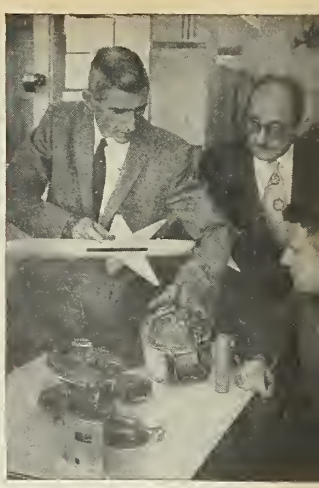
Avco's RVX-4 nose cone crowns an Atlas on launcher at Cape Canaveral. For a report on progress in Air Force nose cones, see p. 32.



29,900 copies this issue

WHO

"MISSILES AND ROCKETS magazine is particularly valuable to us as it helps anticipate new and future trends through its concise technical news coverage." Fred R. Youngren, Manager, Raytheon's Aeromechanical Branch. In the picture above, Mr. Youngren (left) explains to Hal Gettings (center) of the editorial staff of Missiles and Rockets, the Raytheon thermal shock test process for ceramic radomes. It is through tests such as these that improved radomes have been produced to meet the requirements and conditions demanded by higher and faster missile flight.



Clark C. Abt (left), Manager of Raytheon's Advanced System Studies Section and a regular reader of Missiles and Rockets magazine, discusses some of the problems of anti-ballistic missile defense with M/R Editor Hal Gettings. This particular section of Raytheon is working on the design and analysis of systems to detect, track and intercept threatening vehicles from sea, the atmosphere and space. This program is a natural outgrowth of Raytheon's extensive studies of air defense by means of surface-to-air and air-to-air guided missile systems.

"Even when a component is developed to a fine point, there is still a problem of extending the *state of the art*. The weekly issues of Missiles and Rockets keep us posted on the latest achievements of other companies in the missile/space field." Bertrand E. Chatel (left), Gyro Section Manager.

(above right) "High power output in a small reliable package is a basic requirement for electrical power units. Missiles and Rockets continually provides us information in related areas of engineering." John V. Kelly (left), Head of the Engineering and Mechanical Design Section.

READS MISSILES AND ROCKETS?

Well, for example . . .

TOP ENGINEERS AT RAYTHEON

Raytheon's Missile Systems Division has achieved outstanding success in pioneering and producing major missile systems. Two of these have been for the U. S. Navy air-to-air Sparrow III and the U. S. Army ground-to-air Hawk. These achievements, conclusive proof of unlimited capabilities, received their chief impetus when a Raytheon-developed guidance system installed in the Navy's experimental Lark achieved history's first successful interception in 1950 and first destruction of an airplane by a guided missile in 1951.

Much of Raytheon's success in guided missile systems since 1944 is credited to the tight integration of systems and component engineers. Close liaison of these groups provides systems engineers with rapid assessment of potential advances in "state of the art" of components and circuits, and also gives component engineers early indication of future requirements for meeting the needs of new, more complex missile and space systems.

Raytheon's Gnat gyros, for example, were first in the field, have been continuously refined, and now are mass-produced. Thermal effects of ever higher supersonic speeds are continuously being met by newly developed ceramic radomes—the largest being 4 feet long, 15 inches in diameter, and weighing 90 lbs. Highly reliable Electrical Power Units (EPU's) have been compacted into the smallest of spaces.

The further ability to carry these and other developments through flight test and into quantity production has resulted in the present top performance and high reliability for Raytheon's Hawk and Sparrow III missiles.

Experience of accomplishments in the broad field of missile and space sciences has promulgated study and development programs in solar energy conversion, ion propulsion, very-long-range ICBM tracking and identification radar, infrared missile applications and range instrumentation systems. Parallel advances also have followed logically, with studies of AICBM systems and investigation of means for defense against satellites.

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missiles and rockets

AN AMERICAN AVIATION PUBLICATION

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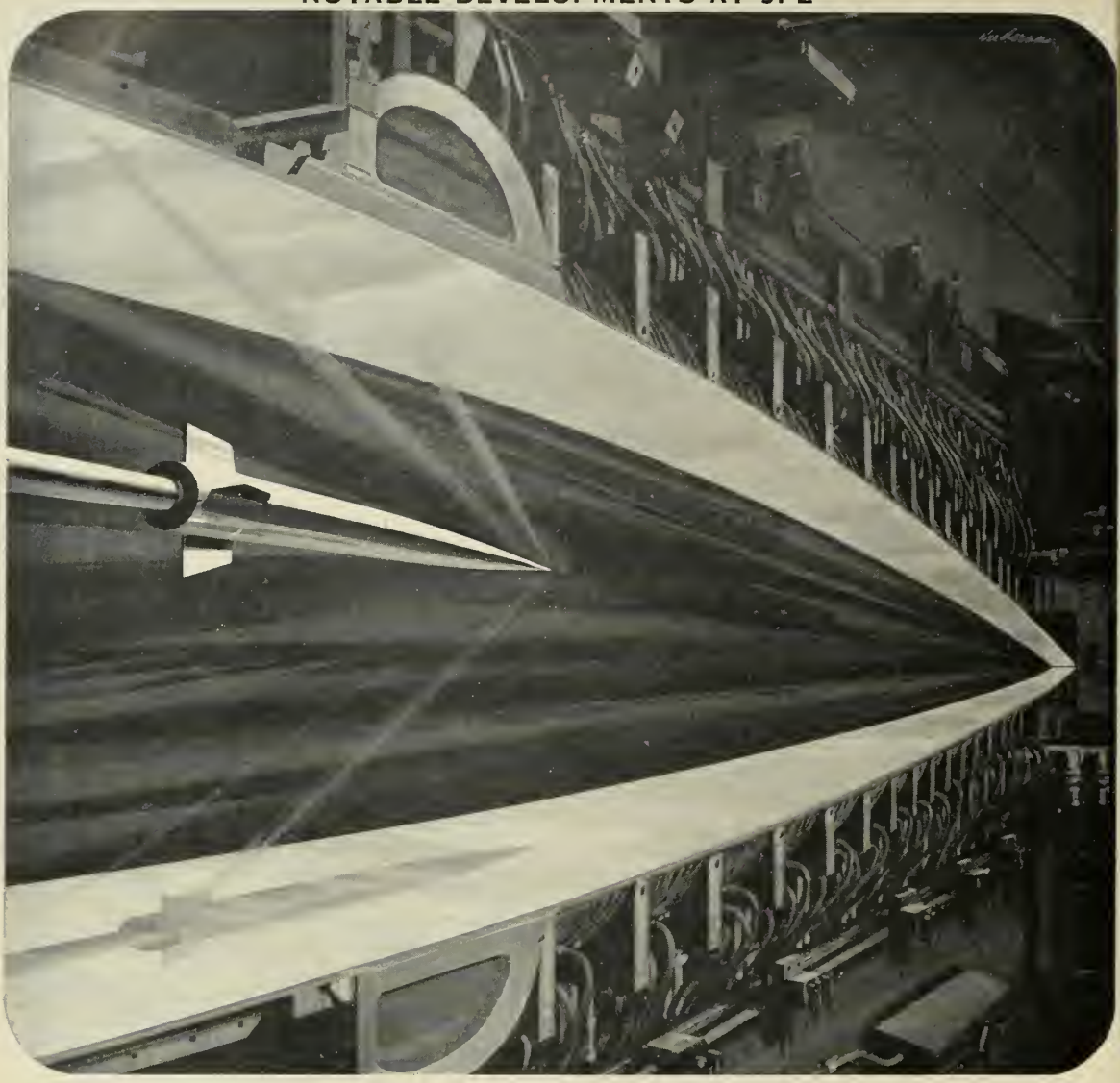

HYPERSONIC WIND TUNNEL

One of the latest research facilities at the Jet Propulsion Laboratory is the recently completed, continuous-flow hypersonic wind tunnel. Developed by the Lab, this new tunnel generates air speeds up to ten times the speed of sound. Its 21-inch square test section provides accommodation for models up to four feet long thus permitting increased model instrumentation. This large test section at Mach 10 with a continuous uniform air flow broadens JPL capabilities in the important area of fluid dynamic research.

To minimize structural deflections due to temperature changes and thus the time required to reach equilibrium conditions, the entire tunnel structure is water cooled and housed in an air conditioned building. Any Mach number between five and ten can be precisely set by means of flexible stainless steel nozzle plates that are positioned to a ten-thousandth of an inch. Calibration results indicated satisfactory solution of the design problems encountered.

The high speed data-acquisition, reduction, and presentation system is designed for high production testing of the nation's most advanced missiles and re-entry configurations. Stability and control phenomena in new regimes can be studied experimentally under carefully controlled conditions.

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Washington Countdown

IN THE PENTAGON

The second *Transit* . . .

navigation test satellite is now scheduled to be launched about mid-April. The launching originally was planned for February, but it was postponed because no booster was made available.

• • •

The new *Thor-Delta Star* . . .

booster under development by the Air Force will be used to boost *Transit No. 2*. Meantime, a *Transit* transmitter will be included in the next *Discoverer* satellite launching. That will be *Discoverer XI*.

• • •

***Minuteman* experts fear . . .**

that East-West negotiations on a nuclear test ban may prevent them from ever increasing the power of the *Minuteman's* nuclear warhead. They feel further testing would make possible a more powerful warhead—closer to the size of the *Atlas* warhead.

• • •

Tank tracks for *Mauler* . . .

are planned by the Army. Plans call for carrying the new Convair missile on the AMF's new 113-tracked chassis. Eventually, the Army wants to carry other missiles on it also.

• • •

***Dyna-Soar*'s master blueprint . . .**

is expected to be laid down by the current Air Force study of the planned space bomber. The blueprint will cover all three planned stages ranging from glider tests through ballistic flights to the operational spacecraft.

• • •

A Navy communications satellite . . .

is being worked on. It will weigh about 50 pounds and will be launched into an orbit ranging between 400 and 600 miles from the earth.

• • •

Designing two missiles in one . . .

is under consideration by the Army. Some Army missilemen want to combine the proposed *Missile A*, a direct battle support missile, and the proposed *Missile B*, an indirect battle support missile, into one bird.

ON CAPITOL HILL

Moneyman for Symington . . .

presidential campaign will be Oklahoman Hal Stewart, who was an assistant AF secretary when Symington was boss of the Air Force. Lots of big oil and defense industry tie-in here. Ed Hogan, former Air Force Association publicist now with GE's Evandale group, has been offered an important spot in the Symington publicity setup.

• • •

Life-long Republicans . . .

in the defense industry will give money, support and votes to Symington. Reason: dissatisfaction with the present defense-space program and budget.

AT NASA

Project *Mercury Redstones* . . .

will use *Jupiter-C* tankage in order to increase their burning time.

• • •

High hopes . . .

are held out for Project *Ranger*, an attempt to rough land intact an operating instrument package on the moon in 1961.

• • •

Wallops Island's . . .

causeway from the mainland has been completed but not surfaced. Light vehicles can presently make the trip.

• • •

***Centaur* . . .**

may be ready sooner than expected. Original launching date was the summer of 1961, but insiders now say that the liquid hydrogen-LOX stage may be completed by March, 1961.

INTERNATIONAL

More Red missile bases . . .

are reported under construction in the rugged Albanian countryside. The Soviet Union is reported to have missile bases ready at Valona, Skutari and Durazzo, from which to strike at Italy.

• • •

Japanese missile experts . . .

will tour the United States and Western Europe within the next two months. The 14-member delegation is headed by the Mitsubishi Electric Co.

DOPLOC Already Operating

To the Editor:

Your article in the March 7 issue has come to our attention.

To clarify the Army DOPLOC position in the dark satellite fence would require considerable space. However, in essence, the DOPLOC system presently in the field is even now furnishing data on satellite "strikes" to the proper agencies. It might be pointed out along these lines that the unknown satellite you mentioned was detected by DOPLOC and reported in early October to the proper agencies.

Realizing that the problem of acquiring unknown targets such as dark satellites is an extremely difficult problem with conventional searching "pencil" antenna beams, the Ballistic Research Laboratories as an interim measure adopted the concept of the fence much as you described in your article. In such a system, the satellite flies through the fixed "fence" antenna beam yielding one bit of information. This concept furnishes limited information for calculating of orbit on one satellite pass.

While still operating a "fence" type of DOPLOC system as an interim measure, the Ballistic Research Laboratories have conceived a more sophisticated system. This proposed system has been submitted to higher authority for approval. This system will allow rapid calculation of orbit on one satellite pass. Use of the Doppler rather than conventional ranging techniques assures the extremely high precision required in orbit determination.

James P. Hamill
Colonel, OrdCorps
Director
U.S. Army Ordnance Ballistic Research Laboratories
Aberdeen Proving Ground
Maryland

Packard Bell's ATE Work

To the Editor:

Your article, "Automatic Test Equipment Burgeons" (M/R, Feb. 29), is a good one, and I am sure it has brought many people up to date on the current status of automatic test equipment.

I would like to point out, however, that you have slighted Packard Bell in your chart designated Missile Systems and Test Equipment. Packard Bell has been a major subcontractor to Douglas Aircraft on the *Thor* project and some $23 million worth of automatic test equipment was delivered under this contract.

Other missile programs that we have worked on include: *Falcon*—$1 million ATE; *Snark*—$.5 million ATE, *Talos*—$1.5 million ATE; on *Polaris*, we received our fair credit.

Jack D. Behr
Director of Advertising and Public Relations
Defense and Industrial Group
Packard Bell Electronics
12333 W. Olympic Blvd.
Los Angeles 64, Calif.

How *Saturn* Arrived

To the Editor:

Congratulations for a very fine piece of friendly reporting on the *Saturn* and the *Saturn* team.

It might be of interest to your readers to correct two items, just to keep the record straight. Preliminary design studies on a 1.5 mill. thrust booster were started at ABMA as early as April, 1957; however, they were based on using four E-1 engines from Rocketdyne at 330K each, an advanced engine at that time under development. These design studies as well as the fact that our test tower with some modification could handle such a booster were brought to the attention of ARPA in July, 1958.

It was R. Canright and D. Young of ARPA who then suggested to use eight *Jupiter* engines instead of the four E-1 engines in order to save some $50 million engine development money which just was not available. They deserve the credit that the *Saturn* finally was approved by ARPA and funded by the amount of $10 million to demonstrate the feasibility of a multi-engine cluster. Thus it was not us who suggested an eight-engine cluster; ours was a four-engine cluster but with the same thrust level.

H. H. Koelle
Chief, Future Projects Design Branch
Army Ballistic Missile Agency
Huntsville, Ala.

Army's Fuel Cell Report

To the Editor:

I have been enjoying your magazine for some time and noticed in the 14 March issue that you have some information on fuel cells.

I would very much appreciate receiving a copy of Report Number 1, Status Report on Fuel Cells by the Army Research Office. If you do not have this report, I would appreciate knowing where I could receive one.

R. J. Boyle
Senior Marketing Analyst
Military Products Group
Minneapolis-Honeywell Regulator Company

In answer to this and numerous other inquiries, the report entitled "Status Report on Fuel Cells," by B. R. Stein, ARO Report No. 1, June 1959, is available from Army Research Office, Office of the Chief of R&D, Dept. of the Army, Washington 25, D. C.—Ed.

Industry Countdown

MANUFACTURING

Another delay . . .

is reported in Project 3059, the proposed Air Force solid-propellant booster with 100 million lb.-seconds total impulse. Although the word until last week was that Aerojet-General would win the contract, competing companies feel the battle is not lost. Thiokol, in particular, feels that the big booster can be its biggest challenge in this decade.

• • •

Minuteman will measure . . .

just under 60 ft. long, according to Capt. Frank H. King of BMD. Fully armed missile will weigh 60,000 to 70,000 lbs., less than *Thor* and about ¼ as much as *Titan* or *Atlas*. Four-nozzle system will permit control of pitch, yaw and roll. Third-stage power will cut off before burnout if desired.

• • •

NASA will select . . .

a contractor this month for Project *Sunflower*, a 3 KW solar power system for use in *Centaur* and *Saturn* space vehicles. *Sunflower* consists of a solar collector that focuses heat on a boiler that vaporizes liquid metal to drive a turbo generator. The competition drew 23 bidders.

• • •

World War II rockets . . .

are being used to cut the cost of *Bullpup* air-to-surface trainer missiles produced by Martin. Under a $700,000 AF contract, Martin is building trainers with obsolete HVAR motors weighing only 125 lbs., about ⅛ as much as operational *Bullpups*, but with the same aerodynamic characteristics.

PROPULSION

Saturn cluster concept . . .

underwent successful first static test March 28 at ABMA. Two Rocketdyne H-1 engines, each generating full 188,000 lbs. thrust, were fired in tandem for a little less than 30 seconds. Resonance was within safe limits and, with the new 30,000-gallon-per-minute water spray in operation, noise was less than in a *Jupiter* test. Results were telemetered on 300 channels.

Tests of four engines, six engines and the full eight-engine cluster are planned in rapid sequence, probably within the month. NASA Administrator T. Keith Glennan told the Senate Space Committee the *Saturn* booster will be flight tested with dummy upper stages in summer of 1961.

• • •

Long production run . . .

of engines for the Army's liquid-propellant *Corporal* is about to end at Ryan Aeronautical with the changeover to the solid-propellant *Sergeant*. Ryan has produced "many hundreds" of *Corporal* engines since production began in 1951. New project at Ryan: cases for the Grand Central *Viper* a small solid motor used to propel research sleds.

ELECTRONICS

Super-accurate data . . .

transmission system has been installed at Atlantic Missile Range. The automatic system, which RCA calls CODIT (Computer Direct to Telegraph) is used to transmit computed trajectory data from Cape Canaveral to downrange radars in a few seconds.

• • •

Navy has almost completed . . .

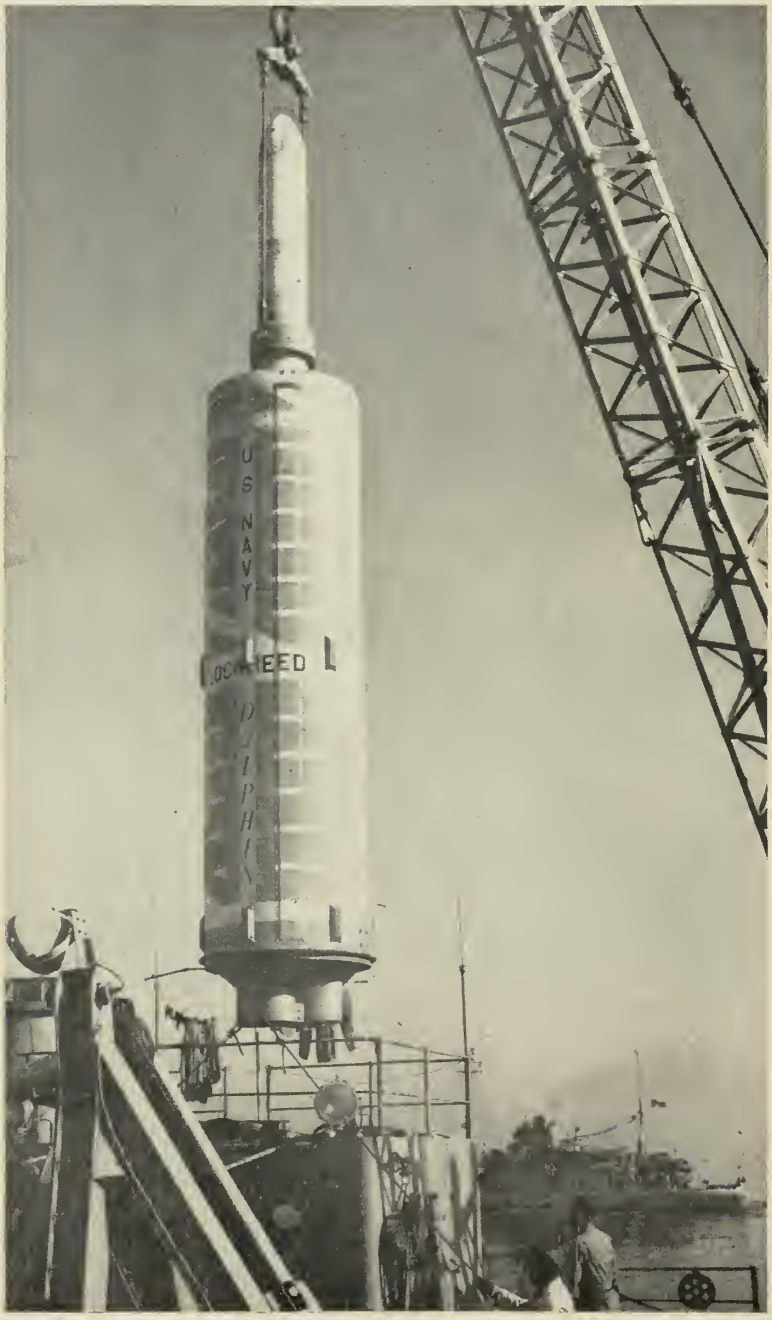
work on Project *Artemis*, a study to establish the feasibility of ocean area antisubmarine surveillance. Meanwhile, Douglas Aircraft's El Segundo Division reports development of an electronic system for detection and analysis of underwater sound.

WE HEAR THAT

Britain has curtailed . . .

work on the *Blue Streak* IRBM, while the government reappraises its whole defense policy . . . Russia is building airport facilities for jet cargo carriers big enough to handle large rockets at the major launching sites in Irkutsk at Alma-Ata, and at Khabarovsk, near the rail line to the Komsomolsk missile base . . . The Navy has deployed two more *Bullpup* squadrons to the Far East, aboard the USS Ranger in the Seventh Fleet.

Navy Opens *Polaris* Assembl



DUMMY OPERATIONAL *Polaris,* **dubbed the** *Dolphin* **is designed for training submarine missilemen and testing equipment aboard** *Polaris* **submarines.**

By James Baar

CHARLESTON, S.C.—The Navy's *Polaris* program last week moved several major jumps forward toward the time later this year when the first operational missiles are scheduled to go to sea.

The Navy officially opened its $27-million *Polaris* Assembly Depot some seven miles up the Cooper River from this old Southern city. From here all *Polaris*-launching submarines will take on their operational 1200-mile-range missiles before going on station somewhere in the world's oceans.

Meantime:

• Some 14 miles off Cape Canaveral on the evening of March 29 an all-but-operational Lockheed *Polaris* roared for the first time from the surface test ship Observation Island and impacted more than 900 miles down the Atlantic Missile Range. The *Polaris* system's operational navigation, fire control, launching and guidance systems were integrated for a firing for the first time. The Navy said all test objectives were achieved.

• In Washington the Navy announced it would pump another $52 million into the *Polaris* program to speed up work on seven *Polaris* submarines now under construction. The money is not connected with Navy Proposals to add more nuclear-powered *Polaris* submarines to its Fiscal Year 1961 budget.

• Somewhere in the Atlantic the nuclear-powered George Washington, first of the *Polaris* submarines, was reported to be launching Lockheed *Dolphins,* the new dummy operational *Polarises* designed for training and testing equipment.

• Rear Adm. William F. Raborn, head of the *Polaris* program, told newsmen that a 2500-mile-range *Polaris* could be developed by the end of 1963 if enough funds were provided.

• **Minor setback**—The only setback of the week for the *Polaris* program turned out to be a random accident.

Off San Clemente Island, Calif., the first "hot" firing of a *Polaris* from a submerged launching tube failed because of faulty wiring in the blockhouse. The 28-foot cut-grain test missile successfully "popped" from the tube but failed to ignite because its internal power had been cut off automatically seconds before the launching

acility

Officials called the setback minor. They said the wiring was not part of the operational system.

• **Producer-to-sub**—The new 880-acre *Polaris* Assembly Depot—called the Navy Weapons Annex—will be the link between the industrial team producing *Polaris* and the *Polaris* submarines.

The missile components will be flown to the Annex and stored. Warheads and motors will be kept in special underground magazines.

A series of specialized buildings have been constructed to check out and service the missile's components before they are assembled into an operational weapon ready to be placed aboard a submarine.

Missiles that already have been to sea will be brought back here for periodic major checkouts and overhauling. All *Polaris* submarines returning from station for overhauling will first unload their missiles at the Annex.

• **Specialized buildings**—One of the largest of the Annex's buildings is the 24,300-square foot Inert Processing Building. This will be used for checking and repairing guidance systems, hydraulic systems and various electronic devices.

A 5400-square foot Motor Inspection Building will be equipped to employ bore-scope, X-ray and ultrasonic methods for checking motors for possible damage in transit from the West Coast.

Smallest of the buildings is a 3300-square foot Re-Entry Body Assembly Building, where the warheads will be readied for emplacement in the missiles. The building, with its rows of consoles, operating tables and little carts, has the air of a hospital.

The Annex has two other large buildings for housing equipment for the upkeep of support facilities and for storing the wide variety of shipping and handling containers used for the assembled missiles and the missiles' separate components. An Engineering Services Building is planned, and construction will begin in the near future.

Final putting together of the missile will take place in a 1500-square foot Missile Assembly Building, where three assembly lines can operate simultaneously. Once assembled, the missiles will first be placed in metal "liners" that will guard them against shocks and adverse temperatures. The liners, in turn, will be inserted into wheeled containers for handling.

• **Tricky loading**—The protected birds will be hauled on railroad flatcars to a new 1000-foot pier about three miles away on the Cooper River. Here a $551,000 crane will carefully load the missiles either into the tubes of a waiting submarine or into the hold of a submarine tender.

In loading a missile, the entire container will be swung over a missile tube and the missile will be lowered into the tube by equipment inside the container itself.

Four miles of the Cooper River were dredged by the Army Corps of Engineers so that both *Polaris* submarines and tenders could have access to the area. The dredging cost $441,000.

The first of the *Polaris* tenders—the Proteus—will be a converted merchantman. The conversion work is being done at Newport News, Va.; the ship is expected to join the fleet this summer.

The Proteus will secretly rendezvous with the *Polaris* submarines at sea and provide them with various services, including the replacement of missiles in need of major work. The ship can handle about 20 missiles.

• **Navy industry staff**—More than 200 Navy officers and men will operate the Annex. They will be assisted by about 125 engineers from Lockheed, the missile's prime contractor; 15 from General Electric, developer of the *Polaris* guidance and fire control systems; and five from Aerojet-General, developer of the missile's big solid motors.

The buildings are laid out in a semicircle fronting the rows of widely spaced magazines. The entire area is surrounded by a high steel fence topped with barbed wire. Marine guards patrol it.

The isolated area in South Carolina's coastal back country was once a large plantation called Liberty Hall. The new buildings are now surrounded by newly bulldozed earth. But not far away Spanish moss clings to the live oaks, like ghosts of the Southern past.

The site was chosen because of a number of geographical and economic factors.

The area has a moderate climate and is an ice-free port throughout the year. It is protected, yet has easy access to the sea. And it is near a sizeable Navy yard at Charleston, which some of the *Polaris* fleet will use as a home port.

The existence of ammunition magazines and other facilities in the area, particularly the Charleston Ammunition Depot, enabled the Navy to cut overall construction costs.

Commissioning ceremonies took place on March 29—two days before the Annex opened. A large delegation of top Navy officials, including Adm. Raborn and Assistant Navy Secretary C. P. Milne, were on hand.

Milne called the Annex "the keystone" in the *Polaris* program.

Rep. L. Mendel Rivers (D-S.C.) proudly underlined the significance of the Annex more pointedly.

"Today Charleston becomes the potent thorn in the side of the Soviet Union," Rivers declared. "Today Charleston becomes the deterrent capital of the world.

"We also will make an indelible mark on the planning maps of the Soviet Union. This is the penalty we must pay for this great honor."

LAYOUT OF *Polaris* Depot, the Navy's new operational missile assembly facility near Charleston, S.C., is shown in an architect's drawing. The buildings lying in the semicircle from left to right are: Missile Assembly Building, Equipment Building, Motor Processing Building, Re-entry Body Building, Container Building, Inert Processing Building. Not shown are the widely spaced rows of magazines where warheads and motors will be stored.

NASA Aims to Push *X-15* Past Mach 3

by William J. Coughlin

EDWARDS AIR FORCE BASE, CALIF.—The National Aeronautics and Space Administration plans to push its first *X-15* rocket craft to speeds above Mach 3 within the next six or seven flights. Record altitudes of more than 24 miles are planned within ten flights.

This was revealed here as NASA Chief Pilot Joseph A. Walker made the initial research flight in the North American Aviation aircraft on March 25, taking it to Mach 2 at an altitude of 50,000 feet.

Walker is the first pilot other than NAA's Scott Crossfield to fly the *X-15*. Seven previous *X-15* flights have been contractor demonstration tests limited to proving out the design.

Meanwhile, the large XLR-99 rocket engine, capable of 50,000 lb. thrust and scheduled for installation in the third *X-15*, was delivered here last Monday (March 28) by Reaction Motors, Inc. The first North American *X-15* flight with the large engine is to be made in about six weeks, after Air Force inspection and test stand runups.

Walker made his flight in the No. 1 aircraft equipped with two interim XLR-11 rocket engines producing a total of about 16,000 lb. thrust. The aircraft was the first of the three *X-15's* to be turned over by North American to the joint NASA-Air Force-Navy program. Next flight in this aircraft will be made by Air Force Maj. Robert M. White, probably within the next two weeks.

Crossfield made the seventh powered flight in the No. 2 aircraft last Tuesday morning, a nine-minute flight to 50,000 feet and 1300 mph which included a negative 2g maneuver. Two powered flights have been made with the No. 1 craft and the No. 3 ship will not be flown until the XLR-99 engine is installed. NASA probably will receive this aircraft in late summer.

• **'Felt wonderful'**—Walker's initial flight was not preceded by glide flights. Obviously relieved after sweating out a three-day delay resulting first from weather and then from a broken LOX line, the NASA pilot emerged from the cockpit with a broad grin to announce that it "felt wonderful."

"The *X-15* seems to be a good extension of our knowledge from the previous X-aircraft," he said, adding that the rocket craft handled "just like the simulator."

PRIOR TO successful first flight in *X-15*, NASA Chief Pilot Joseph A. Walker is shown in simulator chatting with Scott Crossfield, his only predecessor as an *X-15* pilot.

Walker said the NASA program calls for pushing the *X-15* to speed limits of its flight envelope before altitude capabilities are explored. This is expected to take it far enough above Mach 3 to break the present speed record set by the X-2. Walker predicted the X-2 altitude record of 126,200 feet also will be exceeded. A high-speed research is being undertaken first since it makes possible a better check of handling characteristics than the altitude flights.

"How far we get over Mach 3 will be a function of how well we do on scavenging propellants and how much burning time we get," Walker said.

• **Normal landing**—On his initial flights, Walker explored sideslip, longitudinal and directional impulses in addition to familiarizing himself with the ship. After dropping from the B-52 mother ship at 45,000 feet, he climbed back to 50,000 feet and a Mach 2 speed before making a 2½-3g turn back to a normal landing on the dry lakebed.

Despite some slight difficulty in getting one of the upper barrels alight, Walker had all eight firing within a minute after drop. Total flight time was 11 minutes.

Walker said maximum altitudes with the No. 1 aircraft probably will be achieved within eight to 10 flights.

"The only target date we have is to shove along as hard as we can go and still be sure we know what we're doing," the NASA pilot said. Maj. White in his first flight will follow the same familiarization pattern. After that, the two pilots will alternate in stepping up the speed by increments.

Hardware has not yet been installed for the *X-15* reaction controls, although Walker twice has flown the test installation of reaction controls on a Lockheed F-104. This portion of the program still is in the development stage.

• **Oversensitive**—Walker disclosed that some material difficulties have been encountered with the storage bladders which contain the peroxide for the reaction system. He said the present system also has too high an increment of thrust above zero in its initial response, making it oversensitive.

The project has not yet reached the point where the F-104 has been flown while entirely dependent on the reaction controls.

During his *X-15* flight, Walker flew the craft entirely with the center stick, not employing the side stick. He said Crossfield also has switched to use of the center stick on all landings. North

American changed the response rate on the *X-15* tail after the initial landing by Crossfield got slightly out of phase.

In preparation for their own roles in the program, both Walker and White have flown chase on every Crossfield flight. They also have made numerous flights in the so-called "dirty" F-104 configuration to approximate *X-15* landing characteristics. In addition, the two men have attended the Crossfield debriefings and studied his flight reports.

"We three also have gotten together and just talked the thing over," Walker added. But he revealed that only two such talks have taken place.

• **Checks on Crossfield**—Under North American's contract with NASA, Crossfield has been limited to proving flights. There is little doubt the NAA pilot has been chafing under the restriction and this has led to some tension within the program.

Crossfield also will be restricted to low-speed and low-altitude runs with the No. 3 ship when it begins flying with the 50,000-lb.-thrust engine. This is a partially throttleable engine, with the first throttle opening producing about 30% of total thrust. To hold down performance, Crossfield presumably will be forced to employ his available rocket power only in bursts.

XLR-99 engines eventually will be installed in all three *X-15's*. With this engine, NASA expects to achieve speeds of well over Mach 6 as well as the design height of 50 miles or more.

• **100 miles . . . maybe**—D. E. Beeler, Assistant Director of the NASA Flight Research Center here, says the *X-15* "may hit the much-publicized 100-mile altitude mark, but we will have to wait until we get farther along in the program before we make any predictions." The *X-15* is designed to withstand re-entry temperatures of 1200°F.

Research areas to be probed in the high-speed *X-15* program include zero-gravity pilot problems, re-entry maneuvers, structural heating and structural loads during re-entry. North American also has proposed advanced projects which would employ *Atlas* and *Saturn* boosters to put the *X-15* into orbit.

Other pilots scheduled to take part in the *X-15* program include Lt. Cmdr. Forrest S. Petersen, Navy; Capt. Robert A. Rushworth, Air Force; John B. McKay and Neil A. Armstrong, NASA.

Bomarc Money May Go For *Atlases*

Proposed slash in funding for Air defense missile would provide more ICBM's; some sense behind-scenes bargaining

The Air Force-proposed slash of $381.1 million from the Boeing *Bomarc-B* program in FY 1961 made clear more than anything else in recent weeks the nation's capability and need to increase its ICBM power in the face of the growing Soviet missile threat.

However, at the same time, it also demonstrated the dangers of borrowing from one big defense program to pay for another.

The Air Force proposals as outlined to the House Appropriations Subcommittee would result in these major changes:

• Reducing the total number of *Bomarc* squadrons from 12 to eight. Five of the approximately 30-bird squadrons would be 200-mile-range *Bomarc-A*'s; three would be the 400-mile-range *Bomarc-B*'s. Only $40.4 million would remain in the FY '61 budget for *Bomarc-B*.

• Increasing the size of six *Atlas* squadrons from nine to 12 missiles by the end of calendar 1962 at an initial cost of $136 million. Total cost including construction of the hardened sites will be $326 million.

• Improving the radar and firepower of the McDonnell F-101 B and the Convair F-102 and F-106 supersonic interceptors at a cost of $134 million. The jets would be armed with the new nuclear-tipped Hughes *GAR-11 Falcon*.

• Eliminating all eight planned hardened *Sage* interceptor control centers at a saving of an additional $274.2 million over FY 1960 and 1961. The nation now has 11 completed "soft" *Sage* centers and nine under construction.

The effect of the proposed cuts on the *Bomarc-B* program would be to cut off all production orders as of about April 1. However, R&D on the controversial air-breathing missile will continue in order to provide operational birds for the three planned remaining squadrons.

A Boeing spokesman said the effect of the cuts on his firm would be a reduction of the 10,500 employes directly connected with the program by 2700 before the end of the year. He said cuts in employees indirectly connected with the program "will be proportionate" and that more drastic cuts are expected across the board in 1962.

Other increases in programs with funds taken from *Bomarc* and *Sage* include $27.6 million for advancing the operational dates of the second and third BMEWS sites; $61 million for the *Discoverer, Midas* and *Samos* satellites; and $27 million for the Boeing *Minuteman*.

Air Force officials testified that the Defense Department has already approved the proposed cuts but has not acted so far on the proposed increases to be paid for with the savings.

Moreover, the Pentagon already has turned down several Air Force proposals to use more of the savings that would be available for *Minuteman*, space projects and MATS cargo planes.

• **Bucking Administration?**—The Air Force proposal to build more ICBM's and launchers within the next two years ran counter to some Administration arguments that missile production could not be speeded up. It also ran counter to Administration statements that no increase is needed.

The proposed cut in the *Bomarc-B* program appeared to run counter to arguments advanced by the Administration last year in drumming up support for its proposed "master air defense plan" which leaned heavily on both the *Bomarc-B* and the now-dead North American F-108 program.

Finally, it appeared to run counter to the Administration argument that the Mach 3 F-108 could be killed last year because the nation still had the *Bomarc-B*.

Some observers felt the Air Force move followed behind-the-scenes bargaining with the Administration.

The results would be that the Administration could slip a few more ICBM's into the defense program to offset political criticism in an election year and the demands for a much bigger build-up. At the same time, the Air Force would get at least some of the increases that it wanted while cutting a program that seemed doomed to be cut by Congress anyway.

Big Missiles Will Cost $22.9 Billion

Mahon Committee reveals price tags on U.S. programs—Congress shows concern over missile/space gap

by Clarke Newlon

The 941-page report of the House Subcommittee on Department of Defense Appropriations, Chairman George H. Mahon. (D-Tex.), was released this last week. Most revealing facts in the report's two-inch bulk were:

- Costs of our major missile programs.
- Surprising optimism as to the operational dates of these programs.
- Interservice and even Intraservice fighting for millions in funding.
- Continued congressional interest in beefing up our missile and space program.

Chief witnesses in the missile field were: Army, Lt. Gen. Robert W. Colglazier, Deputy Chief of Staff for Logistics; Navy, Vice Admiral John T. Hayward, Deputy Chief of Naval Operations, Development, and Rear Admiral W. F. Raborn, Director, Special Projects; Air Force. Lt. Gen. Mark E. Bradley, Jr., Deputy Chief of Staff, Materiel.

Comparable costs of the big ballistic missile program, potential back-bone of the U.S. deterrent force were:

Atlas, $5.4 billion for 13 squadrons of 10, or 130 ICBM's.

Titan, $5 billion for 14 squadrons of 10 or 140 ICBM's.

Polaris, $9.9 billion for 45 equipped submarines, 16 missiles each or a total of 720 IRBM's.

Minuteman, no overall cost given, 1961 budget $368.3 million. Estimated cost (in production) $1 million each; estimated production 2600. Therefore, a possible program cost of $2,600 million plus development costs.

Operational dates for the missiles were given as follows, all of them with a degree of optimism which is not privately held by many in and out of the military:

- *Atlas,* one-half squadron activated in 1959 and a classified number of additional squadrons to be activated in calendar 1960.
- *Titan,* first operational squadron to enter SAC inventory in June, 1961.
- *Polaris,* available for deployment in 1960.
- *Minuteman,* build-up of operational hard force to start in mid-1962, with mobile system some months behind.

Least careful in their attitudes toward interservice rivalry were the Navy witnesses. Admiral Hayward referred to the *Bomarc* as "that horrible word." (The *Bomarc* program has been cancelled, in effect.) Admiral Raborn repeatedly stressed the advantages of *Polaris* over *Minuteman.*

The Air Force revealed its own family troubles in testimony about the *Titan* and the hot debates as to whether or not the program should be cancelled in favor of *Atlas* and *Minuteman.* The Air Force also revealed—and were questioned sharply about it—that some $579 million had been added to the *Titan* program to beef up its storable fuel potential and its guidance system.

Congressmen repeatedly questioned witnesses as to the missile and space gaps, the advisability of adding additional money to programs, of increasing programs, of speeding up programs by overtime. Many times the committee members invited requests for a speed-up of the defense/space effort.

Highlights of the various missile programs follow:

ATLAS

Thirteen squadrons of 10 each are programed. First four will be in "soft" sites.

Three squadrons with all-inertial guidance are programed to go into sites hardened to 25 psi.

Six squadrons will be installed in silos hardened probably to 100 psi.

One half of the first squadron was activated in 1959. "Additional" squadrons are to be activated in 1960.

Cost of the *Atlas* is $1.9 million, broken down as follows: Air-frame, $1.1 million; Propulsion, $.4 million; Guidance, $.2 million; Re-entry vehicle, $.2 million.

Total cost of the *Atlas* program is estimated at $5,400 million.

Cost per squadron of ten is as follows: Soft configuration, $20.1 million; hardened to 20 psi, $23 million; hardened to 100 psi, also $23 million.

The proposed long-range flight of the Atlas, intended to counter propaganda value of the Soviet Pacific missile shot, has been cancelled or postponed because of the chance it might err in flight and strike another sovereign country, Gen. Ritland, USAF, revealed to the committee.

He said that while the flight—in the 9000-mile category—would clear all land masses by at least 50 miles, this was not considered a sufficient margin of safety.

Maintenance cost is estimated at $5.3 million per squadron per year (the *Atlas* on the stand at Vandenberg for four months was in a state of readiness 98% of the time). No overhaul is planned for the ICBM. There will simply be a replacement of parts—such as the engine package. Eighty percent of the maintenance will probably be on GSE.

The spare parts problem will be handled by electronic data processing machines to keep a constant record of inventory.

Weapon system support equipment lists (WSSEL) on tools to support each *Atlas* unit number 3131 items (against 1905 for *Thor*). The cost is $32 million (the B52 WSSEL contains 2500 items and cost 114 million).

TITAN

The first operational *Titan* squadron is programed to enter the SAC inventory in June, 1961. First launch will be in October, 1960.

The first *Titan* in-silo launch will be made late this year. All-inertial flight testing for in-silo squadrons will begin in 1961.

The *Titan* program includes funds requested for *Titan Dyna-Soar* boosters as part of the *Dyna-Soar* early flight test program.

First six *Titan* squadrons will have radio inertial guidance in-silo sites hardened to 100 psi. They will be lifted by elevators for surface launch.

The last eight squadrons will be hardened 100 psi with storable fuel, all-inertial guidance and will be launched from within the silo.

Distance between silos, as in the *Atlas,* dispersal program will be 7 miles. SAC personnel started training in May 1959. Construction of a silo launch test facility has begun.

Four squadron sites are under construction and/or checkout.

The six successful *Titan* flights (of the 9 attempted up to March 3, 1960) were as follows: 245 nautical miles, 256 nautical miles, 300 nautical miles, 2385 nautical miles, 5050 nautical miles and one unlisted. The first all-inertial guidance flight of *Titan-2* is scheduled for March, 1961.

Actual expenditures on the *Titan* program (in millions):

1959 and prior	$1,132.7
Fiscal 1960	615.2
Fiscal 1961 (est'd)	873
Total	$2,629.9

Total appropriation through fiscal 1960 $2,202.3 million. Request for 1961 is $1,021 million. Total $3,223.3

million.

Total cost of the *Titan* program is figured at about $5 billion.

Cost of 14 squadrons, including development costs, averages out at $335 million.

Not including development costs, the price of a *Titan* squadron ranges from $138 million to $166.5 million, depending on the configuration. However, individual cost of each *Titan* is put at $1.9 million. Cancellation of the *Titan* program would save about $2.5 billion, that is, the $5 billion estimated total costs, less $2.1 billion cost through 1960, less cancellation costs.

On Dec. 1, 1959, the *Titan* was upgraded for the last 8 squadrons to include storable potential, in-silo launch and uprating of the nose cone—at a cost of $400 million. The addition previously of the improved all-inertial guidance has cost $179 million.

MINUTEMAN

Cost of the first *Minuteman* installed in its inverted silo is estimated to be $2 billion. After the missile gets into production this cost is expected to drop to below $1 million.

Annual cost of maintenance is expected to be about $135,000 each.

Minuteman will have two configurations—one hard and dispersed and the other mobile on trains.

Build-up of the operational hard force will start in mid-1962. The mobile system is some months behind this.

Minuteman missile sites will be 5 miles apart with multiple control facilities.

In the mobile configuration each train will carry several missiles with at least one launch control center. According to testimony "the train will be mobile, moving from point to point, depending on the intelligence cycle or the identity of this location to be determined."

All inertial guidance tests have been carried out on the sled track at Holloman AFB.

First prototype rail car test will be made at Canaveral.

OTHER AF REQUESTS

Other Air Force missile procurement requests were: *Hound Dog*, $170.2 million; *Skybolt*, $10 million for operational support hardware; *Bomarc* $50 million (dropped from $421.5 million after appraisal of air-defense program); *Mace* ($91.6 million in Fiscal 1960), $12.8 million to "buy out" remaining leadtime items; *Quail*, $71.2 million; *Bullpup* $16.2 million (operational and training version); *Firebee*, $19.3 million; OQ-1D (Radioplane division drone), $2.6 million.

POLARIS

Polaris will be available for deployment in calendar 1960.

Tactical hardware has been installed in the first submarine.

The inertial guidance system and the fire control system have been successfully tested.

There are 9 *Polaris* submarines now under construction.

Missiles are being produced on a conforming schedule. Crews are in training to be ready for each new submarine. Tenders and operational support facilities are under concurrent construction.

The *Polaris* budget breaks down as follows (in thousands):

Shipbuilding/Conversion ...	$378,032
Aircraft/missile procurement	149,591
Other procurement	13,383
R&D, test and evaluation ...	373,609
Operation and maintenance ..	26,017
Total requested	$ 940,632

Another $11,580,000 for separate military construction would bring the total '61 *Polaris* program to $952,212,000.

Total cost of the *Polaris* submarine program—45 submarines through fiscal 1964—would be $9.9 billion.

PERSHING

The *Pershing*, two-stage, solid-propellant successor to the Army's ground-to-ground *Redstone* has cost about $280 million to date. The 1960 appropriation was $145.8 million including $132 million for R&D and $13 million for procurement. The 1961 request is for $158.8 million. Total program cost is estimated at $1.2 billion through fiscal 1965. The *Pershing* intended for Army field use would carry only an atomic warhead.

The Air Force is still having manual troubles. The following conversation is recorded between Chairman Mahon and General Ritland:

Mr. Mahon: "I would like to know what we are paying in the Air Force for manuals for the missile program."

Gen. Ritland: "All of the missiles, the total?"

Mr. Mahon: "Yes. I have some information to the effect that it runs into many millions of dollars."

Gen. Ritland: "It is costly. However, the complexity of all missiles and all the ground support equipment requires manuals for training for operators and maintenance and repair."

Mr. Mahon: "This is a field which is quite expensive, but to spend $40 or $50 or $100 million on manuals would seem almost beyond comprehension. Do you know about this, General?"

Gen. Ritland: "Yes, Sir."

Mr. Mahon: "How Much?"

Gen. Ritland: "It runs in the order of $100 million."

OTHER ARMY MISSILES

The Army has included $109.9 million in the '61 budget for *Nike-Hercules*. More than 400 will be used for training between now and 1964.

The *Hawk*, a ground-to-air defense missile against low-flying aircraft, is programed for $94.5 million.

Other Army requests: *Redeye* $11.4 million; *Honest John, Little John*, amounts unspecified; the French *SS10* and *SS11* antitank missiles, amounts unspecified; *Sergeant* $52.1 million; *LaCrosse*, unspecified, however, $167,336,765.04 has gone into the *LaCrosse* from inception of the program to 25 Feb. 1960.

NAVY MISSILE SHIPS & NUCLEAR POWERED SHIPS & SUBMARINES

The Navy has 70 guided missile ships authorized.

The Navy has 40 nuclear-powered ships presently authorized with budget request bringing the total to 46.

Ten have been completed, 26 are under construction, 4 are pending contract award and 6 are requested in the '61 budget.

Cost of newest nuclear subs is placed at $57.2 million. The size is 3,750-ton surface displacement or about 200 tons larger than the Nautilus, which cost $90 million.

The Navy budget also includes $4.9 million for an oceanography research ship—a floating laboratory.

It also includes $20.8 million for a deep diving experimental submarine to test hull structures, sonar equipment and weapon systems for combat subs of the future.

ASW

Navy will shortly award a hydrofoil ASW ship contract, first authorized in FY 1961. Specs call for a 115-ton, 110-foot craft with two types of sonar, one conventional and one with a variable depth feature. Initial hydrofoil craft lifetime is pegged at three years.

The service complains that reliability, particularly shelf life, of sonobuoys is too low. Therefore in FY 1961 some sonobuoy money will go into finding out why. Further, sonobuoy specs will be tightened up so that manufacturers will turn out a standard product. Not only performance specs but detailed specs as well will have to be met now. Navy believes that such techniques will go far to solving its reliability problems.

ASW commanders might get some help from two hardware pieces that the new budget will be buying. First is a device said to greatly increase the accuracy of sonor detection and localization at long ranges; second is a modification to existing sonars "that will increase detection ranges about 30%."

Lanphier Hits Hard at Defense Policy

Accuses President Eisenhower of leading 'incompetently to a point where we are in jeopardy of our national life.'

Numbers and mobility of ballistic missiles is our only hope of building an invulnerable deterrent against massive attack, according to Thomas G. Lanphier, Jr., outspoken critic of Administration defense policies.

And accelerated funding and manufacture are necessary if we are to build this deterrent in time to save the nation from disaster, he said in a speech to the National Press Club.

Lanphier pointed out that our entire operational ICBM force is now only one soft aiming point for the enemy. The *Atlas*, although testing out satisfactorily, is not currently planned in significant operational numbers and deployment for another two years. The *Titan* is proving itself a competent weapon, but its development is much farther behind schedule than is popularly supposed, according to the former Convair vice-president.

Continuing his attack on President Eisenhower's defense leadership, he denied any political aspirations. He stated in answer to a question that he believed Sen. Stuart Symington (D-Mo.) is the Presidential candidate most likely to lead the nation in a realistic and effective defense program. He also said that should Symington become President he would be happy to do anything Symington asked of him, but that he was not campaigning for him and was nobody's "advance man."

• **Three musts**—The free-swinging missile man—who quit his job at Convair in order to be free to speak his mind—feels that the U.S. needs three categories of weaponry to survive. These are an invulnerable deterrent against massive attack (all-out war), a limited war deterrent, and a home guard.

As for the first point, Lanphier contended that neither in numbers nor mobility are our present ballistic missiles equal to the job. Mobile ICBM's—such as *Polaris* and *Minuteman*—are highly desirable but will be limited in performance even when finally available and will remain limited so long as we continue to restrict ourselves from underground testing of nuclear warheads. He said that operational *Polaris* systems —complete with submarine, crew, missile, and assigned targets—are still more than two years away.

One of Lanphier's main contentions is that our leaders have been unrealistic in appraising the enemy's missile strength. His opinion is that the Russian ICBM lead "could well exceed the 150 missiles General Power has conservatively estimated as needed to wipe out the Strategic Air Command." He also stated that it's a "critically dangerous fallacy" to assume the Soviet's guidance efficiency inferior to ours.

• **Statement of charges**—Other Lanphier points in criticism of President Eisenhower "for letting the wrong element of the Government dominate the size and shape of our defense forces of tomorrow":

• Present IRBM warheads are too large. They must be made smaller to allow longer range and more effective payload.

• "Push-button war" is here today, and we must recognize the fact.

• World War III has already begun and we are losing it.

• Critics of defense policy are few —not because few feel we are in a dangerous position but because those qualified are in positions where they either cannot speak out or their criticisms would be discounted as coming from "munitions mongers" or partisan, self-serving politicians.

• "New" categories of weapons— unrecognized as such—include national political philosophy, education, economics, propaganda, and outer space. Communism excels in all these; our only hope is to excel in physical military weapons systems including conventional forces needed to deter limited aggression.

• We do not—and will not for several years—have an effective warning system against missile attack.

• We have no home guard or national program for fall-out shelters.

• Our intelligence, sketchy at best, is not affirmatively used by our defense planners.

• Qualitative development in defense is encumbered by peacetime regulations and restrictions, and is largely in the dark as to progress and problems encountered by the enemy and known to our intelligence.

• Our concentrated population, lack of fall-out shelters, and lack of missile attack warning make us more vulnerable in an exchange of nuclear weapons than the Russians.

• **What to do**—To remedy our dangerous situation, Lanphier advocated the following immediate actions:

• Put SAC on alert with a fourth of its bombers airborne and keep them airborne for at least the next three years.

• Add 100 *Atlas* and 20 *Titan* underground sites by mid-1963.

• Accelerate *Polaris* and *Minuteman* toward fully operational status by 1963-4.

• Resume underground nuclear testing.

• Accelerate missile-warning satellites *Midas* and *Samos*.

• Begin serious development of an ASW system.

• Prosecute a sensible anti-ICBM system—most likely from space.

• Fund a modern and sufficient airlift for the Army and Marines.

• Prosecute nuclear propulsion for space and aircraft.

• Cancel the *Bomarc* and *Nike-Zeus*.

• Cancel the nuclear aircraft carrier.

• Unify the services.

• Require Joint Chiefs of Staff to build defense budgets on a functional basis related to the threat.

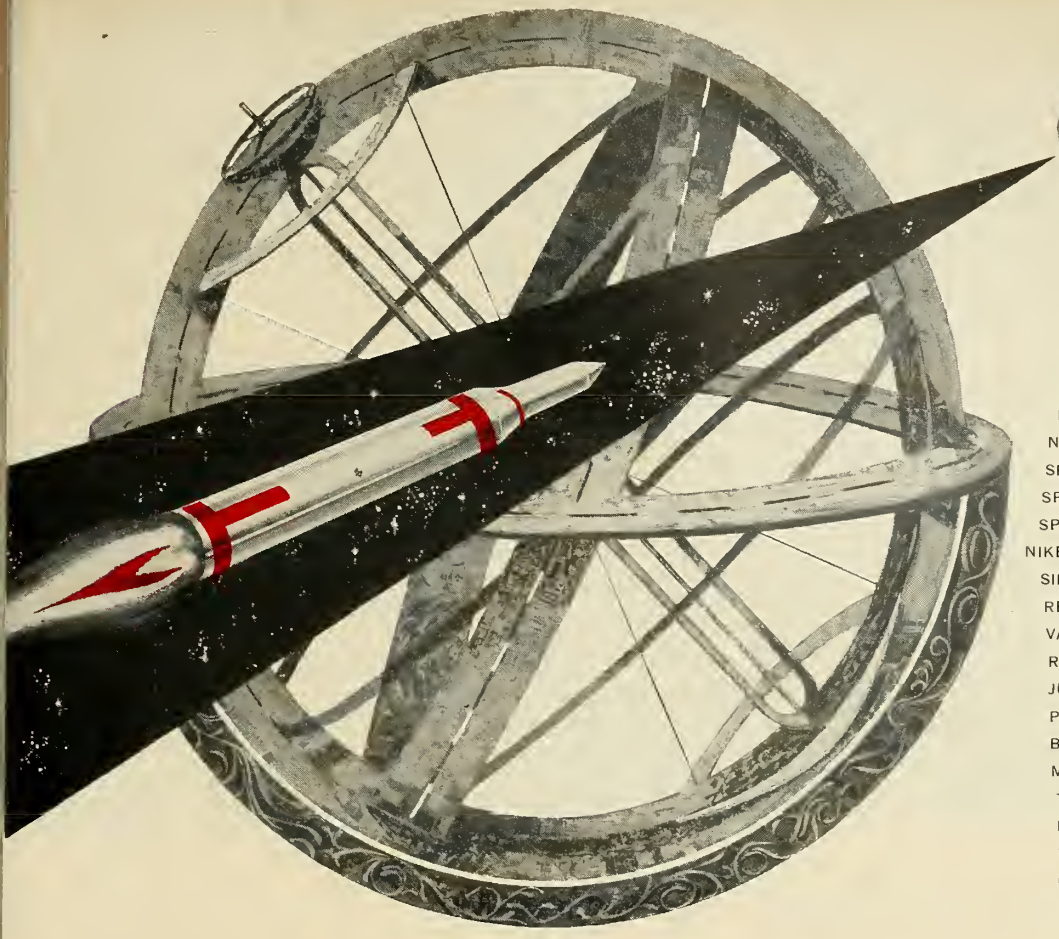
• Unify the space effort.

• Keep Congress and the executive branch advised of the estimated threat.

• Inaugurate a civil defense home guard.

• Establish and maintain a government agency for long-term planning of arms control.

• Substitute "sacrifice and survival" for "peace and prosperity" as a national watchword.



THOR
MACE
TITAN
HAWK
ATLAS
SNARK
NIKE B
BOMARC
NIKE ZEUS
SPARROW I
SPARROW II
SPARROW III
NIKE HERCULES
SIDEWINDER
REGULUS II
VANGUARD
REDSTONE
JUPITER C
PERSHING
BULL PUP
MERCURY
TERRIER
POLARIS
TARTAR
CORVUS
FALCON

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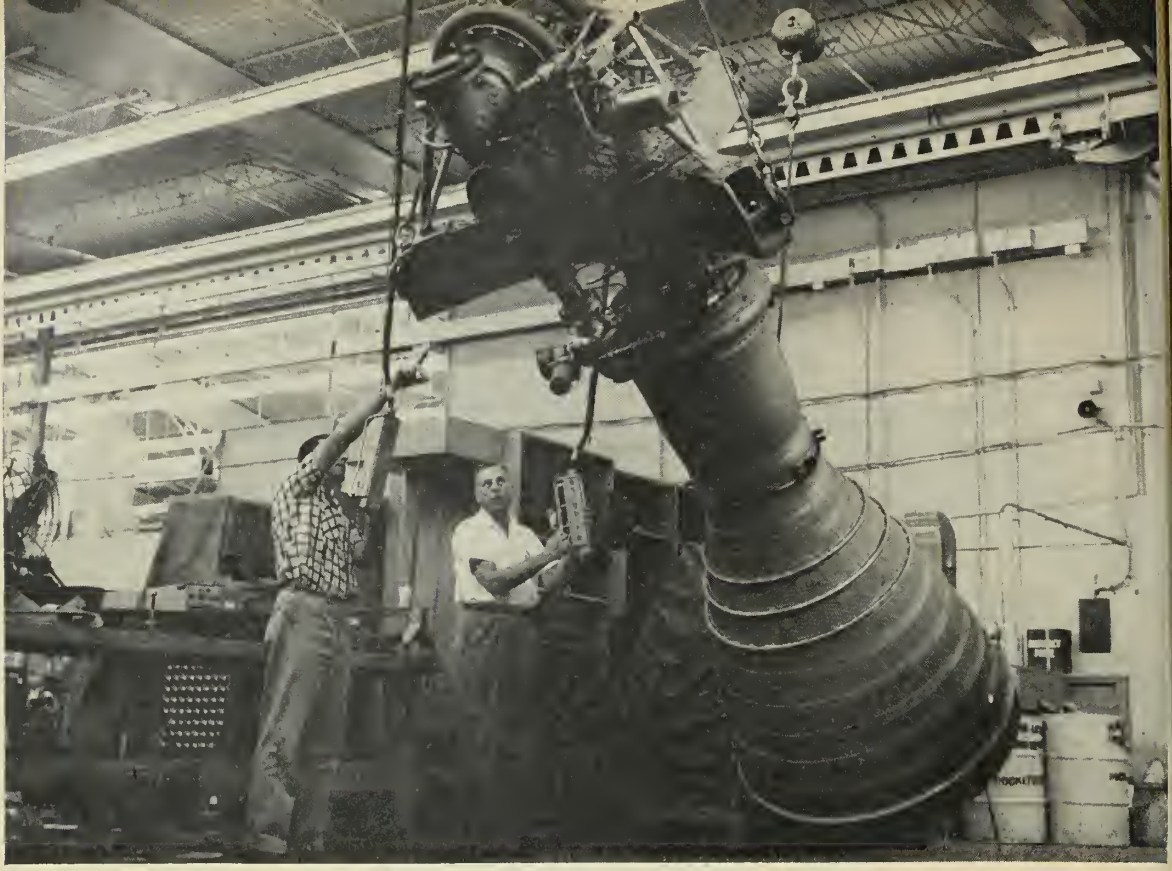


propulsion engineering

X–Series Leads to Simpler Engines

by Frank G. McGuire

CANOGA PARK, CALIF.—Development of a previously unannounced family of experimental rocket engines has been disclosed by Rocketdyne Division, North American Aviation.

The Air Force-funded program has contributed significantly to simplification of large liquid rocket engine designs, according to the company.

In the first of the series, dubbed X-1 by Rocketdyne, the engine was reduced to eight major components, in contrast with the 88 major components of the typical large liquid rocket engine.

The X-1 is a non-flying, test-bed engine. But innovations from the experimental powerplant have been incorporated in the H-1 *Saturn* engine, the MA-3 *Atlas* engine, the *Thor* engine, the 400,000-pound-thrust E-1 and million-pound-thrust F-1.

Development of the X-1 began in mid-1957, with a production-model *Thor* power plant as a start. Rocketdyne engineers began eliminating every system and component possible. Engine thrust was boosted by over 50%. Reliability was significantly increased.

• **Improvements**—The original *Thor* engine was simplified by:

• Eliminating the alternate complete-start system, with its tanks, pressurization and valving. A compact solid-propellant gas generator developed by Rocketdyne's McGregor, Tex., plant was substituted to start the main turbopumps spinning.

• Eliminating the pneumatic system for main fuel valve opening by a new system described only as "utilizing available energy sources."

• Eliminating the lubrication oil tank and its pressurization system. The engine now uses an additive-type, high-pressure lubricant fed into the fuel via a no-moving-parts blending mechanism. (The additive is a commercially available product being used for the first time in this application. Rocketdyne declines, however, to identify the additive or its chemical family.)

• Eliminating vernier engines for roll control by using turbopump exhaust gases to induce the required torque. The pump's exhaust gases are ducted to an appropriate point and deflected as directed by guidance requirements. The deflection mechanism has one moving part.

• Simplifying the propellant duct-

ing system from turbopump to combustion chamber by use of a lightweight, flexible connection designed by Rocketdyne. Brazed joints replace B-nuts wherever practical.

• Improving ignition methods.

The resulting X-1 experimental engine, first run in early 1958, also possesses a higher specific impulse than the original *Thor* engine. Total impulse remained about the same—being principally a function of tankage.

Still another simplification resulted from X-1 performance characteristics. Extremely rapid engine cutoff at a desired point eliminated the need for final velocity control by vernier engines. Engine cutoff impulse time has been reduced by 75% as compared to previous engines, thus bringing it within needed guidance tolerances without vernier correction.

The lack of complexity helps in one more critical operational aspect of large rocket engines—fewer components and systems mean simpler and less time-consuming checkout procedures.

• **Innovations**—The "final" X-1 configuration bears little resemblance to the original *Thor* engine which served as its springboard. Principal *Thor* features retained in the X-1 are the thrust chamber and regenerative cooling.

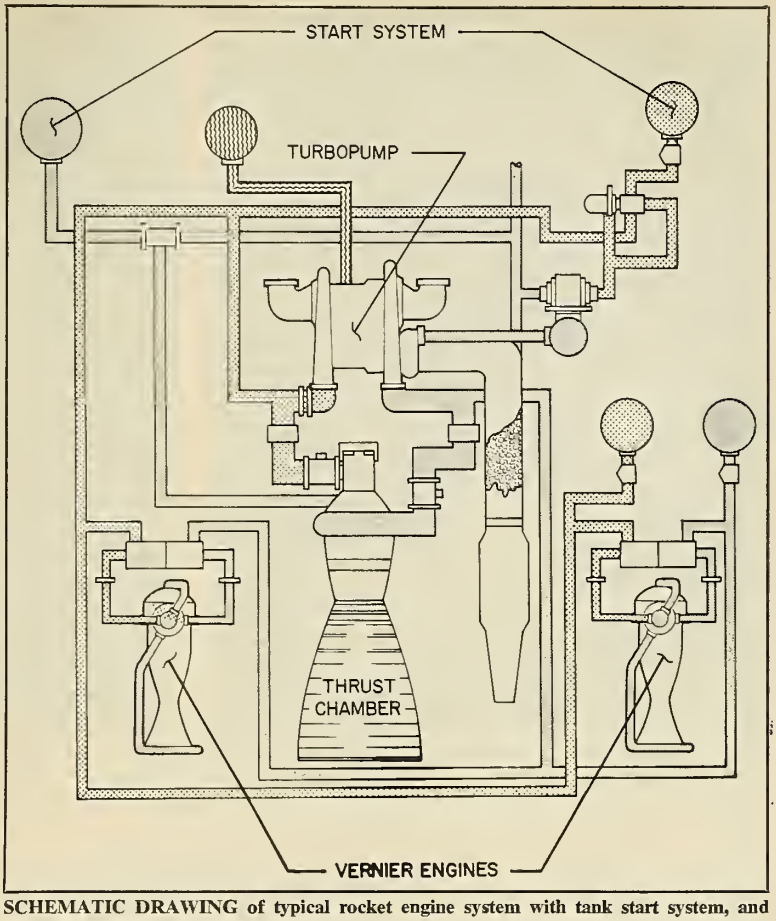
Thrust level of the experimental engine has been varied from 100,000 pounds to "well in excess of 200,000 pounds," the company says. Although not throttleable in present operation, the X-1 may be modified easily to include this capability.

The X-1 concept reverses near-traditional approaches to performance gains, Paul Castenholz, Rocketdyne's program manager for experimental engines, points out. In nearly all propulsion systems, from missiles to automobiles, performance-boosting designs are accompanied by increased complexity and/or increased size. This is not so with the X-1 despite its increased efficiency and use of advanced fuel combinations.

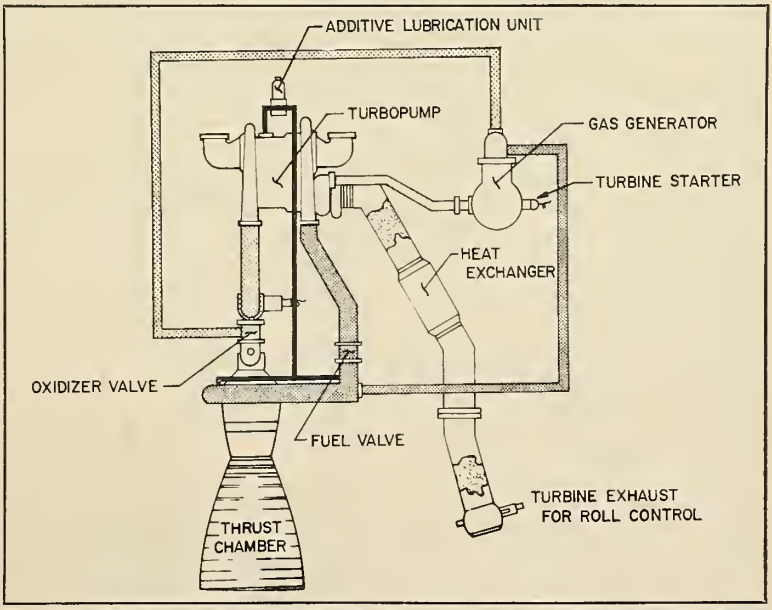
Elimination or simplification of the engine's systems brought greater freedom of tolerance for the remaining systems by reducing the number of critical features involved.

Developments made during the X-1 program have not created or compounded problems in other systems of a missile. Proving the feasibility of eliminating vernier engines for roll control poses no hurdle for guidance and control systems. A simple—almost elemental—circuitry modification would be the sole requirement to control the turbopump exhaust gas deflection system.

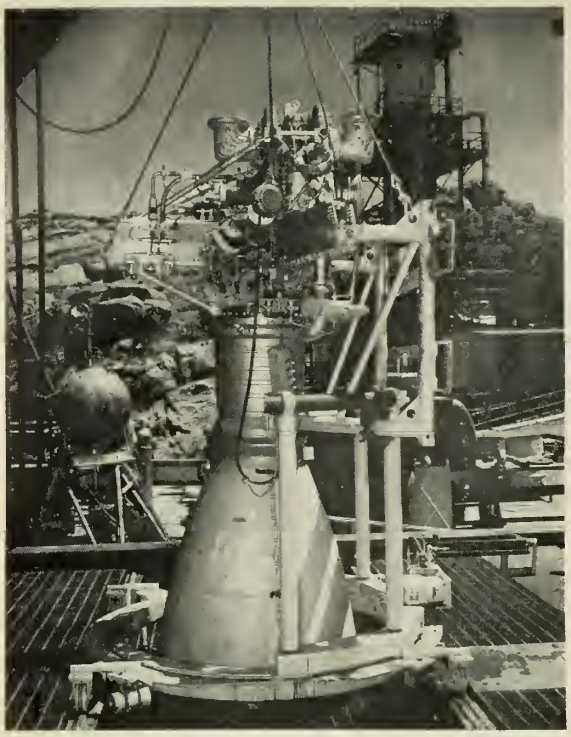
Concepts developed and proven in X-1 studies may be scaled up or down,



SCHEMATIC DRAWING of typical rocket engine system with tank start system, and vernier engines for roll control.



X-1 ENGINE, in similar drawing, shows innovations such as turbine spinner replacing tank start system, additive lubricant system and turbine exhaust for roll control.



ENGINE being installed in static test stand at Rocketdyne's field propulsion laboratory. New concepts were extensively tested over a period of two years.

X-1 ENGINE uses beam-type mount rather than usual tripod type to save weight, reduce fabrication time. Solid propellant turbine spinner is in dome at upper right.

Castenholz says, giving the project almost universal application to other engine design studies.

Such innovations as fiberglass-wrapped combustion chambers, brazed line connections, and other fabrication features have been proven on the X-1. As with any test-bed engine, the location and configuration of advanced hardware can be made with considerable freedom. Incorporating such developments into production "packages" is sometimes a problem. Adapting systems to fit a given space and weight requirements call for imagination.

• **Weight cut**—In the X-1 engine, weight was chopped by about 10% in comparison with comparable-thrust production engines. Minimum X-1 diameter requirements were governed by use of the existing *Thor* thrust chamber. But the engine is about two feet shorter than its predecessor.

The MA-3 engine now being used in *Atlas* is "pretty close" to the X-1 concept of simplified powerplants having greatly improved reliability, Rocketdyne says. The MA-3 uses separate turbopumps for each booster. This allows the turbopump assemblies to be jettisoned with the booster engines, rather than hauled aloft as dead weight.

The H-1 engine for the *Saturn* vehicle is "much closer" to the X-1 than the *Jupiter* IRBM engine generally thought to comprise *Saturn's* powerplant. Size and simplicity of the X-1 approach makes the clustering of such engines somewhat less complicated in terms of overall systems, controls and checkout.

The X-1 has been operated with standard cryogenic fuels as well as storable propellants. Company officials say fluorine and hydrogen could be used also.

Rocketdyne is continuing its X-series experimental engine program with even simpler versions of the X-1. Exactly how many developmental engines are involved has not been disclosed, but the company says it is "well into subsequent X-series numbers."

Part of the advanced design work now underway includes studies in radical thrust chamber design, including the plug nozzle concept.

Funding under a product improvement contract is through the USAF Ballistic Missile Office, Air Materiel Command.

Firing Record Broken

Two crews on Rocketdyne's horizontal test stand at Canoga Park, Calif., have completed a record series of 110 hot firings without a malfunction.

The firings took place between November, 1959 and January, 1960.

'Hottest' College Wind Tunnel Going at Stanford

Stanford University has disclosed the operation of a 12,000-mph wind tunnel, which it calls the "hottest" on any college campus. The hypersonic airstream can be heated to 14,000°F.

The tunnel was financed with a program sponsored by six companies: Convair Division of General Dynamics, Douglas Aircraft, Hughes Aircraft, Lockheed Aircraft, North American Aviation and Northrop. The research program is supported under contracts with the Air Force's Arnold Engineering Development Center at Tullahoma, Tenn.

The hypersonic airstream is designed to imitate conditions a space vehicle meets on re-entering the earth's atmosphere. It operates on the principle of arc discharge. A 200,000 watt-second spark sets off each shot, which lasts a 1/25,000 second. The discharge takes place in a chamber filled with high-pressure air. The hot arc causes pressure to rise to 20,000 psi, bursting a nylon diaphragm so that the air flows into the tunnel's vacuum chamber.

Models and materials are mounted at the mouth of the nozzle. The length of the wind tunnel is over 20 ft. The vacuum in the tank is reduced to one-millionth of an atmosphere.

Continuous Mix

Navy, Aerojet Develop System for *Polaris*

A continuous mixing process has been developed for manufacturing solid propellant for the *Polaris* fleet ballistic missile, the Navy and Aerojet-General Corp. announced last week.

Propellant mixed with the new process has been fired in more than 100 small-scale *Polaris* static-test motors, Rear Admiral William F. Raborn Jr. reported. Raborn, director of the Special Projects Office in the Bureau of Naval Weapons, added: "It gave the desired performance."

In the Aerojet process, only 20 or 25 pounds of the propellant are under preparation at any given moment. Under the process used for the first round of *Polaris* production, propellant is mixed in batches of about 2200 lbs.

Raborn credited Aerojet engineers under Dr. Karl Klager at the Solid Rocket Plant near Sacramento, Calif., for developing the new process in less than a year. ahead of schedule. Klager won the Navy's Distinguished Public Service Award in 1958 for his work in developing the polyurethane propellant used in *Polaris*.

• **Reciprocating Action**—The Navy gave few details about the nature of the process. However, it was learned that Aerojet makes use of a machine manufactured by Baker-Perkins Inc. of Saginaw, Mich.

The machine, which Baker-Perkins calls the Ko-Kneader, consists of a jacketed barrel containing a screw with a complex interrupted thread and a series of projections. The projections create a reciprocating action that achieves intensive mixing. The barrel is hinged longitudinally so that it can be opened for cleaning. The jacket can be used in cooling.

The propellant industry generally agrees that continuous processing reduces the hazards of production, cuts labor costs and improves quality control. Under the gross-mix process, quality tests were made on 10 lbs. of each 2200-lb. batch. With continuous processing, tests are made regularly on small amounts as the propellant passes through the mixer.

Continuous processing also assures more uniform performance. This factor is important for assuring accuracy in firing the weapon from a continually shifting underwater location.

Thiokol Chemical Corp. and Rocketdyne Division of North American Aviation also are developing continuous mix processes. The Navy said the Aerojet facility represents the first large-scale application of the continuous mixing process.

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AEC, NASA Battle for *Rover* Control

Two Atomic Energy Committee witnesses back ground launch for first flight; new reactor tests planned

by Jay Holmes

A tug of war between top officials of the Atomic Energy Commission and the National Aeronautics and Space Administration is under way for control of the Project *Rover* nuclear rocket.

NASA Administrator T. Keith Glennan has suggested that *Rover* administration personnel be transferred from AEC headquarters in Germantown, Md., to NASA. AEC Chairman John A. McCone—following a suggestion by Sen. Clinton P. Anderson (D-N.M.), chairman of the Joint Congressional Atomic Energy Committee—proposes that the *Rover* staff at NASA move to the AEC.

Very few personnel would be involved in the transfer, whichever proposal were adopted, probably only three or four. There is no suggestion of moving people in the field, either at AEC or NASA installations. The issue at stake is merely control of the project. At present, it is divided between the two agencies.

In other developments concerning the nuclear rocket last week:

• Two witnesses before the Joint Atomic Energy Committee voiced support of a plan by the AEC's Col. Jack L. Armstrong for a direct ground launching as the first flight test of the *Rover* rocket, which probably will be in 1964 or 1965.

• The AEC announced plans for two tests this summer of *Kiwi* prototype rocket reactors, following upon the successful first test last summer.

The dispute over *Rover* control was touched off in February when Anderson raised public objection to a Budget Bureau cut in *Rover* funds that would have delayed the completion of ground testing from 1963 to 1964. The Budget Bureau later allowed the AEC to restore *Rover* funds by shifting from other AEC projects. However, Anderson proposed that the nuclear rocket would move faster if complete responsibility were given to the AEC through the ground tests. He said NASA was not as enthusiastic about nuclear rocketry as the AEC.

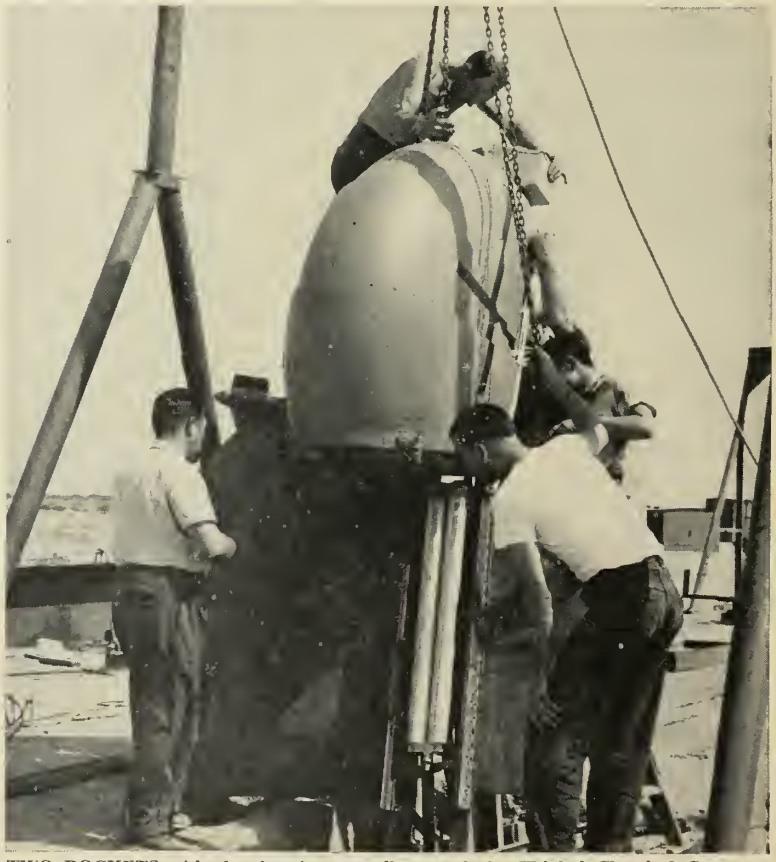
Anderson proposed that NASA and AEC representatives get together for discussions about control of the project. The Glennan and McCone suggestions were made at a meeting held at Anderson's suggestion. A further meeting was to take place last week.

• **Four uses**—At a hearing before the committee, Krafft A. Ehricke, director of the *Centaur* work at Convair Division of General Dynamics Corp., said there are four principal "domains" for a nuclear heat-exchange rocket such as *Rover*. He listed them as: earth-to-moon transport and lunar base maintenance, fast emergency rescue missions to the moon and the inner solar system, instrumented probes to the outer solar system and reconnaissance flights to Venus and Mars.

"I favor development of a demonstration system and flight test as soon as possible," Ehricke declared. He told MISSILE AND ROCKETS this would entail ground launching for the first test instead of orbital or upper-stage launching.

Dr. Raemer E. Schreiber, head of the scientific staff developing *Rover*, told the committee that since Anderson protested the slow pace "things have been occurring rather violently." He urged early flight testing. Asked by M/R whether he favored ground launch as opposed to launch from orbit or as upper stage, Schreiber re-

Ejector Rocket on B-52 Pilot Capsule



TWO ROCKETS with slow-burning propellant made by Thiokol Chemical Corp. are used in B52 ejection system to provide greater acceleration control.

plied, "Yes, emotionally I do."

Harold E. Finger, NASA chief of nuclear engines, is the chief proponent of orbital launching for the first test. Finger favors such a test because, he says, it will provide more useful data for engine development than a ground launching.

Partly, the argument revolves around the point that a ground launching apparently would accomplish nuclear flight somewhat earlier than an orbital or upper-stage launching.

"But the delay caused by orbital launching would not be a delay in the program," Finger told M/R last week. "It would only be a delay in the first flight. Even those who recommend ground launching agree that such a launching is only a preliminary to an orbital test."

"The real point," Finger continued, "is which kind of first test will do more for the overall flight test program."

The NASA official said an upper stage nuclear rocket is a third possibility for the first flight test of the *Rover* rocket.

Finger said there are several possibilities for the first actual *Rover* mission. He said he believes it will be an upper stage of the chemical booster that follows after *Saturn*. This might be a cluster of four to six F-1 engines with 1½ million lbs. thrust apiece. Or it might be a combination of a single F-1 with several smaller engines such as the H-1, eight of which are being clustered into the *Saturn* booster.

• **Summer tests**—The AEC plans for two reactor tests this summer will be designated the *Kiwi-A Prime* series. Like *Kiwi-A*, they will be held at the Jackass Flats area of the Nevada Test Site.

Both tests will use the same test cell and other facilities. The original *Kiwi-A* has been reassembled and connected to the test cell without nuclear components. It will be used as a mock-up for non-nuclear cold-flow experiments prior to the tests of the new reactors.

The first of the two reactors to be tested is designated *Kiwi-A Prime*. It is now being assembled at Los Alamos. After cold critical tests there, it will be moved to Nevada, where tests are expected to begin by midsummer.

The second reactor, designated *Kiwi-A3*, will be tested shortly after completion of the tests on *Kiwi-A Prime*. The AEC said two reactors will be used to perform a wide variety of tests and to obtain more data that would be possible with a single reactor.

The *Kiwi-A3* reactor will undergo endurance testing to determine safety margins and limits of performance. Tests will continue until there is positive evidence of damage to the reactor, the AEC said.

Schreiber told the committee that work is also under way on a new generation of *Kiwi* reactors in which a beginning will be made on marrying the reactor to the liquid hydrogen supply system, the liquid hydrogen pump, the regeneratively cooled nozzle and simplified control system.

A logical extension of the *Rover* program, Schreiber said, will be the investigation of problems related to very high power levels. Detailed studies will be necessary to learn the effects of drastic changes in reactor size or power. New facilities and a general expansion of the *Rover* program will be necessary for actual testing of large engines, he added.

Aerojet to Build SNAP-8 Converter

30KW device to cost $8 million; flight due in 5 years; system designed to operate in space more than a year

The National Aeronautics and Space Administration has selected Aerojet-General Corp. to build the electrical conversion equipment for SNAP-8, a nuclear power system capable of generating up to 60 kilowatts in a space vehicle. This is enough power to operate a small electrical propulsion system.

Atomics International Division of North American Aviation is developing the reactor under an Atomic Energy Commission Contract. The conversion equipment to be developed by Aerojet will generate 30 kilowatts. However, the reactor will generate enough nuclear energy to power two conversion systems in a single vehicle.

NASA and Aerojet reached a preliminary agreement March 24. Aerojet was chosen from eight competing contractors. Formal negotiations on the contract are now in progress. NASA said Aerojet estimated that the contract would cost $8 million.

Robert E. English of NASA's Lewis Research Center told the Joint Congressional Committee on Atomic Energy March 24 that the 30-kilowatt version would be suitable for use with *Atlas-Agena* space vehicles while the 60-kilowatt model will be used with *Atlas-Centaur* vehicles. He said the 60-kilowatt system, including reactor and shielding, would weigh about 3000 lbs.

English said the 60-kilowatt SNAP-8 could be used to power an electric rocket in a 9000-lb. satellite lifted into a low 300-mile orbit by the *Atlas-Centaur*. The electric rocket then would lift the satellite into a 24-hour, 22,000-mile orbit. After the satellite has reached its destination, the power supply then would be available for operating the communications equipment. J. R. Wetch of Atomics International told the committee it would be sufficient for continuous worldwide broadcasts of television signals that could be received by conventional home sets.

NASA said the system will be designed to operate in space for at least a year. The entire system is to be ready for flight in about five years.

SNAP stands for Systems for Nuclear Auxiliary Power. Those with odd numbers are low-output devices that make use of radioisotopes. Even-numbered systems are based on nuclear reactors.

• **Mercury heat transfer**—The conversion system to be developed by Aerojet will use mercury as a heat-transfer agent. A closed loop will carry mercury through the reactor, where it will be heated. This loop will pass through a boiler. A second loop will carry the mercury into the boiler, where it will be vaporized. The gaseous mercury will drive a turbine powering a generator, which will produce electrical power.

The gas then will be routed through

a series of tubes that will form a radiator several hundred square feet in area. On cooling, the mercury will condense into liquid and be pumped through the closed loop to repeat the cycle.

English told the committee an electric propulsion system used with SNAP 8 could raise a payload of 3000 lbs. to a 24-hour orbit if 40 days are allowed for the trip. If the time must be shortened, the payload is reduced as well.

Another application, he continued, is propelling an instrumented probe to Mars. Payload varies with intended trip time in the same way. Both a high-performance chemical rocket and a SNAP 8 electric rocket would deliver 500 lbs. to orbit about Mars in 250 days. But if the time is increased to 350 days, the payload with an electric rocket could be 3000 lbs., with 60 kilowatts available for use by the payload after it arrives.

• **Spectacular performance**—Wetch of Atomics International told the committee that a smaller nuclear power reactor, designated SNAP II, has been performing at design conditions since it was announced last November. The reactor, which weighs 220 lbs. without shielding, generates three electrical kilowatts.

"To date," Wetch said, "it has produced the energy required to replace nearly 100,000 lbs. of batteries at a continuous rate that would require about 1000 sq. ft. of solar cells, which would cost about $3 million. This is 10 times the projected cost of the nuclear power unit."

Wetch said small mercury vapor turbine-generator devices in the SNAP program have been operated for more than 1000 hours. Thompson Ramo Wooldridge Inc. is developing the conversion equipment for SNAP II.

The SNAP-2 reactor uses a homogeneous mixture of enriched uranium fuel and moderating material. The coolant is liquid-sodium.

• **Moon/Mars bases**—At another committee session, devoted to advanced reactor concepts, Dr. B. I. Spinrad of the Atomic Energy Commission's Argonne National Laboratory urged the development of large reactors suitable for providing power to set up permanent bases on the moon and Mars.

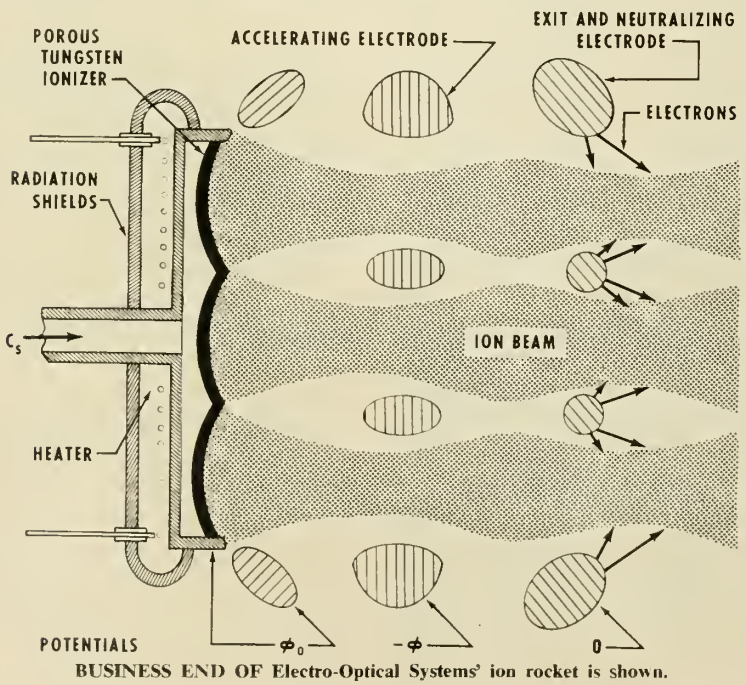
"With enough energy," he declared, "one needs to transport only shop and laboratory equipment to such locations. Ceramics and metals can be manufactured from local rock and converted into the materials for construction of living quarters, complex machines and, in fact, just about everything but biological necessities and (perhaps) the fuel itself.

He said it seems logical to spend from 10% to 20% of the overall cost of putting man on the moon for a power source.

Ion Rocket Efficient Above 1 KV

A cesium ion motor will be efficient only above a potential of one kilovolt, which corresponds to a specific impulse of 4000 sec., Dr. A. T. Forrester of Electro-Optical Systems Inc., Los Angeles, has told a scientific group.

Forrester is head of the Ion Propulsion Laboratory at Electro-Optical, which recently won an Air Force contract for "quick and dirty" construction of an ion propulsion unit. He spoke before a Philadelphia meeting of the American Institute of Electrical Engineers last month.



BUSINESS END OF Electro-Optical Systems' ion rocket is shown.

The optimum exhaust velocity—determined by a compromise between propellant demands and power demands of the motor—is in the range between 10^6 and 2×10^7 cm/sec., he said. This provides for accelerations of about 10^{-4} g—about 0.1 cm/sec^2.

Although this acceleration is very small, he pointed out, very sizeable velocity increases are possible when the acceleration is continued over a long time. For instance, an acceleration of 0.1 cm/sec^2 continued for six months would provide a velocity increment of 16 km/sec. Thus, accelerating for six months and decelerating for six months, it would be possible to travel about 100 million miles—far more than the distance to Mars or Venus—in a year.

Forrester said a cesium ion can be given a velocity of 10^6 cm/sec by an acceleration through 70 volts. A velocity of 2×10^7 cm/sec requires a 27-kilovolt potential difference. He concluded that this covers a fairly convenient range of voltages to handle.

• **Multi-aperture geometry**—Because of space charge limitations, Forrester continued, the cesium ion current from a single aperture cannot be greater than 3 milliamps at 5000 volts. Since the smallest operational ion motors will require about one ampere current, a multi-aperture geometry is necessary.

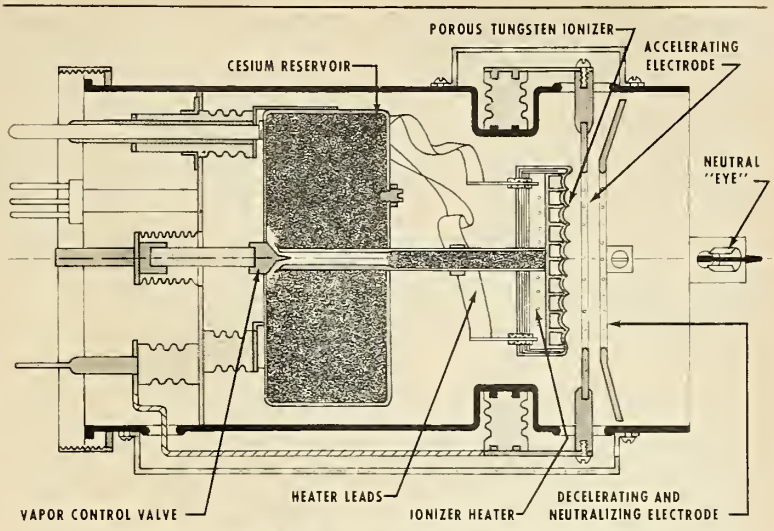
The tungsten ionizer must be in

particles of about one micron in diameter, Forrester declared. This is to provide for surface diffusion to avoid the buildup of cesium on the tungsten particles. He said that available sintered tungsten approaches the required grain size.

To make the exhaust neutral, in terms of both time and space, an electrode arrangement is necessary, so that the right amount of electrons will be mixed with the ion stream. This is accomplished by placing a second electrode downstream from the accelerating electrode. The second electrode is at ground potential, the potential of the hull of the space vehicle. The ion source is at a positive potential corresponding to the desired exhaust velocity. The intermediate, accelerating electrode is maintained at a negative potential. It provides an effective barrier to electrons that might otherwise be inclined to proceed upstream.

Forrester provided the two accompanying diagrams. Fig. 1 shows the business portion of an ion motor—presumably the design of the device his company is building for the Air Force. Fig. 2 is the overall design of an ion motor, including cesium source and body construction.

Since cesium melts at 83°F, it will flow easily into the feed tube. Very little heat is required to keep it in the liquid state.



OVERALL DESIGN of ion engine as seen by Dr. Forrester.

Air Force Gets Rugged Liquid Hydrogen Trailers

Four new 7000-gallon liquid hydrogen trailers were put into service by the U.S. Air Force last week.

The trailers, capable of hauling the supercold (—423°F) liquid from coast to coast, were designed and built by Air Products Inc. of Allentown, Pa.

The bulk of the U.S. supply of liquid hydrogen is produced for the Air Force at a plant operated by Air Products at West Palm Beach, Fla. With the new trailers, the Air Force will be able to ship tonnage amounts of the liquid cross-country to any point where it is needed for testing of nuclear or high-energy chemical rockets.

The Air Products plant is next to a Pratt & Whitney installation where a liquid hydrogen-liquid oxygen rocket is being developed for use in the *Centaur* vehicle. The engine will generate 15,000 to 20,000 lbs. thrust. Two such engines will be used in the *Centaur*, which will be used as an upper stage atop *Atlas* and as a final stage in the *Saturn* vehicle.

The National Aeronautics and Space Administration is receiving bids on a liquid hydrogen-LOX engine with 200,000 lbs. thrust to be used in the second stage of *Saturn*. Companies on the West Coast are among the bidders.

The trailers, built to military specifications, were designed for duty under battle conditions. They are capable of operating over boulder-strewn fields, on desert sands and in subtropical and salt-sea atmospheres. They also can be shipped in transport planes.

Each trailer consists of two chambers, with the space between the chamber walls evacuated to maintain insulation. The light weight of liquid hydrogen lessens the design problem of support for the inner chamber. The 7000 gallons of capacity weigh about two tons. The weight of an equivalent volume of water would be 30 tons.

Air Products will begin commercial production of liquid helium and liquid hydrogen this month at a new plant in Iselin, N.J. The liquid will be delivered by truck throughout an area of 600-mile radius. Shipments are planned by air freight over a much larger area.

Integrated design and construction allow increased production of one liquid when no production of the other is required.

TWO HYDROGEN TRAILERS built by Air Products await delivery to Air Force.

High Speed Underwater Nuclear Jet Invented

A nuclear jet engine that may propel both undersea and surface craft at speeds of more than 100 mph has been invented by a Boeing Airplane Co. engineer.

The inventor, L. J. McMurtrey—Navy systems manager in Boeing's advanced design section—said that operation of the underwater nuclear jet engine would be somewhat similar to propulsion through air except that water would replace air and that no fuel would be used.

In the new engine, water would be passed under ram pressure through a nuclear heat exchanger, then through a turbine and out the nozzle. Either a turbojet or ramjet type of engine could be used.

Materials Gaps Menace U.S. Security

Special committee finds lagging research effort is major factor, recommends a higher national priority

by John F. Judge

A materials barrier is effectively holding up the entire U.S. space effort and seriously endangering the national security.

This is the conclusion reached by the special Committee on the Scope and Conduct of Materials Research organized by the National Academy of Sciences. Its report was released last week.

The Committee, under Dr. Clyde Williams, president of Clyde Williams and Co., surveyed the total materials research and development activities of the nation to identify any critical gaps —and found it riddled with them.

A definite sense of urgency underlined the committee's general recommendation—a higher national priority for the materials research effort.

"If we were alone in the world we could take our time in working out solutions to these problems. But we are not alone. Instead, we are now aggressively challenged by a totalitarian system that is seeking to wrest leadership from us through more effective utilization of scientific progress," the committee report states.

Lack of sufficient basic scientific knowledge was cited by the group as one of the main reasons for the materials gap. Accelerated efforts in chemistry, physics, and mathematics, supplemented by cross-fertilization of scientific and engineering areas, are required. Unexpected potentials will result from such basic studies as investigation of molecular and atomic binding forces. This can only be accomplished through research.

• **Economic benefits**—The national economy can be expected to benefit from developments originally undertaken to meet national security needs. For example, the committee points to the improvements in electrical power generation, and chemical and metallurgical processing that will result from materials with higher operating temperatures and enhanced corrosion resistance.

Many complicating factors are anticipated. High melting materials will require radical changes in the processing and forming equipment currently in use. Most new materials will be of high purity and designed to operate in strange environments.

In addition to these, the necessity to make haste will further increase the cost problem. The demands of the space effort are such that developments that rolled along for years now must be rushed through in months.

The committee emphasized that crash programs, so often the solution in the past, are of decreasing effectiveness. Large research programs, initiated well in advance of actual needs, will reduce the frequency of crash programs and bring an overall savings of money and effort.

In this vein, the committee acknowledged that the pressing needs of national security do not often provide for large enough production runs of standard items to allow for cost recovery. It is obvious that industry cannot be expected to invest its own money and time in major materials efforts without proper arrangements to cover the costs involved.

The committee concluded this aspect by calling for higher national priority in the science of materials and in training of brain power. It said that materials development projects should be given more recognition as end-object programs in their own right.

• **Administrative needs**—Several improvements in administration of security-related materials R&D programs were suggested by the committee. The agencies mainly responsible for this area usually are the Armed Services, the Atomic Energy Commission and the National Aeronautics and Space Administration.

Although many commendable Government in-house, industrial and university laboratories are directly supported in these programs, it is clear that the demand for new materials is increasing much more rapidly than these facilities. End-item contractors have been forced to support research projects directed toward specific production and development problems and much of this work has not been part of any organized national program on materials development. This is simply because these programs of end-item contractors have not been identified as being concerned with materials.

The committee urges greater centralization of responsibility within each department and agency for materials R&D to alleviate this condition.

The Special Committee on Scope and Conduct of Materials Research

Dr. Clyde Williams, Chairman
President, Clyde Williams and Co.

Dr. Allen V. Astin
Director, National Bureau of Standards

Dr. Harvey Brooks
Dean of Engineering and Applied Physics, Harvard University

Alvin J. Herzig
President, Climax Molybdenum Co.

Dr. A. B. Kinzel
Vice President, Research, Union Carbide Corp.

Thomas H. Miller
Deputy Director, Bureau of Mines

Dr. John D. Morgan
Industrial Consultant

Dr. Thomas B. Nolan
Director, U.S. Geological Survey

Dr. Albert J. Phillips
Vice President, American Smelting and Refining Co.

Dr. C. F. Rassweiler
Vice President, Research and Development, Johns-Manville Corp.

E. Duer Reeves
Executive Vice President, Esso Standard Oil Co.

Professor Frederick Seitz
Head, Dept of Physics, University of Illinois

Professor Cyril Stanley Smith
Institute for the Study of Metals

David Swan
Manager-Planning, Union Carbide Corp.

Some of the more specific recommendations in this respect include:

• Within each military service there should be greater support for materials R&D as end-object programs in their own right. Full use should be made of all professionally qualified people, including those in uniform.

• The AEC should closely coordinate nuclear materials programs for military applications of atomic energy with other national security materials efforts.

• NASA should have a central materials staff.

• An agency in the Executive Office of the President of the U.S. should be responsible for assuring that the above steps are taken.

• **Priming industry**—The committee considered the question of providing incentives to stimulate the needed research. Here the specific recommendations include:

• Broadly defined objectives should be written into contracts while detailed reporting and accounting procedures are minimized. Contracts should permit purchase of necessary equipment and facilities construction including pilot plants. Adequate funding should be made available for two- to five-year research programs in the contracts.

• A patent policy based on the current one used by the Department of Defense, allowing the contractor to retain commercial rights to any invention.

• Provisions should be made to limit the extent to which "know-how" acquired over a long period of time with private funds has to be released under a Government contract.

• Existing knowledge should be much more effectively utilized in the solution of pressing national security materials problems.

• **Stockpiling**—In the matter of strategic materials, the committee suggested that the Office of Civil and Defense Mobilization should annually attempt to assess the supply-demand situation that is likely to exist five to ten or more years in the future for each potentially needed element and material.

As specific examples the committee mentioned the elements tellurium and rhenium as being potentially important but not on any present stockpile list. Tantalum, although already on the lists, has such future potential in high-temperature applications and electronics that greater supplies may well be required.

• **Information exchange**—The dissemination of technical information was divided by the committee into two distinct categories: the permanent technical information contained in printed journals, etc., and the information generated currently—either unpublished or not yet within the permanent body of technical literature.

The problem in storage and retrieval of published permanent literature is being effectively attacked by information systems such as the project currently under way at Western Reserve University with the cooperation of the American Society for Metals. There is need for more such projects.

It is in the area of currently generated information that the committee finds room for substantial improvement. It recommended a far greater effort to speed the process of dissemination.

In particular, it should be incumbent upon each agency to establish central organizations for collecting and disseminating information.

Further, management should encourage thorough information searches as prerequisites to any research and development proposals and programs.

Maximum support of technical societies by industry, financially and otherwise, is imperative—and the societies themselves should take on additional screening functions for reports in their particular areas.

The Government should step up its efforts to prompt declassification of all or part of reports as soon as the need for such classification has passed.

There should be greater support of research designed to lead to the swift exchange of information. Current lines, such as the Defense Metals Information Center at Battelle Memorial Institute, should be considerably broadened.

• **Basic research**—The last point of the survey touched on the role of the nation's universities in materials research. The committee makes it plain that the capabilities of universities in this field should not be misused in the solution of short-term pressing problems. Such institutions should be exclusively concerned with the double-barrelled task of increasing the national reservoir of basic scientific knowledge and training increased numbers of scientists.

Considerably more must be done in interdisciplinary materials research at universities supported by the agencies having the authority and funds. The only limitation suggested by the committee is that imposed by the ability of the universities to obtain and retain highly competent personnel and by their own desire to maintain balance within their individual structures.

Threaded through all of the recommendations made by the Academy's committee is a plea for more contact between government and industry—more communication on their basic materials problems.

Although the members of the committee recognize that some efforts have been made along several of the approaches recommended, they said that much more must be done if this country is to maintain and strengthen its position as the leader of the free world.

Metals Behavior

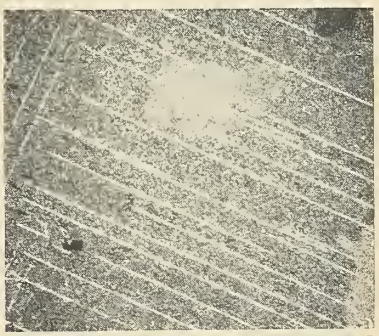
NBS Pushes Studies of Their Basic Properties

Increasing demands of missile manufacturers on common structural metals has revealed an almost complete lack of understanding of these metals' basic properties.

The National Bureau of Standards, in an effort to keep up with the current pace is engaged in studies to provide more information on the nature of the relation of metallurgical structure to the behavior of metals and the effects of heat treatment and temperature extremes on this relationship.

These mechanical studies are closely coordinated with bureau programs in metal physics, chemical metallurgy, and corrosion.

• **Metallurgical structure**—Metal fatigue is the most common cause of in-service components or machine parts failure. The prediction of this phenomena is critical to optimum design and the missile engineer must be able to do so with a high degree of accuracy.



REVERSED torsional loads produced these slip bands (white lines) on the surface of an aluminum specimen. Note that the direction of the bands differ from grain to grain.

In this area the bureau is doing much to foster the understanding of the relation between the structure of metals and the fatigue process.

Studies have shown that individual metal grains act independently of their neighbors and no evidence was found that grain boundaries or interaction with neighboring grains promote cracking.

Results of another study showed

GAS bubbles, resulting from repeated stressing on the surface of an aluminum specimen, appear under a strip of transparent tape. The horizontal line is powdered material extruded from the fatigue crack.

that the preponderance of fatigue cracks starting at the edges of a metal specimen is caused by the stress pattern, rather than by lower fatigue strength at the edges.

It has been long recognized that chemical reactions at the metal surface have an important influence on fatigue behaviour. The bureau observed that if a strip of transparent tape is applied to the surface of a fatigue specimen, bubbles form under the tape at about the same time that fatigue cracks are initiated. Since the bubbles are caused by gas liberated as a result of surface reactions, bureau scientists expect this to provide a useful means of studying such phenomena.

• **Temperature extremes**—With the possible exception of money, temperatures, high and low, are the biggest problem in rocketry today—and will remain so for a long time to come. The bureau has been involved in a long range study in this area.

The notion that the rate determining factor during creep of metals is the motion of defects through the crystal lattice by thermal activation under applied stress is an old one. But the many equations proposed to describe this have not been completely satisfactory. Tests conducted on high purity copper, nickel and their alloys have closely conformed to the concept of generation and exhaustion of lattice defects during the first stage of creep as well as to the parabolic strain-time law over limited ranges of stress and strain during the second stage.

• **High-strength steels**—Ordinarily, the fatigue strength of most ferrous metals is roughly proportional to the tensile strength. But when steels are heat treated to high hardness, this proportionality totally disappears, much to the chagrin of missile fabricators. While the tensile strengths soar to 200,000 psi and beyond, there is little or no improvement in the fatigue strength levels. The bureau's scientists attacked this problem in recent studies of high strength steels.

The studies indicated that retained austenite lowers fatigue strength. Under stress, retained austenite is transformed to untempered martensite, probably accounting for the deleterious effect. Most of this austenite can be eliminated in carbon and low alloy steels by suitable heat treatment.

The bureau's thermal metallurgical laboratory has been developing an ultra high-strength steel for the Navy's Bureau of Weapons. A modification of type 4340 steel attained high hardenability, sufficient ductility for use in the structural members of aircraft and tensile strengths up to 300,000 psi.

As for the future, the bureau expects to place increasing emphasis on the study of all aspects of atomic structure that influence the behaviour of metals in service. Techniques are being developed to obtain basic data that may provide new uses for metals. Ultimately this work may lead to new alloys that will withstand the most rigorous environmental and physical conditions generated by the space marathon.

Two Firms Propose R&D Program for Plastic Rocket

Another flurry of interest in plastic rockets has resulted from a request by the Army's Ordnance Materials Research Office, Watertown Arsenal, N.Y., for proposals involving investigation and development of plastic materials for solid-propellant motors and missiles.

The CTL Division of Studebaker-Packard Corp. and Amcel Propulsion, Inc., a subsidiary of Celanese Corp., joined in a proposal to OMRO which both firms feel could lead to the development of an all-plastic multi-stage missile.

The particular OMRO request concerned the basic task of concretely establishing and defining the criteria for plastic materials in solid rocket motors and missiles.

However, the companies jointly offered to begin immediately on a research and development program—aimed ultimately at the production of the plastic rocket.

The entire long-range program is divided into five phases, including, in addition to the initial research and development effort:

• Plastic rocket motor development —elimination of multiple construction motors.

• Plastic missile body development —include shrouds, nose cones flight cases and other containers.

• Integration of components—evaluation of resins including phenolics, epoxies, silicones and polyesters. Reinforcement materials include glass, Refrasil, quartz, nylon, Fiberfax, graphite and asbestos.

• **Static tests**—including simulated velocities up to Mach 2.5 at 4000°F, and rocket blasts up to 5000°F.

The basic propellant involved would be of the double-based plastisol types.

The concept of an all-plastic rocket was recently advanced by the Norair Division of Northrop Corp. (M/R Feb. 8, 1960, p. 25). At the time the idea was not in the form of a solid proposal, but materials research has indicated the concept's feasibility.

North American to Build Heat-Sound Effect Labs

Heat and sound effect laboratories will be constructed at the Columbus Division of North American Aviation, Inc. to determine what must be built into future missiles and aircraft in order to minimize damage from these two forces.

The heat effect laboratory will be equipped to blast air at more than 1000°F at metals and other materials to test friction resistance. A vacuum chamber will be included to simulate the reduced pressures of the upper atmosphere.

One cell in the sound effect laboratory will encourage the bouncing of noise and another will reduce this effect. A connecting passageway between the two cells will provide the testing area for instruments and materials.

Big Fused Silica Mirror Made for Balloon Flight

The largest fused silica mirror in existence has been fabricated by the Corning Glass Works for Project Stratoscope II.

The blank, currently being ground and finished by Perkin-Elmer, Norwalk, Conn., is 37 in. across, 5.5 in. thick and weighs 450 lbs.

When installed in the unmanned balloon, the mirror will be able to endure sudden temperature changes with-

out distorting the images because of the near-zero thermal coefficient of expansion of fused silica.

Project Stratoscope II will photograph solar and celestial bodies above the turbulence of the earth's atmosphere through a 36-in. telescope.

Information on the atmosphere of Jupiter and Venus, analysis of the division of Saturn's rings, measurement of Pluto's diameter and more insight into the Great Nebula in Orion are some of the results expected from the photographs.

Conducted by Princeton University with funds from the National Science Foundation, Office of Naval Research and the National Aeronautics and Space Administration, the balloon flight is scheduled for 1961.

Plastic Packaging Gives British Corrosion Troubles

LONDON—Plastic packaging incorporating acetic acid to limit chain lengths has caused some corrosion problems in stored munitions at the British Government's Armament Research and Development Establishment, Fort Halstead, Kent.

Trouble sources include materials using hair bonded with polyvinyl acetate, and parts encapsulated in polyester resins.

NRC Sets Up Space Vacuum Materials Lab

A Space Vacuum Laboratory has been established at National Research Corp., Cambridge, Mass., to evaluate materials, components and devices intended for use in space.

Test chambers at the new facility range in size from a 14-in.-diameter by 36-in.-high bell jar type system reaching pressures as low as 2×10^{-10} mm Hg, to a 3.5-ft.-diameter steel tank capable of pressures down to 4×10^{-10} mm Hg.

The equipment can be adapted to permit dynamic testing involving creep-rupture, rotary and linear motion, emissivity, thermal and electro-magnetic radiations and undamped vibrations.

Tests of up to a year's duration on certain electronic components are now being planned for one customer, according to Robert A. Stauffer, vice president and director of research.

Cost of advance tests of equipment to be sent on long missions run less than $200 per day of equivalent flight time.

The new laboratory will be under the direction of Dr. John C. Simons, chief of the firm's applied physics department.

NAVIGATION & CONTROL ENGINEERS EE and PHYSICISTS

...General Electric's New $14,000,000 SPACE RESEARCH CENTER, to be built near Valley Forge Park 17 miles from Philadelphia

The Missile and Space Vehicle Department – responsible for the FIRST demonstration of effective space vehicle stabilization control and navigation – is now embarking on the development of still more sophisticated systems for a variety of space projects. These are concrete long range programs challenging the creativity of the controls engineer and scientist.

Opportunities now exist for qualified individuals to join us, stepping into the early stages of these new programs. General Electric's confidence in the unlimited growth potential of this field is underlined by the $14,000,000 investment now being made in a new SPACE RESEARCH CENTER with unique facilities in scenic Valley Forge, outside of Philadelphia

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SYSTEMS ENGINEER-NAVIGATION & CONTROL. EE with control systems background. Five years' experience in design of control and navigation systems, preferably in space vehicle systems.

ENGINEER-CONTROLS. Will be responsible for analytical studies in adapted controls, non linear systems and analogue and digital computation; requires ten years of controls background with BS, EE or related degree.

ENGINEER-DYNAMICS. To conduct analytical studies in the dynamics of rigid bodies as applicable to navigation and control systems; requires eight years of experience with MS degree in mechanics or physics.

ENGINEER-SYSTEMS ANALYSIS. Requires eight to ten years experience in analytical studies of complex systems, with some control experience. Background in analogue and digital equipment also desirable.

Other significant opportunities exist in the following areas:

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For further information regarding opportunities here write Mr. Thomas H. Sebring, Div. 73WN You will receive an answer within 10 days.

MISSILE & SPACE VEHICLE DEPARTMENT

GENERAL ELECTRIC

3198 Chestnut Street, Philadelphia 4, Pa.

How We Have Progressed in Nose Cones

A report on the work accomplished under Air Force contract by General Electric and Avco resulting in successful noses for both ICBM's and IRBM's; an examination of some of the special problems

Seventy tests of Air Force ballistic missile re-entry vehicles have been performed as of February 3, 1960. These tests—part of the AF IRBM and ICBM research and development program—have led to design of nose cones capable of bringing a warhead through the thermal thicket of the earth's atmosphere.

Both heat-sink and ablation type vehicles have gone through this extensive test phase. The work was performed under a Ballistic Missile Division contract: General Electric (Missile and Space Vehicle Department) and Avco (Research and Advanced Development Division) are prime contractors. Basic experimental work on the re-entry problem was done at Avco's Everett Laboratory and the resulting data furnished to both GE and Avco.

Both companies have developed ablation materials and heat-sink configurations which have been tested in the program. They have cooperated extensively on other phases of the work and several vehicles represent joint efforts.

• **Problems of re-entry design**—Re-entry—the final portion of a ballistic trajectory in which a long-range missile or satellite rips back into the atmosphere at speeds of 10,000 to 20,000 mph—obviously causes tremendous heating and structural loads. When the air becomes more and more dense, the particles of air start piling up ahead of the nose cone and the familiar shock wave appears.

Behind this shock wave, gas temperatures as high as 15,000°F or more are generated. Deceleration forces of 20-50 g's may be imposed on the vehicle as atmospheric drag increases. The duration of the heating and deceleration periods for ballistic missiles, entering as they do at fairly steep angles, is fairly short. In fact, the heat shock is almost explosive.

• **Basic designs**—The designer of nose cones has three objectives: to keep as much heat as possible out of the cone; to take what heat does exist and distribute it uniformly to prevent hot spots; and to select a material that can absorb the amount of heat required.

Several design techniques have been developed to handle the heat problem. One uses a material to absorb the neces-

BALLISTIC MISSILE RE-ENTRY VEHICLES. Air Force IRBM and ICBM re-entry vehicles which have been tested to date in research and development programs. Drawings are roughly to scale except for *Minuteman*, for which no dimensions are available. SERIES II (Avco) is a developmental heat-sink model for the second-stage *Titan*. MARK II (GE) is an operational heat-sink model for *Atlas*. SERIES III (Avco) is an operational heat-sink model for *Titan*. RVX-1 (GE/Avco) is an ablation material test model. Eight have been built and six flown, with two successful recoveries. RVX-2 (GE) is an ablation material test shape. RVX-3 (Avco) is an ablation test cone for Lot C *Titan*. Flown but not re-entered. Seven

sary heat in a straight-forward fashion —a heat sink. Another selects a material that will melt or vaporize. Heat is absorbed in the vaporization process and swept away in the air flow. This is known as ablation.

Heat may also be disposed of by radiation, transpiration, or film cooling. Several different techniques may be combined in a particular application.

The first two mentioned—heat-sink and ablation—have received the greatest attention and provide what appears to be the best solution for present-generation ballistic missiles.

• **ICBM complications**—The problems of designing a nose cone for an ICBM are much the same as for an IRBM except that temperatures and g-loading conditions are much greater for the larger, longer-range missile. In the IRBM, the peak temperatures reached are just beginning to become really difficult. For the ICBM the problems are much worse. As a rule of thumb, the heat flux increases as the cube of the velocity. Comparing a 10,000 mph re-entry with one of 15,000 mph shows that the heating rate of the ICBM nose cone can be more than three times that of an intermediate range missile.

Special rocket test vehicles have been designed for ballistic flights of re-entry models. The Army developed the *Jupiter-C* which uses a 200-mile-range *Redstone* as a first stage and clustered solid-propellant rockets for the three upper stages. This combination was sufficiently powerful to hurl the scaled-down model of the *Jupiter* to actual IRBM re-entry velocities.

In the early stages of the Air Force ballistic missile program, use was made of the Lockheed *X-17* research vehicle. The final stage of the *X-17* was fired as the test nose cone shape fell back toward earth to accelerate it up to re-entry speed.

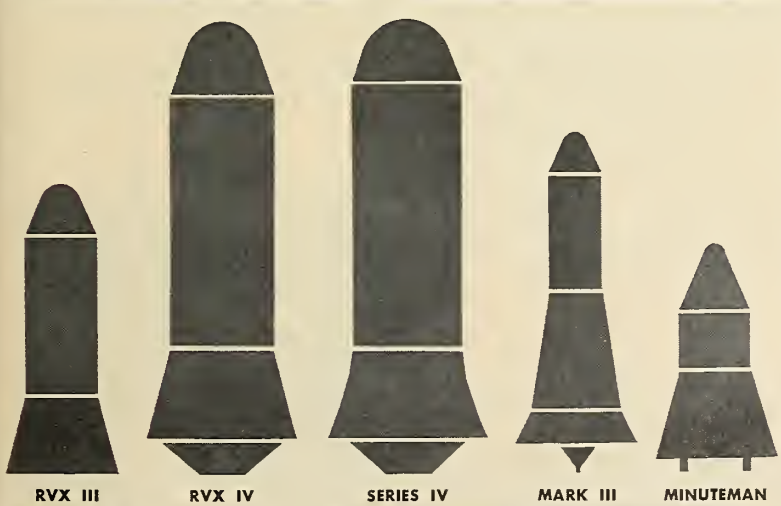
AEC Bought 7899 Tons of Uranium Oxide in July-Dec.

The Atomic Energy Commission bought 7899 tons of uranium oxide from 25 domestic processing plants in the last six months of 1959 at an average price of $8.79 per lb. of U_3O_8, a total of $139 million.

Domestic ore reserves were estimated to total 86,100,000 tons at the year's end. Ore stockpiles totaled 1,449,069 dry tons. Of this, 1,003,000 tons were held by private companies and 446,000 tons by the government. Private plants and government purchase depots received 3,614,000 dry tons in the six-month period, during which 3,623,000 tons of average grade 0.24% were fed to process.

The combined daily capacity of the 25 operating mills was 22,100 tons of ore per day. The only government-owned mill, at Monticello, Idaho, was closed at the end of the year.

About 65% of the nation's ore reserves are in New Mexico. Wyoming has about 18%. Most of the remainder is distributed through Utah, Colorado, Arizona, Washington, Oregon and Nevada.



built. RVX-4 (Avco) is a developmental model for Lot G *Titan*. Also flown on the *Atlas* (see cover, this issue). Eight have been built. SERIES IV (Avco) is a developmental and training vehicle for *Titan*, and a possible forerunner of an operational model. MARK III (GE) is an ablation type intended for the operational *Atlas*. MINUTEMAN (Avco) is a test shape used in range tests (not drawn to scale).

Sierra Metals to Build Big Vacuum-Melt Furnace

Sierra Metals Corp., Wheeling, Ill., will install one of the world's largest induction-heated vacuum melting furnaces.

Sierra, a subsidiary of American-Marietta Co., has ordered the furnace from the Vacuum Metallurgical Division of F. J. Stokes Corp., Philadelphia. It is expected to be installed by August and in operation by September.

The furnace is designed for volume production of Sierra's nickel and cobalt-base alloys, used for jet engine turbines and other high-temperature applications. It will have a nominal rated capacity of 4000 lb. at pressures in the range below one micron. With eight, 32-in. oil diffusion pumps, it will be one of the largest vacuum pumping systems ever built, Stokes said.

Sierra's new alloys have shown good properties at turbine temperatures higher than the present practical operating temperature, Stokes said. Turbine vanes and blades made from the alloys have been tested in experimental engines by Pratt & Whitney Division of United Aircraft Corp.

U.S. Borax Will Install 1300-ft. Conveyor Belt

A 1300-ft. mechanized conveyor system will be installed to provide increased flexibility and reduce costs at the big Boron, Calif., open-pit borate mine of the U.S. Borax & Chemical Corp.

The project is due to begin within a month and be completed in the fall. Trucks now haul the ore from the bottom of the pit 2½ miles to a surface crusher. The continuous-belt system will rise 315 ft. to the surface. The pit is 2000 ft. long, 1700 ft. wide and 275 ft. deep.

Trucking still will be used to transport ore from electrically operated shovels to a new hammer mill to be installed at the bottom end of the conveyor system.

Mercury Capsule Parachute To Be Woven by Stevens

The parachute that returns the Project *Mercury* astronaut's capsule to earth will be woven by J. P. Stevens & Co.

Radioplane Division of Northrop Corp. is producing the *Mercury* landing system under contract to McDonnell Aircraft Corp., prime contractor on the National Aeronautics and Space Administration project. The parachute will be of Ringsail, developed and produced by Radioplane from fabric woven by Stevens, the textile company said.

Data Cassette Recovered

This data cassette was recovered from the Atlantic Ocean after a successful flight in an Avco RVX-4 nose cone. The material research re-entry vehicle flew on a *Titan* Lot J missile over a 4385-nautical-mile range and ejected the cassette prior to impact at an altitude of 12,000 feet while traveling at 2500 feet per second (Mach 2.4).

The package contains a Cook Research Laboratory tape recorder which stored data during atmospheric re-entry. It records what happens to the long range missile cone as it reenters the earth's atmosphere and is subjected to temperatures of 12,000°F.

The cassette was recovered attached to a balloon which floats it after water impact. It was shot from the nose cone by small rockets. A skirted balloon cushioned its drop into the ocean. Signals from the capsule's radio antenna, a flashing beacon, luminous dye markers and shark repellent aided in locating the package 25 minutes after impact.

Cal Tech Radio Telescope Spots Space Radio Sources

Nine extra-galactic radio sources, ranging to one billion light years from the earth, have been located by a unique new twin radio telescope. This compares to five radio sources from other galaxies previously identified by all radio telescopes in the world up to the end of 1959.

The new instrument is part of the radio astronomy program of the office of Naval Research. It was built and is operated by California Institute of Technology under contract with ONR. It consists of two 90-foot parabolic antennas mounted on a 1600-foot-long east-west railroad track.

Working in tandem as a radio interferometer, the twin dishes produce a resolving power greater than any radio telescope in operation or under construction.

Cal Tech is now attempting to identify more than 100 extra-galactic radio sources which have been detected by various radio telescopes but not precisely located. Such extra-galactic sources are identified by correlating their direction from earth with visual observations made by optical telescopes. Some of these sources are so faint they are mere pin pricks of light on a photographic plate.

A north-south track will soon be added to the facility. By placing a radio dish on each track, the present fine resolving power will be significantly increased.

Westinghouse Develops 'Near-perfect' Amplifier

A small electronic tube developed at Westinghouse research laboratories reaches the near-ultimate in its ability to amplify ordinary light. The Astracon tube is so sensitive that it makes visible a single electron released at the tube's input by an individual photon—the smallest unit quantity of light that exists.

The tube operates on a unique amplifying principle discovered at Westinghouse five years ago. The image of an object, so dim that it is invisible to the naked eye, is focused by lenses onto a light-sensitive photosurface at the input end of the tube. The individual photons strike the surface and eject electrons from it.

By using five acceleration steps, a single electron is multiplied into about 3000. They are given a final 20,000-volt boost and aimed into a thin layer of fluorescent material at the output end. Here they release 20,000 or more photons of visible light. Thus, if the light striking the input photosurface is a dim, invisible image, the Astracon exactly reproduces that image on its output, thousands of times brighter.

EJECTED electrons in astracon tube crash into film to begin acceleration.

Study Reports on Likely Communications Satellites

The passive spherical reflector in a low-altitude orbit and the active repeater in a 24-hour orbit appear the most promising choices for communications satellites, according to a recent study by ITT Laboratories. Reporting on this study at the recent IRE Convention, L. Pollack and D. Campbell of ITT said that system engineering requirements determine the choice.

The low-altitude passive relay requires no electronic equipment and can be of simple lightweight construction. It can be launched with present boosters and tests have already perfected techniques for putting the "balloon" in orbit.

The passive reflector has almost unlimited bandwidth and can be used with a wide range of frequencies and power levels.

On the other side of the ledger, such a system has several disadvantages. For a given traffic channel capacity, it requires very high transmitter powers, large antennas, and extremely sensitive receivers. At its low altitude it will be in sight of only a relatively small area of the earth's surface.

Problems exist in acquisition and tracking and elaborate system coordination between stations is required. High transmitter powers will introduce severe interference problems.

The 24-hour active satellite overcomes almost all these problems. Its high altitude (22,000 miles) will make it visible over more than a third of the earth. Since it will be effectively "stationary," tracking will be no problem.

Low transmitter powers will be sufficient both on the ground and in the vehicle. Interference with other systems will be unlikely.

The active repeater has its own problems, however. It requires large booster vehicles, precise guidance and attitude control, and high component and system reliability. Definite bandwidth and peak power limitations will demand rigid control to prevent overload.

Ruled out in the study were low-flying repeater satellites such as Project *Score* which relayed a Christmas greeting from President Eisenhower to earth. This system provided storage and transmission of voice information and, according to some proponents, indicated feasibility of such a method. An improvement on this system will have a storage capacity of 12 million bits in each of five storage devices and will provide both real time and delayed re-transmission of the desired data.

Far IR Scanner Developed

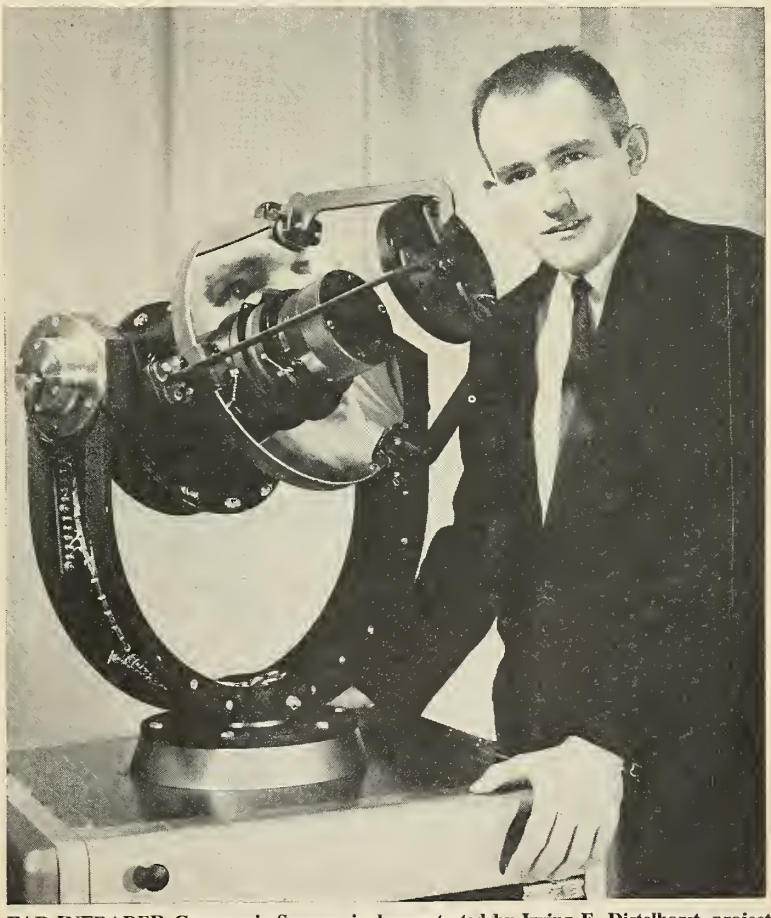
Development of a 50-pound gyroscopic far infrared scanner, adaptable for anti-ICBM missile guidance or interplanetary navigation, has been revealed by The Martin Co., Baltimore Division.

The new device permits detection of objects having very low temperatures such as the temperature of a satellite's outer skin surface. Its sensitivity enables it to distinguish between objects with small differences in temperature at distances in excess of the known current state of the art, the company said.

The scanner uses a 12-inch aperture and is equipped with an advanced optics system and a series of highly sensitive super-cooled detectors in combination with extremely low-noise amplifiers. Development of a new laboratory technique in crystal growth, according to Martin, has made it possible to combine relatively volatile elements with a single crystal of germanium in the detectors, thus permitting detection of "cool" far infrared radiation.

The entire scanner, including mirrors, detectors, and detector amplifier, can be rotated as an integral unit to create a gyroscopic effect. This will permit the device to remain stable during spins or turns of a rocket vehicle in which the scanner might be carried.

Designed for antimissile use, the unit can detect IR radiation emanating from an approaching enemy ICBM nose cone, distinguish this and decoys, and guide an antimissile missile to target intercept by means of a sensitive electromechanical system.



FAR INFRARED Gyroscopic Scanner is demonstrated by Irving E. Distelhorst, project engineer at Martin's Baltimore Division. The 50-lb. unit was displayed publicly for the first time at the recent IRE convention in New York. The gimbal support ring, mounted on a controls console, can rotate 360° on its vertical axis; the scanner and mirrors assembly can rotate 360° on a separate horizontal axis.

Are Big Conventions Worthwhile?

by Hal Gettings

NEW YORK—The annual Institute of Radio Engineers International Convention reached its peak this year, some observers feel. With its steadily increasing crowds, more and more exhibits, more lavish entertainment, and ever-rising costs, the huge technical meeting and exhibition is rapidly arriving at a point of diminishing returns for many participants.

One small company figures costs for the four-day affair as $20-25,000—and wonders whether it's worth it. Such an investment represents the profit on almost a million dollars worth of military business. Of course, some of the cost can be charged off to overhead, but a considerable investment is still represented.

Costs are easy to figure. Benefits are somewhat intangible and it is hard to put a dollar figure on them. But many companies are apparently taking a hard look at the investment and the expected return. Some drop out each year; many others feel they should but don't dare to. Still, there is always more demand for exhibit space than is available.

• **Swelling chorus**—Each year, the Convention is subject to much grumbling and criticism. This year it appeared to be even more widespread and vehement. Some of the beefs: The show is too big; it's hard for the small exhibitor to compete for attention with the larger, more spectacular displays and elaborate hospitality functions; costs are increasing; crowded conditions cause poor exposure; labor creates troubles.

• **"Featherbedding?"**—One of the biggest gripes is the labor situation. Almost all exhibitors complain of the exorbitant rates and "featherbedding" of the unions involved in handling and assembling the displays. Many felt that this year was much worse in this regard than ever before. Technically, a display can be put up by exhibitor personnel if no tools are necessary. The unions won't allow even this, however, and insist that their people do the work. Failure to comply results in immediate threats to close the show.

Such pressure, of course, has its desired effect; the reluctant exhibitor learns his lesson. Displays have a way of getting lost and work orders shuffled to the bottom of the pile.

One exhibitor complained that four of his people could set up their display in eight hours while it required six union assemblers 12 hours. And the work had to be done at premium weekend rates.

• **Boondoggle?**—There is no question that the show attracts engineers. Attendance this year was around 70,000 as compared to 60,000 in 1959. Many feel, however, that much of this engineering time could be better spent and that many engineers regard the show as purely a boondoggle—interesting, certainly, but often not really worth the time and money charged to the company footing the bill.

Many of the papers read in the technical sessions fail to reveal anything really new. Others are so poorly presented that it is difficult to dredge any significant information from them.

The crowds themselves are a source of irritation to the exhibitors. It's hard for the spectators to really see and evaluate the displays in the middle of jammed aisles with other spectators standing on their feet.

Bigness is a problem, too. Areas of interest of few manufacturers are broad enough to cover the spectrum of the IRE. Companies with products for specific and limited application—and these are many—feel they are paying for exposure to a large group of which only a small percentage can be classified as potential buyers.

• **Circuses**—Indicative, perhaps, of the sometimes oversold high technical level of the meeting is the low technical level of many of the displays that seem to attract the most attention. Mobs gather to watch such erudite exhibits as ball bearings jumping through hoops, a large dial indicating angle displacement, and a machine which dispenses free shoeshines.

Unquestionably, there are certain worthwhile benefits inherent in engineers getting together to see and hear new ideas and products. Such cross-fertilization has contributed greatly to progress. The question is whether the benefits are worth the candle.

In any case, such mammoth conventions as the International IRE and WESCON will probably continue to be popular and well-attended and bigger every year. Whether they will recognize their function as a means rather than and end—and serve this function is another question.

Possible Power for Future Spaceships

THIS LOCKHEED plasma accelerator produces thrust by ejecting ions and electrons at velocities of 220,000 mph. The possible forerunner of the first interplanetary space ship's propulsion system, the device produces the equivalent of two pounds of thrust.

Symposium Seeks Ways to Cut GSE Costs

by Paul Means

DETROIT—Principal speakers at the American Rocket Society's Ground Support Symposium here March 23-25 ranged in their talks from present missile and space problems to what type of equipment will be needed to support the moon bases of the future.

Main theme of the panel discussions was: How to reduce the cost of support equipment, which now accounts for two-thirds of the missile budget. Other information given included a description of the support for second-generation missiles such as *Minuteman*, *Polaris* and *Pershing*.

Dr. I. M. Levitt, Director of the Fels Planetarium of the Franklin Institute, and contributing editor of MISSILES & ROCKETS, described a detailed support system for a permanent moon base 20 years from now. He described how lunar rocks could provide the atmosphere and fuel for the base and how food could be derived from algae tanks.

Lunar structures and clothes, according to Levitt, would be fashioned out of synthetic fibers, and the first houses would be in lunar caves for maximum protection from space hazards.

Levitt predicted that man will have created a thriving civilization on the moon by the turn of the century.

Other comments by Levitt included:

• "The Russians have the capability to soft-land an instrument package on the moon today, and I would not be surprised if they did so this year. Such a package would weigh about 100 lbs."

• The Russian photograph of the back side of the moon taken by *Lunik II* is no fake, and bears out a theoretical picture he drew of it which first appeared in MISSILES & ROCKETS early last year. (See M/R, Feb. 16, 1959, p. 14.)

• The Russians will probably accomplish a manned lunar landing in 1966. Given a breakthrough on *Saturn*, the U.S. might also be able to do this by 1966.

• The moon is important as a launching base. Any nation which attempts to conduct its space program solely from earth "is courting suicide."

Dr. Homer Joe Stewart, Director of the NASA's Office of Program Planning and Evaluation, was not as optimistic as Dr. Levitt in his crystal ball gazing.

Stewart contended that many are too optimistic about what the U.S. can accomplish in space during the next few years, but not optimistic enough about what can be accomplished 15, 20 and 30 years from now.

He pointed out that our present capabilities in space are a long way from state-of-the-art. Of the 45 attempted satellite launchings of all U.S. organizations to date, Stewart estimated that only 14 were successful and three or four partly successful. This is the success ratio, according to Stewart, that the U.S. space program will be working with during the next few years.

• **Defense of variety**—Stewart also defended NASA's program of conducting research in a wide range of areas rather than concentrating on a few which might have more immediate and sensational results. The NASA program, he declared, is to place heavy emphasis on basic engineering techniques and equipment. By pushing development in all areas, and especially in the areas of vehicle development and space applications, Stewart predicts, the U.S. will be much further ahead in the long run.

Other comments made by Stewart included:

• Ground support equipment for space vehicles will be cheaper than it is for missiles, because re-use of the equipment lowers the overall cost.

• Industries doing space work will perform a great deal of research and development, but very little production.

• The ratio between engineers and production workers in space industries may become as high as three engineers for every production worker. In the missile industry presently there is approximately one engineer for every production worker.

• The lead time on a manned lunar space vehicle after completion of the booster will be about four to five years.

• **Military preserve**—Brig. Gen. A. W. Betts, Director of the Advanced Research Projects Agency, defended the viewpoint that there was a military space mission, and that the military

ARS meeting said to overlap others

Was the American Rocket Society's Ground Support Equipment Symposium worth while?

M/R asked this question of missile and space industry representatives attending the ARS' most recent meeting in Detroit.

The consensus was that though the Symposium was sometimes informative and generally interesting, it wasn't worth spending three days away from the job.

For those who did not have security clearance, only one panel discussion of any length was offered. Although the luncheon and dinner speakers were interesting and noteworthy from a news standpoint, most did not relay much technical information, and many did not relate their talks to present problems in the support equipment field.

The problem, as most observers saw it, is that there are too many organizations holding the same type of meetings in the missile and space field. The Institute of Electronic Engineers, holding a meeting at the same time as the ARS Ground Support Equipment Symposium, was conducting seminars into the same support equipment electronics problems. It was impossible to attend both meetings, and it raises the question as to whether both meetings are worth while.

General feeling of those attending the Detroit gathering seemed to be that while the ARS meeting was helpful in someways, it overlapped with meetings being conducted by other organizations in the missile field, and that some cooperation between professional organizations might do much to eliminate the problem. Joint meetings conducted by the ARS and IRE, the American Chemical Society, and others in areas where their interests overlap would eliminate many meetings, and heighten the value of those few meetings scheduled.

should have an active part in space research.

Betts did not believe it detrimental to the military space mission for NASA to build the early large boosters.

"I don't think anybody in the military would have said they should have developed the early supersonic aircraft rather than the old NACA," Betts said, "but if they had been denied the opportunity of modifying the NACA design for military purposes and carrying the work forward . . . then the military would have protested."

The initial military mission in space, according to Betts, is to "learn about it, and learn to use it to upgrade our military capability."

"The military has to be in the space business," Betts said, "but they don't have to build everything. When we see a specific need for a large booster, we will carry on from where NASA has developed it."

In the same vein, Betts predicted that NASA will get a great return out of ARPA's research in large solid propulsion systems.

Other remarks by Betts included:

• "The nation's missile and space missions have spread so fast and so rapidly that the government is supporting marginal companies . . . Time will shake these out as competition increases."

• "I believe strongly in the competitive bidding system."

• One reason for the Russian missile and space advantage is that they put their German rocket experts to better use during the late 40's and early 50's than the U.S. did, Betts said. The Von Braun team should have been used in the U.S.'s ICBM program.

• **Stressing balance**—C. S. Draper, head of the Department of Astronautics and Director of the Instrumentation Laboratory of the Massachusetts Institute of Technology, said that the balance between vehicle-borne equipment and ground support equipment will be one of the most important factors in determining the vehicle systems that will win the privilege of defending our country in this age of space.

Draper believes that missile support equipment should be light, simple, and moveable. He characterized the "hard" base as a sitting duck, and that an important factor of future missile units will be their flexibility and their transportability.

Draper warned against making missile support systems too complex and heavy. The goal, according to Draper, is a system where weight and bulk are "reduced to the point where even the highest-performance missiles could be serviced and provided with accurate guidance settings by mobile support equipment so flexible that it does not limit operations in any way."

Draper criticized the procedure where the complete vehicle is developed and then support equipment is designed to work with the existing vehicle. What usually happens, according to Draper, is that the equipment tests more components and functions than are strictly necessary. Adding to the problem is the necessity of having equipment to check the support equipment which in turn checks out the missile.

Draper recommended that support equipment be reduced to the simplest "go," "no go" and numerical identification type, and that no repairs be made in the field. Instead, "repairs might be made in factories or shops equipped with automatic check-out arrangements much more complex than the support equipment."

• **Closed sessions**—Of the four panel discussion sessions, three were classified "secret." These covered the problems encountered in actual field experience with currently deployed equipment; a review of second-generation missile ground support equipment; and current advances in mechanical and electrical ground support equipment.

One of the two non-classified sessions on Russian ground support equipment was cancelled. The other non-classified session was a summary of unusual chemical, transportation and legal risks involved in operation of the systems.

Brief summaries of the non-classified papers given at the Symposium and available from the American Rocket Society follow.

Operational Design—The Effect of Operational Concepts upon Weapon System Design. Peter B. Weiser, Space Technology Laboratories.

A summary of the maintenance, logistic, and personnel problems in firing missiles in the field which must be taken into consideration when the missile and its support equipment are designed.

Requirements and Trends in Standardization. Col. Thurston T. Paul, Army Ballistic Missile Agency.

A history of the efforts to standardize military support equipment, especially in electronics, instrumentations and communications, and the problems making standardization in some areas difficult.

Advanced Automatic Checkout Equipment. James Q. Maloy, Senior Program Manager, Bendix Support Equipment.

A review of present concepts in automatic checkout equipment, with specific emphasis on the "universal" and "adapter" module philosophies and applications.

How much Automaticity For Checkout Equipment? Sidney I. Firstman, the Rand Corporation.

An analysis of the virtues and faults of various types of programers with respect to the several design and operational features: malfunction detection and isolation; speed of test; control capability-versatility; self-test and verification; emergency shutdown capability; and reliability and maintainability.

Failure Prediction—A Method of Predetermining the Success or Failure of an Individual Missile. Allan T. Kneale, Motorola, Inc.

A definition of the function of ground support equipment with respect to the necessity of life prediction. The theoretical background required for a life prediction system is developed and a possible implementation is described.

Handling and Launching Considerations in Missile Design. by Michael L. Mastracci, American Machine and Foundry Co.

A presentation of the problems of designing handling and launching equipment around an already developed missile, and some suggested solutions.

Logistic Supply and Handling of Liquid Helium. John W. Marshall, Air Force Flight Test Center, Edwards AFB.

A proposal to have liquid helium available from a national supply systems, and some suggestions as to how this can be accomplished.

Use of Standard Vehicles for Missile Ground Support Equipment. Peter L. James, Missile Division.

A proposal to cut down the high cost of support equipment by using existing military vehicles instead of specialized vehicles, and examples of how this was done in the case of *Redstone's* support equipment.

Legal Aspects of Missile Handling. G. Vernon Leopold, chairman, Special Committee on Space Law, State Bar of Michigan.

A discussion of the legal problems connected with injury or damage due to negligence of inadvertent accidents in the handling and transporting of missiles.

Chemical Hazards in Handling Rocket Propellants. Alfred J. Zaehringer, American Rocket Company.

A review of chemical hazards in terms of overall systems. All chemical propellants are treated.

Transportation and Handling of the Saturn *Booster. Julian S. Hamilton,* Army Ballistic Missile Agency.

A review of the plan to transport the *Saturn* booster to Cape Canaveral by river barge.

Handling of Large Rocket Engines. Stanley R. Parker, Rocketdyne, North American Aviation, Inc.

A discussion of rocket engine handling problems and the host of factors to be considered in the development of a handling equipment system serving large rocket engines from their inception to their use at remote test sites.

Low-Altitude Exploration Stressed

Britain's workhorse Skylark sounding rocket will be given longer range; U.K. satellite program will use Black Knight for testing

by G. V. E. Thompson

LONDON—A great deal of exploration still must be done under the 125-mile altitude attained by satellites, cautions Sir Harrie Massey, British scientific space expert.

At the Royal Aeronautical Society symposium on upper atmosphere and space research, Massey emphasized the importance of vertical sounding rockets below the usual satellite altitude.

Most experiments of the lower altitudes have been carried on by the principal British sounding rocket, the *Skylark*. The first large solid rocket to be used for upper atmosphere research, the rocket weighs 2550 lb. at launch. It is made up of the 2200-lb. Raven rocket motor, 100-lb. nose structure, 100-lb. fins and 150-lb. payload.

The motor was designed by the Rocket Propulsion Establishment (RPE), Wescott, who was also responsible for installing the 1800-lb. propellant. The Royal Ordnance Factory, Waltham Cross, produces the propellant, which contains ammonium picrate, ammonium perchlorate and polyisobutylene. It has a specific impulse of 177 sec. and is case bondable. Cases are made by Bristol-Aerojet. Raven can exert a thrust of 12,000 lb. for about 30 sec.

Skylark is launched from a tall tower to minimize dispersion. The roll rate of the rocket is kept as low as possible, since it tends towards instability near the end of burning as a result of roll resonance.

Skylark has carried a wide range of experiments, including magnetometers, ion probes, cameras, grenades, sodium vapour ejection, photometers, etc. Data is usually transmitted by a 465 mc/s. telemetry system, although if necessary the payload can be recovered by a parachute.

The range of the rocket is expected to be increased in the near future. A new three-axis stabilized platform will be introduced, using a gyroscopic reference system in conjunction with stabilizing air jets of 5 lb. thrust, maintaining control within 2 or 3 degrees. A new high-thrust booster will be fitted to the vehicle, increasing its ceiling to 120-130 miles. Named Cuckoo (it kicks the Raven out of its nest), it will burn for about 4 sec. and develop a total impulse of 81,000 lb-sec. Cuckoo and Raven cost about $2000 and $8500 respectively.

• **British satellite**—At the same meeting, experiments in space physics proposed for the U.K. satellite program were outlined.

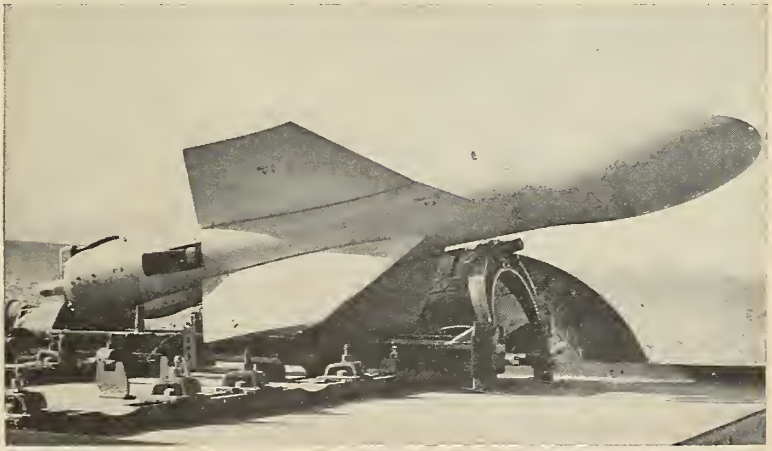
Black Knight (Saunders-Roe) is expected to be used for some experiments, including sphere drop tests to determine air density above 100 km. The instruments being developed for the Anglo-American *Scout* satellite would first be tested in *Black Knight*.

Design studies for an all-British launcher were discussed, calling for a de Havilland *Blue Streak* topped by a modified Saunders-Roe *Black Knight* (the propellant tanks would be less elongated). This combination would give the required altitude and orbital velocity, but rather than relight *Black Knight* to apply the final burst to put the payload into orbit, it is proposed to incorporate a third-stage rocket with vernier motors of 500-1000 lb. thrust. Since it would be fired before the cut-off of the *Black Knight,* there would be no coasting to final altitude; the third stage would rise under a continuous low thrust. This was thought to offer better opportunities for correcting the course and to provide some saving in weight.

One possible source of trouble would be the bumping of the third stage by the separated *Black Knight,* because of outgassing of propellants in the latter. This phenomenon of residual thrust spoiled one of the *Explorer* launchings and has been observed in trials of *Black Knight* at Woomera.

The launcher could place in orbit a payload large enough to include the fully stabilized platform necessary for some of the astronomical experiments; 1750 lb. could be placed in a circular orbit at 300 miles altitude, or 200 lb. in an elliptical orbit (perigee 300-apogee 100,000 miles).

French Antitank Weapon



NORD AVIATION'S new *SS 12* is reported to have a 4-mile-plus range, more than twice that of the *SS 11*. The antitank weapon can be launched by infantrymen, from tanks, light aircraft or helicopters. Overall length is about 6 ft., weight about 150 lbs. and guidance is either wire or radio controlled. Nord expects to put the *SS 12* into mass production within 14 months at its plant near Chatillon, France.

Future Red Rockets To Aid In Forecasting

Instruments in future Soviet rockets launched toward the sun and around the earth will be designed with an eye to long-range weather forecasting, according to recent reports from Soviet journals.

A great deal of work is being done at the Crimean observatory to prepare for experiments in identifying the particles emanating from the Sun and in solving the problem of the earth's corona. The laboratory reports success in simulating "solar flashes" through compression of magnetic fields of extremely high intensity.

Earth satellites will carry special light, photo, and television equipment to report on various meteorological processes. The Soviets hope to investigate the matter of shifts in the geographic pole which they believe affects these processes. Other experiments will explore the effect of solar radiation energy and heat exchange in the atmosphere, and the relationship between the build-up of the Siberian anticyclone in winter and geographic pole shift. (*Literaturnaya gazeta,* Jan. 23, and *Sovetskaya aviatsiya,* Feb. 9.)

German Rocket Men Will Hear U.S. Papers

The German Society for Rocket Engineering and Space Flight Research will hold its 12th annual meeting at Heidelberg, May 23-25, with Prof. Dr. Eugen Saenger presiding.

Work of several top U.S. scientists will be represented among the approximately 20 papers to be presented. Drs. E. R. Roberts of Aerojet-General Corp., Geissler and Gerathewohl of Army Ballistic Missile Agency will be contributors.

The 8th "Hermann-Oberth Medal for Outstanding Merits in Astronautical Research" will be awarded at the session. It is expected that the constitutional session of the Advisory Space Flight Committee at the German Federal Ministry of Traffic also will be held this time.

Pneumatic Steering

LONDON—A pneumatic apparatus for steering a guided missile has been developed here by T. J. Dorricott and C. L. Paice of Pye, Ltd.

The apparatus swivels an extension to the rocket venturi. Gas pressure is bled from the combustion chamber and used to operate pistons disposed symmetrically around the venturi axis. The invention is covered by British Patent Specification 827,299.

soviet affairs

By DR. ALBERT PARRY

U.S. short-range missiles . . .

are the subject of a special series of four articles in *Krasnaya Zvezda,* the foremost daily of the Soviet armed forces. Appearing on January 19 and 28 and February 9 and 18, the series was done (apparently on assignment) by four specialists, three of them officers of the Red engineering troops, and the fourth a nonmilitary expert: Lt. Cols. V. Kruchinin and N. Avilov, Maj. V. Zhukov, and Engineer L. Giagzhnas. The first three are Russians; the civilian may be a Lithuanian. The American missiles they discuss are the *Honest John,* the *Corporal,* the *Redstone,* and the *Mace.* A subtitle of each of the four articles states that the authors gleaned their information from Western literature. The content of the series shows that U.S. journals were the main source, but that some West European channels were also utilized. The articles carry diagrams and other pen-and-ink illustrations clearly of Western origin.

Considerable respect . . .

for American-made tactical missiles is manifested by the Soviet authors' selection of Western comments. Thus Kruchinin stresses Western opinion that nonguided missiles such as the *Honest John* can shoot further and have heavier warheads than conventional artillery. He also points out that the *Honest John* weighs less than an American atomic gun "while on the move" and that the missile "can be equipped with the same nuclear warhead as can the gun's shell."

On the negative side . . .

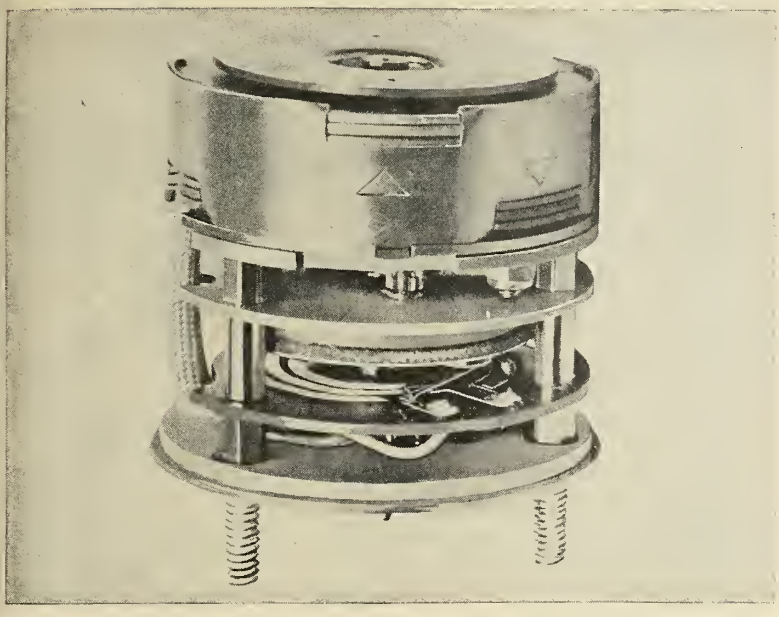
more briefly, Kruchinin records the Western consensus that nonguided missiles are less precise than conventional artillery in reaching their targets and that they can't be fired as rapidly—in other words, that these missiles cannot be sent to the enemy lines in a veritable barrage typical of conventional artillery shells. In describing the liquid fueling systems of the *Corporal* and the *Redstone,* Kruchinin observes that this fuel requires special equipment and exact handling, which "complicates the exploitation" of these missiles. Giagzhnas, while praising the *Mace,* enumerates several of what he calls its deficiencies, among them the fact that it can be rather easily spotted by the foe, "as its guidance equipment emanates electromagnetic energy."

Actual handling . . .

of U.S. tactical missiles during maneuvers approximating actual combat conditions is discussed in detail by Zhukov. His article is supplemented by particularly graphic illustrations, based no doubt on American sources. Some French and Swiss sources are used in the last article of the series, by Avilov, on the Western family of antitank guided missiles. He concludes by saying that "the introduction of antitank guided missiles into the military business is due to high combat qualities of such weapons." At the same time, he quotes approvingly Western statements to the effect that this innovation does not mean the abandonment of other antitank weapons.

No comparison . . .

with Soviet tactical missiles is even hinted at in any of the four articles. But a careful study of this series by our experts could reveal just what in our short-range weapons attracts the Red specialists—just where they deem our weapons to be on a par with theirs, and where we may possibly be either behind or ahead.



Stepping Devices Feature Accuracy

A line (series 18400) of compact stepping devices which can perform high speed sequencing, pulse control and switching functions has been introduced by the A. W. Haydon Company.

Characteristics of the new units include low power consumption and extreme reliability. The rotary stepping switches, pulse dividers and precision sequencers can in many cases replace conventional solenoid or relay-actuated units. Stepping action is achieved magnetically, without ratchets, linkages or contacts.

Printed circuit rotary stepper switches contain up to 30 positions on a single deck. Each pulse cycle advances these switches one position. They can be operated continuously or at random intervals to produce up to 2400 steps per minute, at 24 volts DC. Optional motor control circuits can provide for "home to reference" by self stepping or with 60 CPS external power supply. With power off, switches are magnetically locked. Optional shaft extensions can be provided for manual override of the magnetic detent. Stepper switches are available with solder terminal headers, AN connectors and hermetic sealing.

Precision gated stepping switches can serve as pulse dividers for random or variable pulse sources or as frequency dividers when the pulse source is constant. Units can be factory-set to produce output pulses in any desired proportion to input, i.e., for 100 pulses fed into the unit, 1 pulse is sent out.

Circle No. 225 on Subscriber Service Card.

Two-Frequency Heating Unit

A dual frequency 10 KW output high-frequency induction heating unit (Model LI-10D-1) operating at approximately 400 KC and 4 MC is being offered by Lindberg Engineering Co.

This unit has been specially designed for research and development work and for production of semiconductor and other conductive materials.

The unit has a totally enclosed cabinet with a gasketed door for dust and fume protection. Outside dimensions of the cabinet are 40 in. wide by 40 in. deep by 76 in. high with a 30 in. x 30 in. x 16 in. (approx.) cubicle mounted on top for dual frequency requirement. The entire unit is mounted on heavy channel iron skids, and overhead cross members are available for lifting. Net weight of the entire unit is approximately 2150 pounds.

Power input is 230/460 volts, 3 phase, 60 cycles. Other voltages and frequencies can be supplied. Power consumption is 20 KVA maximum at 90% power factor. Power for the type 6420 water-cooled oscillator tube is obtained from six industrial type 575-A mercury vapor rectifier tubes employed in a 3 phase, full wave rectification system. Filament voltages are automatically controlled through constant voltage transformers to maintain proper tube filament voltages regardless of line voltage fluctuations.

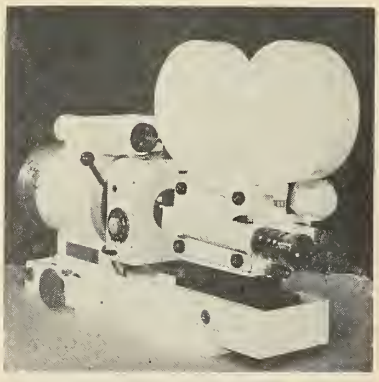
A type 6420 water-cooled, industrial tube is employed in an extremely stable tuned plate circuit. Maximum oscillator tube life is assured by conservative use under proper operating conditions. Filament voltage is automatically controlled through a voltage regulating transformer. In the 400 KC circuit the water-cooled, hermetically sealed tank capacitor contains a low loss high frequency liquid dielectric. In the 4 MC circuit the tank capacitors are low loss heavy duty industrial type vacuum capacitors.

Output power is available at two different frequencies (approximately 4 MC and 400 KC) from two separate sets of output terminals. One terminal of each frequency pair is at ground potential. Internal adjustments can be made on the respective tank circuit to match a variety of work coils.

Circle No. 226 on Subscriber Service Card.

Sensitive Volt-Ammeter

A model of the Hermach-Engelhard Transfer Volt-Ammeter for ranges not covered by the earlier version has been introduced by the Instruments and Systems Division of Engelhard Industries, Inc. Both units are for precision measurement of alternating voltages and currents between 5 and 50,000 cycles per second with an accuracy within 0.05%.



Voltage ranges of the new model "B" are 0.5, 1.5, 3.0, 6.0, 7.5 and 15 volts, while current ranges may be set at 7.5, 25, 50 or 100 milliamperes. Comparable ranges on the Model "A" are 15, 30, 75, 150 and 300 volts, and

100, 250, 500 milliamperes, 1.0, 2.5, and 5.0 amperes. Instruments of this high precision and versatility have heretofore been unavailable; the wide ranges of these meters make them particularly useful in the aircraft and missile fields.

A major application for both models is in standards laboratories for the original calibration and later checking of other instruments. Engelhard can also furnish, at extra cost, a certificate from the National Bureau of Standards, if desired by purchasers of either model.

Operating principle is the comparison of heating effects of an unknown alternating current with an accurately adjusted direct current, which can then be measured directly with any good null potentiometer. Internal mercury cells provide the DC source. Balancing of the AC and DC heating effects also employs the null principle for utmost accuracy.

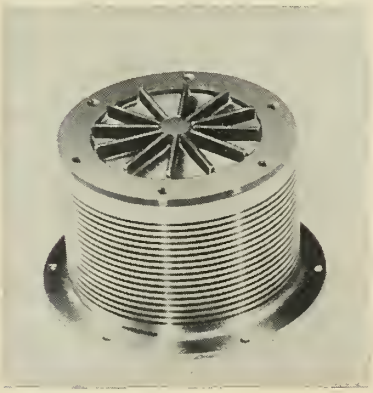
A 5%, direct reading rectifier-type meter is incorporated in the instrument to indicate approximate values of voltage and current. This indicates the approximate setting for the potentiometer and also serves as a range checker to prevent accidental burnout of the thermo-element. The thermal converter element, in turn, can be simply replaced without necessitating recalibration or affecting accuracy of the meter.

Circle No. 227 on Subscriber Service Card.

LOX Pressure Equalizers

Hydrodyne Corp. is producing a line of pressure equalizers for use with LOX and other fluid tanks wherever there is a pressure differential.

This particular equalizer incorporates the principle and materials of Hydrodyne's machined aluminum bellows. Its design resembles a top hat with the end cap of machined aluminum, nickel-plated, and strengthened with ribbing soldered thereto. The bellows, which is hermetically sealed, will take three quarters of an inch minimum stroke at 70 psi. Temperature range is from –400°F to 750°F.



The bellows section is machined from various aluminum, nickel and other high-strength and high-temperature alloys. The particular method of machining this bellows permits a "controlled wall thickness"—concentrating thickness or strength where needed. Failures are eliminated due to fatigue, with some of these having been tested to 100,000,000 cycles without failure.

These units are available for pressures up to 4000 psi. Current sizes are from ¼ in. to 36 inches in diameter.

Circle No. 228 on Subscriber Service Card.

Aluminum Alloy Tool

A tool that performs a wide variety of milling, drilling and tapping operations on cast aluminum alloy missile wings at a rate of 17 pieces per hour at 100% efficiency has been designed and built by Snyder Corporation.

The unit is a line-index type in which the missile wing is clamped in a fixture and traversed on hardened and ground ways to various machining positions. In completing the machining of the part, the work fixture is moved by a hydraulic cylinder arrangement along a 68-in.-long path.

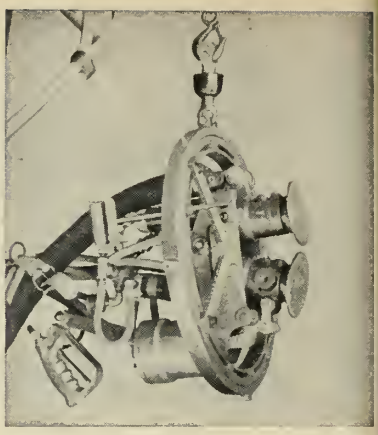
The tool has a welded steel base to which are bolted welded bases, arms and columns for several different types of moving and fixed machining units. The fixture is located by shot pins for machining operations in intermediate positions and by stops at each end of the travel. Some machining operations are carried out while the fixture is being indexed from one fixed position to the next.

Eleven different machining operations are performed at five fixture positions on the missile wing by an assortment of machining units including a Snyder standard way-type unit, two air-powered motorized drilling units, two motorized three-spindle drill heads, a two-spindle motorized tapping unit, nine motorized precision spindles, four air-powered, air-fed single-spindle drilling units and three air-powered, air-fed lead screw single-spindle tapping units.

Circle No. 229 on Subscriber Service Card.

Roll Spot Welder

A Portable Roll Spot Welder, especially designed to weld three thicknesses of metal which require high clamping pressure, is now being produced by the newly-consolidated Progressive Welder and Machine Company.



The machine is patterned after Progressive's single-drive Roll Spot Welder, except that the new unit has synchronized, double-wheel, air motor drive. Unusual strength and clamping pressures up to 1000 pounds are attainable, and its compact design and light weight permit efficient production speeds of up to 250 inches per minute.

The portable welder is applicable for use on cumbersome jobs such as automotive roof panels, deck lid openings, and wheel housings. Spot frequency is adjustable between ½" and 1½" automatic spacing, and two or three thicknesses of .032 sheet are not only easily handled, but present a much improved appearance.

The synchronized, special alloy drive and contact rollers are available in various diameters to meet work requirements. They turn on special, current-carrying needlebearings to withstand the high clamping pressures and to assure long service life and minimum maintenance under high production usage.

Circle No. 230 on Subscriber Service Card.

Smallest Sealed Switch

The KLIXON AT1-1 ("aspirin tablet") Precision Switch establishes a a miniaturization record for hermetically sealed switch design. Weighing less than 1/28th oz., it is also the lightest switch of its type on the market. The KLIXON AT1-1 is 95% smaller and weighs 93% less than the KLIXON KX Series hermetically sealed switches.

Size reduction is made possible by use of a unique, snap-acting, "W-blade" element, a design which lends itself to miniaturization. The envelope dimensions of the AT1-1 are 0.320 in. diameter by 0.440 in. long.

This subminiature switch has been especially designed for applications which require a true hermetically sealed unit of the smallest and lightest

configuration possible, combined with high reliability for aircraft, missile and electronic uses.

The hermetic sealing is accomplished by applying the techniques of seam and stitch welding to switch assembly. Welding eliminates solder flux contamination and contributes to miniaturization by requiring less volume for the weld than for solder. Terminals are brought out through a fused glass seal to make the assembly completely environment-free. Casing is stainless steel.

Prior to being hermetically sealed, the precision calibrated switch is filled with a dry, inert gas to ensure reliability for dry circuit applications.

Exacting tolerances on tiny detail parts are kept by the use of Swiss Screw Machines.

Current capacity is 3 amperes, 28 volts dc, resistive. Ambient temperature range is −65°F to +275°F. Other specifications include: contact arrangement, S.P.D.T.; 10,000 cycle life min.; resistance to 40 g's vibration and 100

g's shock; overtravel, 0.003 in. min.; movement differential, approx. 0.002 in.; pretravel, 0.005 in. Actuating force is 12 ozs. ± 8 ozs. and release force, 1 oz. min.

Circle No. 231 on Subscriber Service Card.

New Literature

POLYCARBONATE RESIN. Mobay Products Co. has published a new Technical Information Bulletin describing the physical and electrical properties of its polycarbonate resin, "Merlon," a new thermoplastic for engineering applications. The Bulletin compares Merlon with seven other plastics to show its unusual combination of characteristics which makes it suitable for engineering applications now far beyond the range of present materials. The resin, a linear aromatic polyester of carbonic acid, now is being evaluated for applications in the electrical, automotive, lighting, general industrial, graphic arts and engineering fields. A few of these applications include switchboard connectors, coil forms, relay bases, printed circuit card holders, safety helmets, drafting film, and heat resistant diffusion lenses.

Circle No. 200 on Subscriber Service Card.

STEEL CORROSION. Cobalt additions to chromium stainless steels have a favorable effect on their resistance to corrosion, say researchers of the Cobalt Information Center. The influence of cobalt additions on the structure of the mechanical and chemical properties of ferritic and austenitic stainless steels is being studied at the Centre National de Recherches Metallurgiques, Liege, under the sponsorship of the Centre d'Information du Cobalt. First results of this investigation are now available in a report entitled, "The Corrosion Resistance of Some Stainless Steels Alloyed with Cobalt," published in the fifth issue of *Cobalt*. Stainless steels investigated contained 17 and 27 per cent chromium and had nickel contents of 0, 2, and 9½ per cent. Cobalt additions ranged from 1.5 to 10 per cent. Tests were made by total immersion in sulfuric acid, intensiostatic and potentiostatic methods of electrochemical testing, and for susceptibility to intergranular corrosion after heat treatment. The first tests confirmed that cobalt increases corrosion resistance in acid solutions; after appropriate heat treatments, the cobalt-alloyed steels were less susceptible to intergranular corrosion.

Circle No. 201 on Subscriber Service Card.

SEMICONDUCTORS. An eight-page technical newsletter published by International Rectifier Corporation contains a four-page article entitled "Properties of Semiconductor Devices Affecting Voltage Division," in which voltage distribution and various methods to achieve equality are discussed, analyzed, and recommendations made for the solution of specific problems.

Circle No. 202 on Subscriber Service Card.

SILICA AEROGEL. Monsanto Chemical Company's Inorganic Chemicals Division has announced the publication of a new technical bulletin on Santocel A, a silica Aerogel used for thermal insulation. This product, through its unique structure, gains an amazingly low thermal conductivity, which is less than the theoretical value for "still" air, Monsanto said. The bulletin contains product descriptions covering chemical, physical and structural properties, in addition to shipping and handling notes and suggestions as to use.

Circle No. 203 on Subscriber Service Card.

SUPPORT EQUIPMENT. An illustrated four-page brochure describing the capabilities of the GSE Systems Div. of Adler Electronics, Inc. for design and manufacture of production-line to pre-flight missile and satellite checkout systems is available.

Circle No. 204 on Subscriber Service Card.

GROUND SUPPORT. An illustrated brochure containing photographs and descriptions of ground support equipment for the *Redstone, Jupiter,* and other missiles is available from Designers for Industry, Inc. In addition to GSE produced by DFI, various Frequency Standards and Programmers are illustrated and specifications given.

Circle No. 205 on Subscriber Service Card.

HYDRAULIC RELIEF VALVES. In-line hydraulic relief valve, type 415745, weighing less than 8 ozs., is manufactured to MIL-V-5523B. The new line features full reverse flow and surpasses specification crack and re-seat requirements. All-hardened steel moving parts are used in the valve, thereby eliminating sliding "O"-ring seals. An integrated fluid dash pot and a velocity-sensitive poppet are responsible for absolute stability, exceptionally flat performance and virtually no discernible hysteresis. The type 415745 configuration conforms to MS-28887. A smaller external configuration is available. Operating temperature is from −65°F to 275°F. Gladden Products Corp.

Circle No. 206 on Subscriber Service Card.

STEEL CASTINGS. The use of steel castings in the defense industry is featured in a new booklet published by the Steel Founders' Society of America. Entitled "Sinews of Modern Living," the 28-page booklet dramatically presents the multitude of uses for steel castings. Line drawings of more than 200 representative steel castings, selected from over 1000 photographs and references are contained in the booklet. In addition to the section devoted to the use of steel castings in the defense industry, the booklet also explains and illustrates the use of cast steel parts and components in these particular fields; railroad, utilities, machine tool, construction and construction equipment, petroleum, mining, forestry and materials handling.

Circle No. 207 on Subscriber Service Card.

GLOSSARY. Standard Wire and Cable Company has published a pocket-sized "Glossary of Wire and Cable Terms." The booklet lists alphabetically common terms, expressions and units used in the electrical wire and cable industry. It is very handy as a reference to engineers, designers, technicians and purchasing personnel.

Circle No. 208 on Subscriber Service Card.

$2 Million More For *Minuteman:*

Boeing Airplane Co. will centralize electronic systems work for the *Minuteman* ICBM ground support equipment in a specially equipped building now undergoing a $2 million renovation program. Formerly used for B-70 developmental work, the Boeing Field site will have over 17,000 sq. ft. of "clean" area with precise temperature and humidity control. It will be the largest controlled environment facility owned by Boeing and among the largest in industry.

Test and bench equipment is to be checked out in early June. Operations will begin later in the month. By July 1, Boeing expects to have over 150 employes assigned to the new area on *Minuteman* work.

TEFLON FACILITY PLANNED: Tri-Point Plastics Inc. plans a 15,000 sq. foot plant to process "Teflon" fluorocarbon resins exclusively. It will be adjacent to the firms existing building in Albertson, N. Y.

NEW MILITARY PRODUCTS DIVISION: A new Military Products Division to work exclusively on defense products has been created by Bausch & Lomb Optical Co.

Heads of departments are: sales, J. W. Wright; manufacturing, C. N. Hendershott; research and engineering, Dr. L. S. Packer. Herron Optical Co., a B & L subsidiary, will be utilized by the new division.

The divisions will work with both government and prime contractors, and do extensive work in the field of integrated optical-mechanical-electronic systems.

GOOD-ALL ACQUIRED: Thompson Ramo Wooldridge Inc. has concluded an agreement to acquire controlling interest of Good-All Mfg. Co., Ogallala, Nebraska, manufacturers of electronic components. More than 80% of Good-All stock would be acquired through exchange of TRW common stock. Good-All, with 1127 employes, holds a minority interest in Radio Kenmetal, Inc., part of which was acquired last year by TRW when the latter bought control of Radio Industries, Inc., Des Plaines, Ill. Milam Electric Mfg. Co., Providence, R.I., is a Good-All subsidiary which produces plastic-laminate materials for electrical insulation.

ENGLISH EXCHANGE: English Electric Valve Co. Ltd., England and Eitel McCullough Inc. U.S.A. have agreed to exchange technical information and manufacturing know-how on klystrons, travelling wave tubes and power tubes.

DOUGLAS REALIGNS: The Thermodynamics Section of Douglas Aircraft's Missiles and Space Systems Engineering division has been re-named Thermodynamics and Nuclear Science Section in keeping with a realignment of the group's efforts. A communications systems section has been established also in Missiles and Space Systems Engineering to work in such areas as electronic countermeasures, counter-countermeasures, integrated command-function communications and decoy discrimination.

EIA Chief Honored

AT BOARD of Directors Meeting of Electronic Industries Association in Washington recently, H. Leslie Hoffman (left) chairman of EIA Awards Committee, and Leslie F. Muter, EIA treasurer and past president, congratulate EIA President David R. Hull on his selection to receive the Association's 1960 Medal of Honor.

financial news

• **Lear, Inc.**—Lear, Inc. reports a 50% increase over 1958 in 1959 net earnings.

Net income of $2,407,022 in 1959 topped $1,607,751 in 1958. Shipments of $87,002,497 were 37% over the previous year's volume of $63,627,475. New business brought in a record $100,800,000 in new orders. Year end backlog of $76,000,000 compared with $71,900,000 at 1958 year end.

• **Thompson Ramo Wooldridge**—Sales hit a new high of $417.7 million. The missile electronics and space category accounted for $167 million of this, over an $89 million total for the category in 1958. TRW's semiconductor subsidiary, Pacific Semiconductors, Inc. doubled sales in 1959.

• **Bell & Howell**—Net income amounted to $3.4 million with sales of $61.2 million. Combined 1959 sales of Bell & Howell and Consolidated Electrodynamics Corp. (CEC) recently merged, were $105 million—net earnings $5 million.

• **General Precision Equipment Corp.**—Sales reached 28% over 1958, with a total $215.6 million Net income was $4.2 million.

• **Temco Aircraft Corp.**—Sales of $100.7 million fell under 1958's total of $119 million. Earnings of $1.2 million were also under the 1958 total of $2.6 million. Missiles and electronics accounted for 27% of sales.

• **Ionics, Inc.**—Ionics pulled out of a loss year in 1958 of $16,128 with a net profit in 1959 of $83,188.

—when and where—

APRIL

Solar Energy Symposium, American Society of Mechanical Engineers, and Mechanical Engineering Dept., University of Florida, Gainesville, April 4-5.

1960 Nuclear Congress: "What will the future development of nuclear energy demand from engineers?" includes 6th Nuclear Engineering and Science Conference; 8th NICB Atomic Energy in Industry Conference; 6th International Atomic Exposition, New York Coliseum, April 4-7.

Society of Automotive Engineers, National Aeronautical Meeting and Missile and Aircraft Engineering Display, Commodore Hotel, New York, April 4-8.

American Chemical Society, 137th National Meeting, Cleveland, April 5-14.

American Rocket Society, Structural Design of Space Vehicles Conference, Biltmore Hotel, Santa Barbara, Calif., April 6-8.

1960 National Meeting "Hyper-environments—Space Frontier," Institute of Environmental Sciences, Biltmore Hotel, Los Angeles, April 6-8.

Royal Aeronautical Society, Coventry Branch, "The Optimum Size of Rocket Engines," Coventry, England, April 7.

Society of Instrument Technology, "The Electronic Computer as a Unit in an Automatic Data-Processing System for Missile Trials," Overheu, London, April 7.

ASME-SAM Management Engineering Conference, Statler-Hilton Hotel, New York City, April 7-8.

IRE and ARS, Southern Ohio, Fourteenth Annual Spring Technical Conference, Hotel Alms, Cincinnati, April 12-13.

British Institution of Radio Engineers, Computer Group, London, April 13.

International Symposium on Active Networks and Feedback Systems, sponsored by Polytechnic Institute of Brooklyn, Dept. of Defense Research Agencies, Institute of Radio Engineers, Engineering Societies Bldg., New York City, April 19-21.

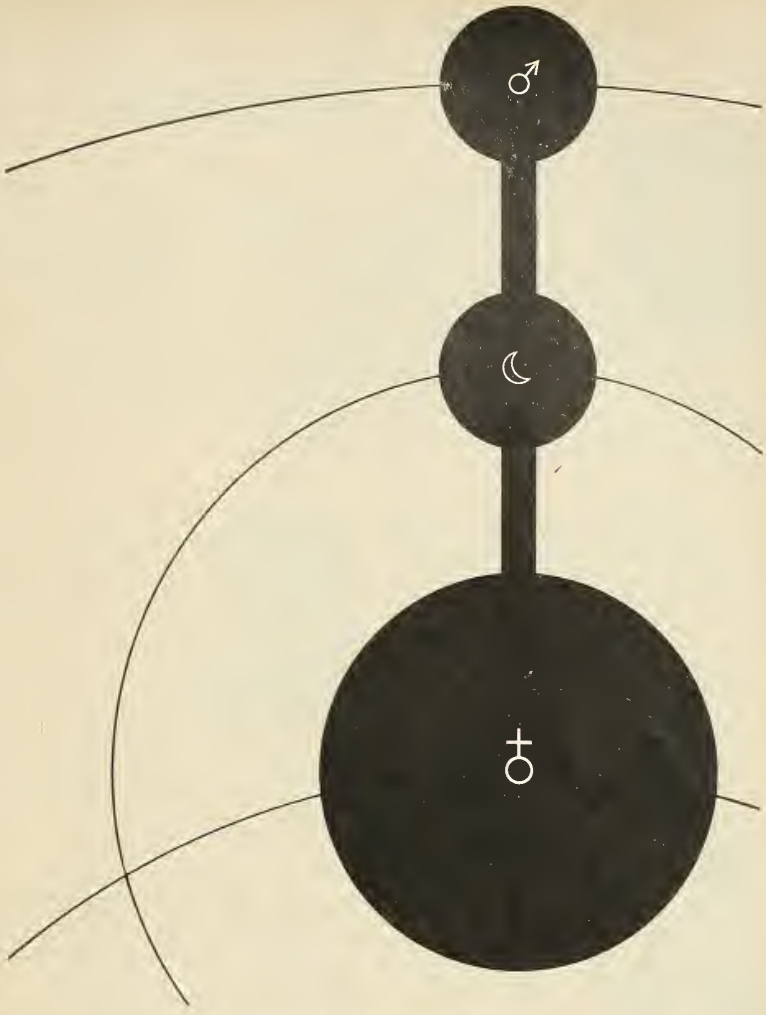
Society of Plastics Engineers, North Texas Section, Annual Regional Technical Conference, Hotel Texas, Fort Worth, April 20.

Symposium on Electrical Conductivity in Organic Solids, Air Force Office of Scientific, Research and Office of Naval Research, Duke University, Durham, N.C., April 20-22.

Royal Aeronautical Society, "On Reducing Costs of Space Research," London, April 21.

Southwest Metals & Minerals Conference, "Metals and Materials for the Space Age," American Institute of Mining, Metallurgical and Petroleum Engineers, Ambassador Hotel, Los Angeles, April 21-22.

American Ceramic Society, 62nd Annual Meeting, Bellevue Stratford Hotel, Philadelphia, April 24-28.



SYMBOLS IN THE SKY

The Moon (☾) ... Mars (♂) ... and other planets are getting closer to our doorstep (♁). A great American team... the huge complex of industry, science, military and civilian workers, are building the vehicles which will soon make the planets our next door neighbors. **California General**... fabricators of assemblies for rockets and missiles... is a significant part of this team. California General salutes this industrial and scientific complex... and its contribution to the conquest of space... the 20th century miracle.

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Circle No. 7 on Subscriber Service Card.


GIBSON

James A. Gibson: Named manager-communication and navigation systems engineering of General Electric's Light Military Electronics Dept. Formerly supervisor - radio guidance and instrumentation systems, he succeeds **W. J. Kuehl,** promoted to manager - engineering. Gibson joined GE in 1950 and transferred in 1953 to LMED, where he continued to work on airborne search radar until assigned as project engineer on *Atlas* radio guidance.

Sven H. Dodington: Promoted to technical director-government projects at International Telephone and Telegraph Corporation Laboratories. Will continue as vice president and director of the Avionics laboratory.

Fred M. Kinney: Former manager of industrial sales, Vickers Electric Products Division of Sperry-Rand Corp., joins Good-All Electric Mfg. Co. as chief engineer of the Electrical-Mechanical Division.


GILBERT

Jack B. Gilbert: Appointed quality control manager, *Titan* fabrication, at The Martin Co.'s Denver Division, responsible for procurement and receiving, planning, fabrication and test laboratory functions. Prior to joining the division in February, 1960, held positions with Republic Aviation Corp. and Boeing Airplane Co.

Dr. Howard R. Hegbar: Formerly manager of Avionics and Electronics Engineering Division, Goodyear Aircraft Corp., appointed assistant chief engineer. Also serves as a member of the company's forward planning and development committee and is a member of NASA's research advisory committee on control, guidance and navigation.

Robert Englert: Joins the components division of Telemeter Magnetics, Inc., as applications engineer. Was formerly western manager of field engineering for Telecomputing Corp., and prior to that with Western Electric Co.

Lt. Cmdr. Linwood L. Leftwich (USN, Ret.): Resigns as vice president of Feedback Controls, Inc. Prior to joining the firm, served as project officer, Guided Missile Test Instrumentation Systems, Bureau of Aeronautics, where he was responsible for the development of the AN/FPS-16 missile and satellite tracking radar.

W. Harold Edmunds: Former chief engineer of the small circuit breaker division, I-T-E Circuit Breaker Co., named manager succeeding **William P. Bolger,** now manager of the special products division.

Robert M. Wood: Former plant manager for the Semiconductors Division of Sylvania Electric Products, joins Pacific Semiconductors, Inc. as manager of the transistor plant; **David M. Edwards** has been selected as manager of planning and control.


DANYOW

S. E. Danyow: Formerly general manager of The Talco Engineering Co. operations at Falcon Field, appointed vice president, Rocket and Ballistic Operations of Rocket Power-Talco Div. of The Gabriel Co. Previous posts: Aerodynamic design at Boeing Airplane Co.; aeronautical research at the University of Michigan Research Center and engineering supervisory work at Ogden Air Material Area Headquarters.

Edward O. Johnson: Appointed chief engineer at RCA's Semiconductor and Materials Division. Joined the firm in 1948 and has served as manager high-temperature product development, Materials Division, and manager, advanced development. Holder of 12 patents.

Capt. Sheldon Brown, USN (Ret.): Named assistant manager of Aerojet-General Corp.'s Atlantic Division. Formerly served as consultant to the general planning staff of All American Engineering Co.

Dr. John A. Snover: Appointed to the research and development laboratory staff of Metal Hydrides Inc. and **V. Anthony Cammarota,** former research chemist at Gulf Research and Development Co., appointed to the metallurgical group.


FEINSTEIN

Samuel Feinstein: Elected manager of the Applied Research Laboratory of Servomechanisms, Inc.'s Research Division. Before joining the firm in 1947, was associated with the Fairchild Camera and Instrument Corp., where his work included designs for automatic tracking systems for radar and the Fairchild Navigational Star Follower.

Raymond S. Stewart: Named government liaison engineer for Texas Instruments Inc., Metals & Controls division and TI's subsidiary, M & C Nuclear, Inc. Was previously senior project engineer in charge of commercial products development at M & C Nuclear, Inc.

John A. Swint: Former president of Vard, Inc., elected director of operations for the Ogden Division of The Marquardt Corp., in charge of manufacturing, plant engineering, industrial relations and security.

Gerard R. Selg: Joins the technical staff of Electro-Optical Systems, Inc., as a member of the fluid physics division and will be responsible for the design of control circuits and instrumentation for ion propulsion motors. Previous posts: Electrical development engineer at Aerojet-General Corp.; electrical design engineer for Lockheed Aircraft Corp.

James D. Burns, also joins the firms energy research division, where he will be concerned with analytical investigations of power systems for space application. Was previously engaged in missile systems analysis on radar and infrared tracking systems at Hughes Aircraft Co.

Jack T. Cairns: Former director of sales, Daystrom Pacific Division, appointed manager, customer relations, Precision Power Division, American Electronics, Inc.


ADAMS

Lee Adams: Former manager of Electric Circuits, Inc., joins Curtiss-Wright Corp. as manager of its new etched circuit department. Earlier posts: Supervisor of manufacturing engineering and quality control at Graphik - Circuits; production supervisor and manufacturing engineer, U.S. Chemical Milling Corp. and head of the etched circuit department at Amelco.

A. F. Beale, Jr.: Elected director of research for Dowell Division of Dow Chemical, succeeding **Dr. W. W. Love** now research consultant.

W. C. Purple, Jr.: Formerly production manager named to the newly created post of vice president-production at Melpar, Inc. a subsidiary of Westinghouse Air Brake Co.

Dr. Frank E. Swatek: Joins American Electronics, Inc., American Laboratories Division, in the newly created position of staff consultant.

Joseph G. Neuland: Appointed to the

new post of southwest district field engineering manager for the Systems Division of Beckman Instruments, Inc. Was a member of the field engineering staff and is a former manager of systems engineering.


KUCK

Burton M. Kuck: Appointed senior project engineer at Kinetics Corp. Was formerly with Bell Telephone Laboratories, specializing in military communications system design and underwater sound development.

Stanley Abkowitz: Elected manager-refractory metal product development of Kelsey-Hayes Co., Metals Division, responsible for development of new products for ultrahigh-temperature service. Previous posts: Plastics engineer, Foster Grant Co.; materials engineer, Watertown Arsenal, staff metallurgist, Mallory-Sharon Metals Corp. Holds five patents on titanium alloys.

Eugene Dowd: Former general sales manager of Markite Products Corp., elected president of the newly established Bowmar Pacific, Inc., a subsidiary of Bowmar Instrument Corp.

Seymour Weiner: Advanced from product planning manager to product engineering department head at Sperry Semiconductor Division of Sperry Rand Corp.

Leonard S. Hermelin: Joins Emerson Radio and Phonograph Corp. as vice president of engineering and manufacturing for the Government Electronics Division. Was formerly with Republic Aviation Corp.

Robert V. Johnson: Formerly with Lenkurt Electric Co., appointed manager of applications engineering in the Equipment Division of Levinthal Electronic Products, subsidiary of Radiation Inc.

John B. Hamre: Formerly divisional sales manager, appointed director of sales for the Electronics Division of The Gabriel Co.

H. S. "Penny" Bellue: Former vice president of Hughes Aircraft Co.'s Products Group, joins Osborne Electronic Sales Corp., as vice president in charge of marketing.

Carl R. Jardine: Joins Aeronutronic, a division of Ford Motor Co., as manager of computer components, Computer Operations Marketing, responsible for the marketing of BIAX memory and logic devices, digital components, memory drums and devices. Was formerly with Burroughs Corp. as manager of Defense Marketing for the western U.S.

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NASA

$100,000—**Hydromatics, Inc.**, Livingston, N.J., for valve parts for use in developing the interplanetary rocket "Nova."

NAVY

General Dynamics Corp.'s Electric Boat Division, Groton, Conn., for plans and design services for a fleet ballistic missile submarine. Amount not disclosed.

Solar Aircraft Co., San Diego, for fabrication of rocket motor cases for new *Eagle* missile. Amount not disclosed.

$47,099,934—**Puget Sound Bridge and Drydock Co.**, subsidiary of **Lockheed Aircraft Corp.**, for construction of three guided missile destroyers.

AIR FORCE

Cook Electric Co., Chicago., for conducting a study of performance and aerodynamic deceleration devices at high mach and high altitude. Amount not disclosed.

$273,000,000—**Lockheed Aircraft Corp.**, Sunnyvale, Calif., for continued research and development on the *Discoverer, Midas* and *Samos* satellites. (Three contracts.)

$3,000,000—**Hughes Aircraft Co.**, Culver City, Calif., for manufacture of 79 single sideband receiver units. Subcontract from **Philco Communications Div.**

$2,000,000—**Reynold Electrical and Engineering Co., Inc.**, and **Fischbach and Moore, Inc.**, Los Angeles, for electrical work on three *Titan* missile launching complexes at Ellsworth AFB.

$700,000—**Boeing Airplane Co.**, Wichita, for B-52/*GAM-87A* weapon system development program

$400,000—**Yardney Electric Corp.**, New York City, for manufacture of Silvercel batteries.

$231,000—**Avien, Inc.**, Woodside, N.Y. for manufacture of timers and transmitters for use in fuel and temperature measurement systems.

$230,355—**North American Aviation**, Los Angeles, for rocket package spares in support of F86, D, F aircraft.

$125,000—**Aeronca Manufacturing Corp.**, for study of launching and ground support complex associated with the operations and maintenance of manned and unmanned space systems.

$95,000—**Cleveland Pneumatic Industries, Instrumentation & Control Div.**, Grand Rapids, Mich., for developing a "sky hook landing gear" capable of orbiting space vehicles for landing a space ship on the moon.

ARMY

$4,672,467—**North American Aviation, Rocketdyne Div.**, Canoga Park, Calif., for design and development of motors. (Three contracts.)

$3,000,000—**The Martin Co.**, Orlando, for an antiaircraft defense system patterned after the missile master system.

$666,982—**Chrysler Corp.**, Detroit, for continuation of engineering services on the *Redstone* missile program.

$354,800—**McDonald Contractors, Inc.**, Los Angeles, for G/M test shop, components at Edwards AFB.

$300,000—**American Missile Products Co., Inc.**, Lawndale, Calif., for flight telemetering equipment on the *Sergeant*. Subcontract from **Jet Propulsion Laboratory.**

$298,772—**Gilfillan Bros. Inc.**, Los Angeles, for engineering services related to *Corporal* missile system. (Two contracts.)

$261,000—**Firestone Tire & Rubber Co.**, Los Angeles, for guided missile, XM2E1.

$200,000—**Ryan Aeronautical Co.**, San Diego, for XM-21 target missile flight service program.

$135,640—**Cubic Corp.**, San Diego, for fabrication, installation and check out of electronic trajectory measuring system

$100,000—**RS Electronic Corp.**, Palo Alto, a subsidiary of **Regan Industries, Inc.**, for design and production of automatic systems to test electronic controls of the RP-76 rocket target missile. Subcontract from **Radioplane Div., of Northrop Corp.**

MISCELLANEOUS

$75,000—**Hermes Electronics Co.**, Cambridge, Mass., for study and development of a satellite digital program and storage system to be used in the *Transit* satellite navigation system. Subcontract from **Applied Physics Laboratory, Johns-Hopkins University.**

BIDS

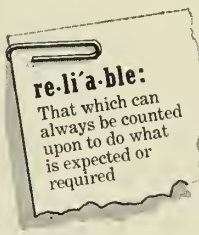
Purchasing and Contracting Div., White Sands Missile Range, N. Mexico: Antenna range tower-north, project consists of construction of wood fabricated antenna tower with appurtenances —Job—IFB RD-29-040-60-198—Bid opening 19 April '60. Bid sets available 5 April '60 unless previously exhausted.

Central Procurement Div., U.S. Army Support Center, Chicago, 1660 E. Hyde Park Blvd., Chicago 15, Ill. Installation of telephone cables and terminals at Nike site MSP 70, St. Bonifacius, Minn.—Job—IFB AV-11-175-60-12—Bid opening 7 April '60.

Purchasing Dept. Naval Supply Depot, Newport, R.I. Oscillograph, thirty-six channel, Minneapolis-Honeywell, visicorder or equal with Heiland series M galvanometers or equal, delivery desired 20 June '60—1 each—IFB 298-181-60B—Bid opening 19 April '60.

Warner Robins Air Material Area, Robins Air Force Base, Ga., Attn: Director of Procurement and Production. Tape, magnetic: compatible, for use on UNIVAC file computer model I and UNIVAC IAW purc desc—700 reels—IFB 09-603-60-77B, local purchase—Bid opening 8 April '60.

U S. Army Engineer District, Pittsburgh Corps of Engineers, New Federal Building, Pittsburgh, Pa. Construction of support facilities, missile master, Pittsburgh defense area, Collier Township, Allegheny County, Pa. Bid sets available after 22 Mar. '60. Non-refundable $10.00 charge for set of specs and dwgs. Completion 380 calendar days—Job—IFB ENG-36-058-60-21B—Bid opening on or about 28 April '60.



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reviews

AIR TECHNICAL DICTIONARY, (German-English)—Duell, Sloan & Pearce, New York. $10.

Experts from the various fields of German aviation research and development have compiled a dictionary of essential terms relevant to each field.

AERODYNAMIC PHENOMENA IN STELLAR ATMOSPHERES—A BIBLIOGRAPHY, Boulder Labs, NBS. Order PB 151389 from OTS, U.S. Dept. of Commerce, Washington 25, D.C. 95 pp., $1.25.

Prepared for the use of aerodynamicists participating in the Fourth Symposium on Cosmical Gas Dynamics, the bibliography covers material giving specific information on an inference or a theory of aerodynamic motions in the stellar atmosphere.

FUNDAMENTALS OF STRESS ANALYSIS, Albert Deyarmond and Albert Arslan. Los Angeles, Aero Publishers, 256 pp., $5.75.

This is the Second Edition of a text that discusses classical strength of materials adequately and applies the techniques to solving typical aircraft stress problems. The work is on an elementary level and for this reason would be good for an aircraft designer trying to refresh his memory about stress problems, or for recent college students who wish to apply to practical problems that which they have already learned academically.

Advanced techniques such as the analysis of indeterminate structures, flutter, and effects of elevated temperatures and fatigue are only casually mentioned or not touched on at all.

ROCKET PROPELLANT HANDBOOK, Boris Kit and Douglas S. Evered, Macmillan, New York, 354 pp., $12.50.

Here, for the first time, is a complete, unclassified survey of rocket propellants. It is bound to become a standard reference, needed by every library in the industry. It seems also to be wholly suitable as a college text.

The authors have reported on the general characteristics, physical and chemical properties, storage and handling methods and performance characteristics of almost 100 chemicals used as propellant ingredients.

In a three-chapter opening section, the basic principles and the fundamental equations of propulsion are detailed, after which a chapter apiece is devoted to liquid and solid propellants.

The major portion is divided into inorganic and organic propellants, rather than by application. The chapter on each chemical states whether it is useful in solids or liquids, or as fuel, oxidizer or monopropellant.

The inorganic section includes chapters on aluminum, ammonia, beryllium, boron and boron compounds, fluorine and related compounds, hydrazine and hydrazine hydrate, hydrogen, hydrogen peroxide, lithium and lithium hydride, mixed acid, inorganic nitrates, nitric acid, nitrogen oxides, oxygen and ozone, perchlorates, water.

The organic section includes chapters on alcohols and ethers, amines, aromatic hydrocarbons, metal organic compounds, nitroparaffins, organic nitrates, petroleum fractions, polymers, saturated hydrocarbons, unsaturated hydrocarbons, miscellaneous organic propellants.

A concluding section discusses properties of the pressurizing gases, air, helium and nitrogen.

Both authors were with the Missile Division, North American Aviation, at the time they worked on the book, and others at North American checked the manuscript. Kit is now head of the Physics and Chemistry Program at the Air Information Division of the Library of Congress, while Evered is head of market requirements at Hughes Aircraft Co.

THEORY OF MECHANICAL VIBRATION, Kin N. Tong, New York, John Wiley & Sons, 348 pp., $9.75.

Simply written, this text explains modern techniques of vibration analysis as painlessly as a good teacher can. The book is called "advanced" because it treats the conventional problems from the modern viewpoint that its students know some mathematics and that there are such things as digital computers. This is a commendable attitude because so many textbook writers continue to assume that no engineering student has gone beyond integral calculus, and that the slide rule is the only computing device around.

The text is admittedly "theory centered," with engineering applications coming in only as illustrations of method. It treats the theory of linear mechanical vibrations.

Topics that receive special attention are: principle of superposition, eigenvalue problem in matrix, differential and integral equations, and energy methods.

EMPLOYMENT

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W. D. Linkenhoker, Technical Personnel Supervisor

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editorial . . .

The Divorce of STL and the Air Force

Sometime within the coming months the Air Force must come up with a substitute for its unique relationship with Space Technology Laboratories, the captive systems engineering corporation which managed the development and production of the first U.S. intercontinental ballistic missile.

Two paths are open and the Air Force is not looking at either happily.

The Air Force can organize another corporation, hoping to eliminate the factors which made STL unpopular.

Or, the Air Force can try to build up a technical capability within its own ranks.

If the USAF sets up "Corporation A," now under consideration, it must recruit scientists and engineers from industry, possibly many from STL itself.

If the USAF takes the in-house road it must build up a competent task force from a relatively small nucleus within itself—a nucleus which, Cinderella-like, has occupied the C-Ring chimney corner of the Pentagon for many years.

Manpower will be the problem in either case: finding it, holding it and inspiring it.

STL is a group of scientists and engineers organized to handle systems engineering for the Air Force, working for and with the Ballistic Missile Division.

STL is also a private corporation working for profit—and the profit it made for its incorporators was quite handsome. It stepped on a number of industrial toes and their cries of pain reached Congress. It is a congressional mandate which forces the Air Force divorce from STL. Whether this disunion is for better or worse is debatable, and many of the points on either side are highly emotional.

Actually, in the present climate of the nation's missile/space program, it is probably just as well that STL be severed from the USAF and join the normal competitive industrial companies.

STL was formed when we had just achieved a breakthrough which permitted packaging a hydrogen warhead within the thrust capability we could foresee in an intercontinental ballistic missile. We knew the Russians were concentrating on a similar weapon. It was recognizably imperative to our national safety that our ICBM be produced in the shortest possible time.

Working together so closely that it is difficult now for the members of either organization to separate their activities and credits, STL and BMD achieved a miracle of modern systems engineering to come up with the ICBM 18 months ahead of the schedule laid down for them.

Hundreds of corporations were called upon to contribute the genius and skills which went into the missile. It was the job of STL to so integrate these skills and this genius that the production miracle could be accomplished. The team had few precedents—they set their own. A thousand technical problems they solved as they went along. They cut corners and red tape, they devised and improvised—and they got the job done.

Many things contributed to their success. They had a priority on manpower and money. They had great leadership which inspired enthusiasm. They had the knowledge of a tremendous need. They were imbued with a sense of urgency.

Today the urgency and enthusiasm is gone from the nation's missile/space program. We have politics and business as usual. Even STL's leaders admit the old combination probably couldn't duplicate the miracle of the ICBM now.

What the Air Force will come up with as a substitute we haven't any idea. But we hope it will be good enough to at least help perform the second miracle which will be necessary to catch Russia in space—when some administration gets around to calling for it.

Clarke Newlon

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