AUGUST 17, 1959

'S EXPERIMENTAL
LAS NOSE CONE

missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS

AN AMERICAN AVIATION PUBLICATION

TYPE 9234-4550 2PDT, 2AMP, MAGNETIC LATCH RELAY (BRACKET MOUNTING, SOLDER HOOK TERMINALS, HERMETICALLY SEALED)

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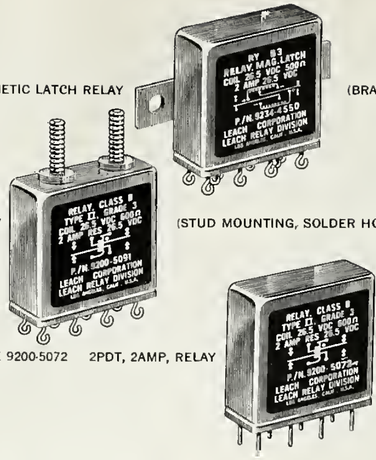

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Missiles and Rockets Volume 5 Number 3

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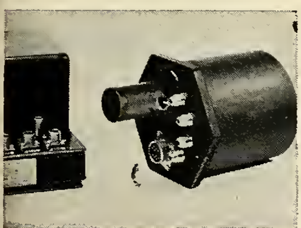
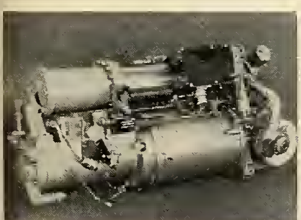
COVER: An Air Force experimental *Atlas* ICBM nose cone, which on July 21 became the largest re-entry vehicle recovered after intercontinental flight. Built by GE.

VACUUM-jacketed liquid hydrogen transfer line 2000 feet long connects Air Products' West Palm Beach, Fla., plant with a Pratt & Whitney test area. See report on liquid hydrogen, p. 21.



PART of propellant utilization control system produced by Servomechanisms, Inc., to provide for simultaneous depletion of missile engine fuel and oxidizer. See controls story, p. 23.



SIMPLIFIED APU developed by AiResearch uses only half the valves and parts of conventional units and can be modified for use with solid propellants. See APU story, p. 31.

missiles and rockets ®

MAGAZINE OF WORLD ASTRONAUTICS

AUGUST 17 HEADLINES

MISSILE SUPPORT
U.S. Reg. Pdg.

ASTRONAUTICS ENGINEERING
U.S. Reg. Pdg.

ASTRIONICS

THE MISSILE WEEK
U.S. Reg. Pdg.

DEPARTMENTS

NEXT WEEK

Telemetry Receivers: A 'Coasting' Industry
Batteries Outlook for Space
Reds Research Lightning as Weapon

How to turn your telephone into a conference room

Another of the many ways ITT electronics saves time and money and speeds output

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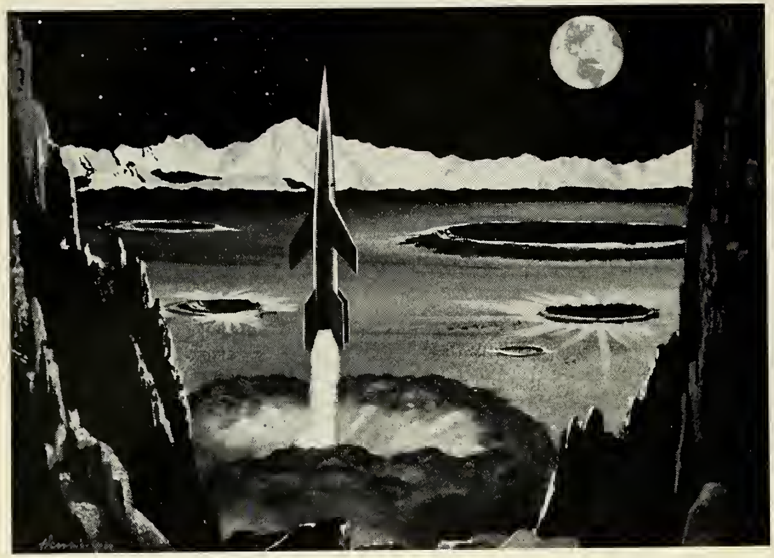

"MISSION ACCOMPLISHED: DEPARTING LUNA 2205 ZEBRA"

This message, flashed across a quarter-million miles to Washington, D.C., will be awaited anxiously by millions.

But even then our first expedition to the moon will still face its most crucial test—the journey home to earth.

The success of that trip will depend in large part on rocket propellants—fuels and oxidizers that will have been stored for days in the tanks of the expeditionary vehicle and yet will respond instantly when needed.

Storable liquid propellants is one of the fields in which Rocketdyne has anticipated the future. For more than ten years, its propellant chemists have been studying, engineering, and testing combinations of storable fuels and oxidizers for greater storability and higher energy.

Storability PLUS high energy

Rocketdyne has tested these combinations in all production and experimental engines. The results prove that today's storable fuels and oxidizers have these important capabilities:

(1) High performance, even after months or years of storage; (2) Stability over a wide temperature range, permitting storage in missile tanks without rigid environmental controls; (3) Dependable performance, predictable even at extremes of heat and cold; (4) Instant readiness for firing at any time during the storage period; (5) Energy yields equal to or higher than those of conventional propellant combinations.

Second-generation missiles

The tests also prove that engines developed for conventional propellants can be converted to storable combinations rapidly and inexpensively—a significant consideration in the development of second and third gene[ra]tion strategic, tactical, and air [de]fense missiles.

Significant, too, is the *potent[ial]* performance of storable combi[na]tions. Research points to energy yiel[ds] as high as 400 seconds of altitu[de] specific impulse—performance 20 p[er]cent higher than that of today's co[m]binations. These high-energy yiel[ds] will offer new capabilities and great[er] flexibility for America's scientific a[nd] military programs.

Stepping stones to Space

Rocketdyne has designed and bu[ilt] much of today's operating hardwa[re] in the high-thrust rocket field. E[n]gines by Rocketdyne power most [of] the military and scientific projec[ts]

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Thrust chamber producti[on] line for Thor and Jupi[ter] at Rocketdyne's Neos[ho,] Mo., facility moves smooth[ly]

sponsored by Air Force, Army, a[nd] NASA. This experience now becom[es] the point-of-departure for tomorrow['s] journeys into the unknown.

FIRST WITH POWER FOR OUTER SPACE

ROCKETDYNE

A DIVISION OF NORTH AMERICAN AVIATION, INC.

Washington Countdown

IN THE PENTAGON

Davy Crockett is seen . . .
more and more as the Army's limited war weapon par excellence. *Davy*—an in-house project at Rock Island, Ill.,—is reported to be designed to carry a nuclear warhead of sub-kiloton yield. The still secret missile will be fired by a GI from a bazooka tube.

• • •

The Navy is pushing . . .
for a joint space command to operate the vast military space and missile facilities on the West Coast. Of course, such a command would include the huge new Pacific Missile Range.

• • •

Lack of missile ranges . . .
in Western Europe will lead to the increasing use of U.S. ranges for the training of European NATO missile units. Suggestions that France open up its Sahara Missile Range south of Colomb Bechar for NATO training have received a very chilly reception in Paris.

• • •

The cut in B-58's . . .
from 40 to 32 for FY '60 is only a sign that the bombers cost more than anticipated—not a sign that manned bombers are being phased out in favor of missiles—at least so far. The Mach 2 B-58 price tag: about $15 million each.

• • •

The codeword *Agena* . . .
is ARPA's new name for the orbiting upper stage of its *Discoverer* vehicle. The **Lockheed** upper stage is powered by the **Bell** *Hustler* liquid engine.

• • •

The smart money . . .
now is on an early September launching of an operational **Convair** *Atlas* from Vandenberg AFB. The successful launching of an *Atlas* from Cape Canaveral Aug. 11 appeared to cinch the matter.

ON CAPITOL HILL

The last act . . .
of the Hébert Investigation may not come until shortly before Christmas. The House subcommittee probably will adjourn its investigation of the so-called "munitions lobby" when Congress quits for the year—sometime in the next few weeks. The hearings then would be resumed about early December for an airing of some specific cases.

Congressmen are worried . . .
over the possible development by Russia of poison gas missiles. Experts have told the House Space Committee that chemical warfare could be as dangerous an all-out threat as nuclear war . . . and more advantageous to the enemy.

AT NASA

NASA's deep space probe . . .
schedule this fall includes one moon orbit and one sun orbit. An attempt will be made to orbit the *Atlas Able IV* vehicle around the moon about Oct. 8—the date when the moon is farthest south. In December, NASA will attempt to send *Thor Able IV* to join *Mechta* and *Pioneer IV* as a miniature satellite of the sun, but with a transmitter which would send information to earth from as far away as 50 million miles.

• • •

Amateur hams and astronomers . . .
are furious over NASA's decision not to release the frequency of *Explorer VI's* big 40-watt transmitter. NASA contends that the frequency must be kept secret because it is one used by the military. The hams contend NASA released similar information on *Pioneer IV's* frequency. Among the protesters is a group of scientists at the Case Institute of Technology and **Standard Oil** in Cleveland. They have their own satellite tracking station and were one of the few western groups to track the Russian *Mechta*.

AROUND TOWN

Speculation is . . .
that the Soviets may try to strengthen the hand of Premier Krushchev on his U.S. visit by either orbiting the moon or sending man into space. The most favorable astronomical time for a moon shot would be a few days before the beginning of Krushchev's visit on Sept. 15. That would give the Soviets time to determine the success of the launching before the visit and "to time the announcement" with his arrival.

• • •

Sept. 5 is a likely time . . .
for the Russians to announce a manned space flight—simple ballistic trajectory. It's the birthday of Russian rocket pioneer Konstantin Ziolkovsky.

• • •

Shipments of *Nikes* . . .
will soon be heading for Denmark. The Danes are expected to be sent a total of 40 **Western Electric** *Nikes*—some *Ajax*, some *Hercules*.

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simple solution

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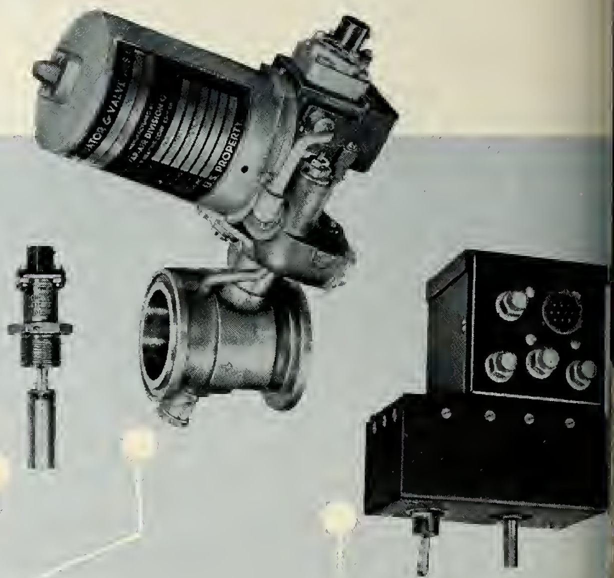

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LIQUID TEMPERATURE: All liquids, including fuel systems, batteries, exotic rocket fuels, H_2O_2, acids.

SURFACE TEMPERATURE: Anti-icing, de-icing, nacelles, primary heat exchangers, generators, alternators, canopies, bearings, gyroscopes, accelerometers.

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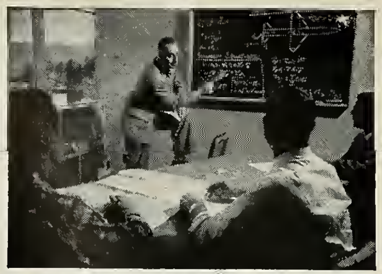
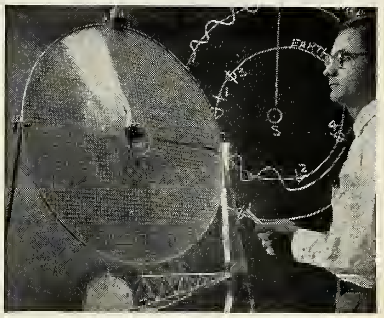


Boeing engineers work in small groups. Ability and initiative get plenty of visibility.

Test of ballistic missile propulsion system. Other tests cover space vehicle control units.



1/20th scale model of unmanned Martian reconnaissance vehicle, a Boeing study project.

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Industry Countdown

MANUFACTURING

Total of 6000 *Sidewinders* . . .
will be produced in Europe—5000 by **Bodenseewerk Perkin-Elmer** of Ueberlingen, Germany. The air-to-air missiles will go aboard **Lockheed** F-104G's, which are being bought in quantity by West German Air Force. *Nord* 5103 will be standard armament of **Fiat** G-91 lightweight fighters also being supplied to West Germany.

• • •

Still alive. . . .
transpiration cooling for re-entry. **General Electric's** Missile and Space Vehicle Department, Philadelphia, is devoting considerable research effort in this direction. Needed: proper materials.

• • •

All-out campaign . . .
for missile business is being cranked up by **Bethlehem Steel.** Despite late start, company figures it soon can equal and pass **U.S. Steel's** present lead in field of high-strength, high-temperature steels.

• • •

New Pacific press brake . . .
(with 500-ton push) is being used by **Boeing Airplane** to hasten developments in titanium and other high-temperature metal shaping.

• • •

Re-shaping *Titan* nose cone . . .
for faster re-entry is called for in $73 million Air Force contract awarded **Avco's** Research and advanced development division. Aim is to nullify enemy countermeasures. New design will require development of materials with greater heat tolerances.

PROPULSION

Multi-vehicle lunar . . .
expedition will have greater chance of success in the opinion of ABMA's Dr. Wernher von Braun. He proposes that instead of single vehicle, the operation include about six *Saturn* vehicles to serve as tankers for a seventh, which would carry a returnable payload.

• • •

Industry can solve . . .
orbital refueling problems, says von Braun, if it devotes all the engineering attention they require. The rocket expert says all three military services and NASA would have to pitch in together on logistical support of a moon mission—much like the all-out Navy support of Admiral Byrd's South Pole expedition.

ELECTRONICS

Inside word has it . . .
that both operational *Atlas* and *Titan* ICBM's originally scheduled for gas-turbine APU's will have to fall back on battery units. Reason: Inability to meet extreme design specs within development time allowed.

• • •

Difficulty in getting . . .
"on target" with narrow band (7°) radar is causing modification of Pacific Missile Range's FPS-16 tracking radar to incorporate optical acquisition.

• • •

DOD now is standardizing . . .
environmental requirements for electronic components. MIL-STD-446 sets forth eight "discrete levels" of environmental conditions applicable to equipment and component design. In the past, parts have been designed to withstand random conditions. Standard also is aimed at ultimate reduction of multitude of electronic items entering military supply channels.

WE HEAR THAT—

Latest wrinkle in . . .
hydraulic fluids is a metal with low melting point. Fluid would be held by metal seals perhaps at 1000°F and 6000 psi . . . Joint French-German research center at St. Louis, France, is being modernized. Facility dealing primarily with ballistic problems is 50-50 proposition with two chief execs—one German and the other a Frenchman . . . Although delivery isn't required until next year, **Bristol Aircraft Ltd.** has just supplied Sweden with the first of a batch of *Bloodhound* surface-to-air missiles to facilitate training program for initial unit to be located at Norrtälge . . . Need for working as well as equity capital brought on merger of **C. T. L. Inc.,** creator of first U.S. ablation re-entry nose cone (for *Jupiter*), with **Studebaker-Packard**—which is now diversifying into the missile industry . . . **General Electric's** Lamp Metals and Components Department, Cleveland, is offering pure molybdenum "HD" sheets with five times the room temperature ductility of ordinary moly . . .

• • •

Molybdenum has cut the price of consumable electrode "Climelt" pure moly and moly alloys from $9.85 a pound to $8.00. . . .

(Continued on page 40)

Radioplane drones shown left to right: XQ-4B; RP-76; RP-77D; OQ-19; SD-1

RADIOPLANE CREATES FIRST FAMILY OF UNMANNED AIRCRAFT TO TRAIN MEN, EVALUATE WEAPON SYSTEMS, AND SURVEY ENEMY TERRITORY

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For 20 years Radioplane has led in the production of drones. Radioplane's leadership in the field typifies the years-ahead thinking that continues to produce design concepts for tomorrow, hardware for today–developed, produced, and delivered on time–at minimum cost to the taxpayer.

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East Fights for Missile Dollar

Business booms in the New York industrial complex but area has yet to receive big prime missile contract—battle with California grows hotter in congress

by William E. Howard

NEW YORK—Inside the East oast's huge industrial complex sprawlg from New York to Philadelphia, issiles today are big business. But ere are strident complaints that they ould be much bigger.

Missile manufacturing tops $1 bilon a year in New York—yet the state oes not have a single major missile ime contractor. Some congressmen aim bitterly that California is getting r more than its rightful share. They e now fighting for legislation to roaden" geographical distribution of efense procurement. (California is ghting back.)

Over in New Jersey, despite the ck of a prime missile systems conact, the picture is brighter. **Radio orporation of America** is prime conacting BMEWS for an estimated 440 million and is heavily engaged radar, missile guidance and other ork, including test equipment for the rmy's anti-aircraft *Hawk*. And the ate generally is packed with missile omponent and electronic production.

At Philadelphia, **Philco Corp.** is corime with **General Electric,** Utica, .Y., on the Navy's air-to-air *Sideinder*. GE's Missile and Space Vehicle epartment in the "City of Brotherly ove" holds over $100 million in conacts for *Atlas* and *Thor* nose cones nd the *Discoverer* satellite re-entry ehicle.

Throughout this industrial "heartnd" there are scores of big and little rms hard at work on large missile subontracts. Across Pennsylvania to ittsburgh, through "upstate" New ork to Buffalo and out on Long sland there are many more.

Defense Department procurement gures indicate that the total for all issile-related spending in the threetate upper mid-Atlantic region is $3 illion or more.

• **New York slipping**—But industrialists and lawmakers fear that unless prime missile/space contracts are brought into the area, the industry will shrink. They point out that in 1961 missile appropriations very likely will equal the amount for manned aircraft, and after then, missiles will exceed aircraft spending.

One Long Island banker notes that during the Korean War, New York firms received 15.3% of the dollar value of prime contract awards, against 13.6% received by California firms. For fiscal 1958, New York slipped percentagewise to 11.6% while California climbed to 21.4%.

What does this mean in money? The banker says the shift in percentages when applied to huge missile programs translates into one billion dollars more for California than for New York.

Sen. Jacob K. Javits (R-N.Y.) puts it this way:

"At the present rate of acceleration, and with nearly $10 billion in prime missile contracts already awarded to California, New York can fall more than $3 billion behind California in defense procurement by 1961 . . ."

Javits is co-sponsor along with Sens. Kenneth B. Keating (R-N.Y.) and Clifford P. Case (R-N.J.) of S.1875, a competitive procurement act which they believe will have a scatter effect on future placement of missile contracts. At a Senate Armed Services subcommittee hearing last month on the measure, Javits declared that only $3.5 billion—15%—out of total defense procurement orders values at $23.8 billion is presently placed through competitive, formally advertised bids. And he added, "the proportion of negotiated contracts seems unusually high."

An aide of Sen. Javits commented to M/R this week that he had found the percentage of negotiated contracts "has increased with the number of retired military officers hired by defense contractors." He conceded: "This could be coincidence, of course."

• **Wants more open bids**—S.1875 spells out a Congressional directive to the Defense Department to replace negotiation with open bidding where there is no danger to national security. It would give prime consideration to small business; to concerns in labor surplus areas and to "eligible suppliers who have received the smallest share of business as well as being in different geographical areas of the nation."

Aerospace Industries Association opposes the Javits bill.

New York's congressional delegation touched off a transcontinental battle when they mounted a bi-partisan drive this year behind the competitive procurement bill. Californians retaliated in Congress. The Los Angeles Chamber of Commerce formed an "industrial task force to defend California's missile and aircraft defense business from further attacks by New York and other eastern legislators." The LA chamber has produced what New Yorkers call a "slick magazine presentation" detailing the state's "qualifications" for continued defense business. It is being distributed on Capitol Hill.

West Coast newspapers have added to the furor by implying the New York campaign is part of some strategy by Gov. Nelson Rockefeller to wrest the GOP presidential nomination from Vice President Richard M. Nixon, a Californian.

New Yorkers refuse to accept arguments that their state receives just as much missile business through subcontracts even though the prime is in California. They say subcontracting is erratic and that to build a stable missile industry New York should have prime systems contracts.

• **Long Island growth**—While the verbal battle continues (no action is expected on S.1875 this session) New York industry is moving to snare a prime contract. **Grumman Aircraft Engineering Corp.,** principal subcontractor to the Navy *Eagle,* is in a $4 million expansion program. The firm is building a 55,000-square-foot center for complete avionics systems test, evaluation and development.

Recipient of military contracts exceeding $271 million in the past 12 months, Grumman's major production is aircraft for Navy anti-submarine warfare. It has created a small army of vendors in the state to which it paid $45 million last year.

Republic Aviation, the Island's other big aircraft company (F-105 interceptors) is constructing a $14 million R&D center and has under full steam a missile/space research program valued at $35 million. One Air Force project is trying to determine what vegetables will grow on the moon.

The state's two other aircraft concerns have hit rough going. **Fairchild Engine & Aircraft** sold a Long Island plant recently after cancellation of the Air Force *Goose* decoy missile. **Bell Aircraft** at Buffalo as a result of a cutback in military work has let go about half of its 12,000 employes in the past 18 months. Last week, however, the firm picked up three AF R&D contracts totalling $575,000, including one for developing a storable propellant flow system for rocket engines.

Sperry Rand Corp. is in the vanguard of Long Island's fast-expanding missile component industry. One division, **Sperry Gyroscope,** has been steadily enlarging facilities and its work force to produce SINS (ship's inertial navigation systems) for *Polaris* submarines; **Ford Instrument** is turning out computers for Navy *Talos, Tartar* and *Terrier* missiles and guidance controls for the Army *Jupiter.* In the past fiscal year Sperry has received defense awards exceeding $220 million.

Other vital missile systems and ASW devices are being developed and produced by **Hazeltine Corp.,** which has just purchased **Wheeler Laboratories** in New Jersey and which is now setting up a 50,000 square foot engineering laboratory on the Island.

Dynamic Gear, producer of miniature precision gears for missile guidance systems, is building a $200,000 plant at Amityville. At Westbury, **IMC Magnetics Corp.** (electro-mechanical missile components) is doubling its plant capacity. **American Bosch Arma,** Garden City, developer of missile fire control systems and space vehicles is one of the Island's leaders with $66 million in defense sales in the past year.

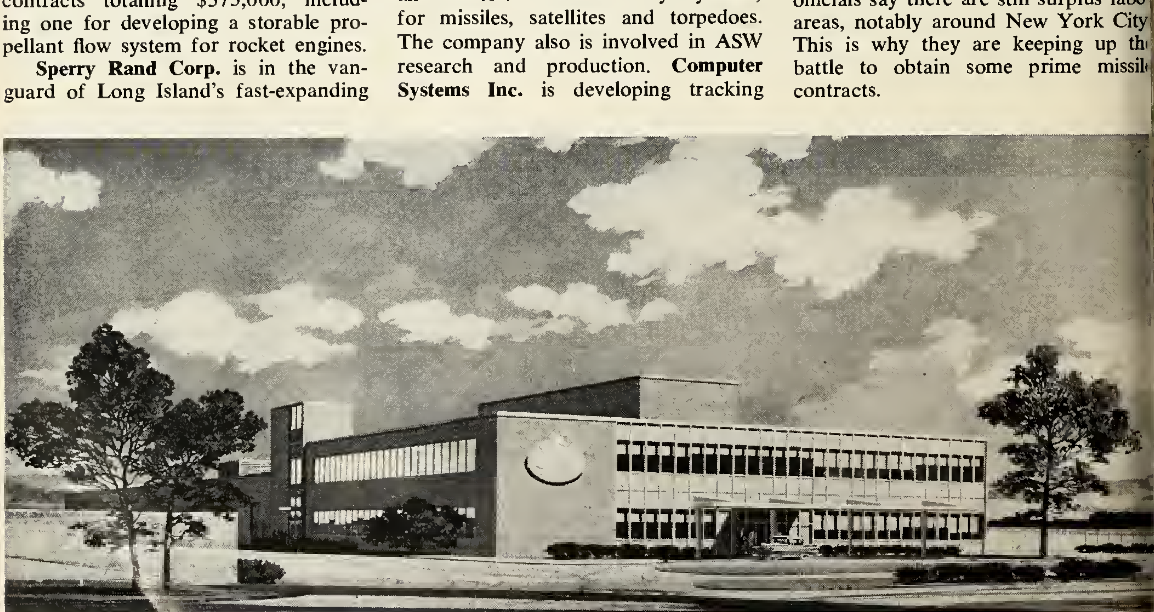
• **Missiles upstate**—There is considerable missile activity in metropolitan New York among such firms as **Yardney Electric,** which rolled up second quarter sales of $1.6 million with auxiliary power units (silver-zinc and silver-cadmium battery systems) for missiles, satellites and torpedoes. The company also is involved in ASW research and production. **Computer Systems Inc.** is developing tracking computers and plotters for the Pacil Missile Range, Point Mugu.

Just outside the city, **Stauff Chemical's** eastern research center . Chauncey, N.Y., is working on mon propellants for the Navy; at Whi Plains **Chromalloy Corp.** is pushir explosive forming of refractory meta under a "substantial" Navy contra and **Polytechnic Institute of Brookly** is trying to come up with the answ for WADC as to why plastics crack i space environments.

Upstate at Poughkeepsie and King ton, **IBM** is making automatic dat processing machines and compute totalling some $140 million for mil tary customers.

In addition to its Utica *Sidewinde* operation, **General Electric** is makin high power acquisition radar for th improved *Nike-Hercules* and *Atla* guidance at its Syracuse plant. G New York plants have received con tracts totalling some $160 million sinc July 1958. At Rochester, **Eastma Kodak** is fuzing and arming *Sidewind ers* and *Sparrow III;* in nearby Corning **Corning Glass** is developing glass ceramic materials for nose cones. I the Buffalo area **American Machin & Foundry** is manufacturing *Tita* launchers and **Alco Products Inc.** i principal subcontractor of JATO meta parts for the Army's *Honest John.* An other Syracuse company, **Carrier Corp.** is a principal supplier of air condi tioners for missile systems.

There are hundreds more missil subcontractors all over the state. Bu officials say there are still surplus labo areas, notably around New York City This is why they are keeping up th battle to obtain some prime missil contracts.



GROWTH of industry on Long Island is typified by architect's sketch of Republic Aviation Corp.'s new $14 million Research and Development Center under construction at Farmingdale. It is scheduled for completion early next year and will be staffed by some 500 scientists and engineers working on missile/aircraft space research projects.

AF Wants Extra Billions for Space

It seeks to outstrip Soviets in third genera- on ICBM, military satellites, maneuverable spacecraft, ALBM and moon bases

SYMBOL of Air Force space effort is ***Discoverer*****, the forerunner of the** ***Sentry*****.**

Behind closed doors in the Pentagon, the nation's top military men are rking out the defense budget for FY 1961. Its effect on the nation's missile d space programs will be tremendous. Here is the first of a series of ticles on how the military men are thinking. NEXT WEEK: Navy planning.

by James Baar

WASHINGTON—The Air Force uld like to find two things in its cking this Christmas:

• An extra $5 to $7 billion for mis- e and space R&D.

• Much greater authority over the tion's space programs.

It won't get either. And it doesn't pect to get them. But both are ex- mely important to bear in mind. ey are strongly felt needs. And they m the parameters within which Air rce missile and space planning for e early 1960's is taking place.

Many Air Force officials see the xt several years as a great second nping off point in the East-West race r missile and space leadership.

They feel that R&D work done— not done—in these years could well termine the fate of the United States the late 1960's and early 1970's. erefore, they feel that the Air Force ould be permitted to push forward the job vigorously and unstintingly.

Here are some of the key missile d space systems that a number of r Force experts believe must be de- loped as rapidly as possible:

• Reconnaissance, early-warning d communications satellites.

• The *ALBM*, the air-launched bal- listic missile—and its strategic partner, a nuclear-powered bomber.

• A third generation *ICBM* to suc- ceed the **Boeing** *Minuteman.*

• A maneuverable, recoverable space vehicle.

• A space vehicle capable of ren- dezvousing with another vehicle or pieces of equipment in space.

• Establishment of bases in space and on the moon.

Early types of all three of the satel- lites are already being developed under the direction of ARPA. The Air Force is developing *Midas* and *Sentry*. The Army is developing *Courier*.

Lockheed's *Sentry* will evolve from the *Discoverer* series of satellites. It is being designed as a long-life, unat- tended reconnaissance satellite.

Lockheed's *Midas* would provide early warning of *ICBM* attack. The satellite, through use of infrared sen- sors, would be capable of reporting the launching of an *ICBM* before it left the launching pad.

Courier, primarily an in-house proj- ect, is the first of a series of com- munications satellites. It will be a de- layed repeater system. Later, active re- peater satellites are planned for sta- tioning in 24-hour orbits.

Douglas Aircraft is still working on design studies for the *ALBM*. How- ever, it is hoped that development can begin moving forward by the end of the year.

• **Delays in** *ALBM*—Many Air Force experts regard the *ALBM* as one of the top weapons of the mid-1960's— particularly when placed on nuclear- powered bombers.

The bombers, armed with possibly eight *ALBM's*, would be placed on sta- tion for long periods, much like *Polaris* submarines. *ALBM's* could be launched 1000 to 1500 miles from their targets.

New delays in the nuclear-powered plane program have forced the Air Force to shelve this strategic idea in- definitely. Meantime, the *ALBM* is be- ing designed for launching from Mach 2 B-58's and Mach 3 B-70's.

The *ALBM* also is seen as the pro- genitor of the space-launched missile. Such a weapon would be launched from either a maneuverable space craft or a satellite.

• **Shape of third generation**—The Air Force has yet to decide on the specific requirements for a third gener- ation *ICBM*. They probably will be written within the next six months or a year. However, the general nature of these requirements is clear.

The Air Force candidate for suc- cessor to *Minuteman* will ideally be lighter and somewhat smaller. It will have extremely accurate guidance. It will be easier to control and may be capable of changing course. It will pack bigger warheads.

money is the prime problem . . .

The solid *Minuteman*—expected to be operational about early 1963—is about a third the size of the huge liquid **Martin** *Titan* and **Convair** *Atlas.*

It is designed to be fired from hardened underground sites where it can be kept for long periods. It also will be designed for firing from railroad cars and large vans.

However, *Minuteman* packs a much smaller warhead than *Atlas* or *Titan.* And although its guidance will be improved it will be able to fly only a predictable ballistic path like its predecessors.

The third generation *ICBM* will be a far deadlier and trickier weapon.

Its guidance will enable it to score a direct hit on any hardened site. U.S. experts agree that not even a hardened site can withstand a direct hit by a nuclear warhead.

Its ability to maneuver will enable it to avoid attempts to stop it with an anti-missile missile. Its improved control system will enable launchers to direct it to a variety of targets while it is in flight.

Its relative lightness and size will greatly increase its mobility. Its bigger warhead would eliminate the need for continued maintenance of the first generation missiles in the nation's strategic arsenal.

Finally, the development of such a weapon probably would lead eventually to abandonment of fixed, hardened *ICBM* sites.

Presumably Russia by this time also would have improved its guidance systems to a point where any known hardened site could not survive an attack.

• **Toward rendezvous**—*Dyna-soar I* is the Air Force program aimed at development of a maneuverable space vehicle. However, it is not in itself aimed at development of a weapon system. Rather, it is a research program.

Dyna-soar I, estimated to cost possibly $1 billion, would test out the concept of launching a space craft from the earth into orbit and returning it into the atmosphere at will and landing it.

Dyna-soar II, also known as *Mrs. V,* would be the true weapon system: A maneuverable, recoverable space bomber. It also would lead to a vehicle capable of rendezvousing in space.

Air Force officials feel that the ability to rendezvous in space will become essential in not too many years.

Unknown satellites will have to be identified. U.S. satellites will have to be repaired and re-equipped. Space stations will have to be built. And, finally, the stations will probabily be used as staging areas for space exploration.

A number of Air Force officials feel that such stations also could serve as military bases in space. On the other hand, some feel that moon bases would be more efficient.

• **Robbing Peter**—All of these programs are running into the major obstacle of money.

The Air Force feeling is that as much as $5 to $7 billion more is needed each year. At the same time, the Administration has made clear that the Defense Department's budget for FY '61 will be the same as this year if not lower.

This means that much of the money needed for missiles and space must be found in other programs or not at all. For example, the Air Force might have to decide to drop development of the B-70—possibly a $10 billion program —in order to press ahead with development of *Dyna-Soar* and other space projects.

Or, the Air Force could be faced with losing a project like the B-70 anyway so that money can be found by the Defense Department to press on with new Army and Navy space and missile projects.

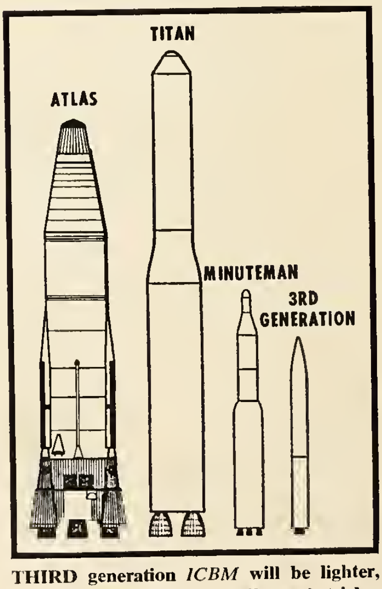
• **Private preserves?**—This raises what the Air Force sees as another major obstacle in the path of its space programs: Division of authority.

The Air Force feels that space is not divisable; that the Army and N[...] are encroaching on space and in eff[...] impeding progress; and that the res[...] is a net gain for Russia.

As one Air Force officer has put [...] "Space is not a new ocean for [...] Navy and it is not an artillery ra[...] for the Army. There are too da[...] many cooks."

The Air Force feels that beca[...] the Army and Navy do not have [...] same needs as the junior service, t[...] will not push essential space progra[...] as hard as the Air Force would.

Needless to say, both the Army a[...] Navy have stiff counter arguments.



THIRD generation ***ICBM*** **will be lighter, more accurate, more deadly and tricky.**

NASA Official Proposes Outer Space Definition

WASHINGTON—How high does [...] space extend, and where does ou[...] space begin?

Dr. Robert Jastrow of the Natio[...] Aeronautics and Space Administrati[...] suggests that this important legal qu[...] tion be settled by reference to or[...] characteristics of a typical satellite.

Jastrow, chief of NASA's theore[...] cal division, proposes that outer sp[...] should be defined legally as the regi[...] traversed by vehicles that have be[...] placed in orbit about the earth, or t[...] have escaped from the gravitatio[...] attraction of the earth.

At low altitudes, a satellite [...] quickly destroyed by atmospheric fr[...] tion. To be considered an orbiting sat[...] lite, Jastrow says, it should make [...] least one circuit of the earth. Thus, [...] suggests that air space be defined as t[...] altitude at which the density of atm[...] phere is sufficiently low to permit c[...] circuit.

"Our calculations of satellite li[...] times indicate that this critical altit[...] is 100 miles for a satellite of a typi[...] weight and dimensions, i.e., a wei[...] of one ton and a cross-sectional area [...] 30 square feet," he says.

New Compound Excels as Corrosion Inhibitor

COLUMBUS, OHIO—Ammonium h[...] afluorophosphate is better than hyd[...] fluoric for inhibiting the attack of fu[...] fluoric nitric acid on several metal all[...] ing nitric acid on several metal all[...] over an extended storage period.

Three **Bell Aircraft Corp.** [...] searchers made this report recently [...] a paper read at the American Roc[...] Society conference on propellant th[...] modynamics and handling.

Sam A. Long, William H. Bergd[...] and Edward J. Kinsley tested 70 co[...] pounds suggested as possible corrosi[...] inhibitors. The tests ran for 30 days [...] 120°F in liquid and vapor-phase con[...] tions.

U. S. Liquid Hydrogen Stream Swells

Industry and government cooperate in building large tonnage plants to make 'ultimate' chemical fuel more than a laboratory curiosity

by Jay Holmes

WASHINGTON—Hydrogen, in the m of an odorless, colorless, frigid id—the lightest there is—has pro- ssed in seven years from a labora- y curiosity to the product of a good- ed industry.

Rocket fuel and research needs for liquid—which boils at –423°F— ve created a multi-million-dollar rket. And with increasing use of drogen as fuel for big rockets—be- nd *Centaur*—now in the thinking ge, the market is bound to increase.

Seven years ago, the largest instal- ions produced less than 15 pounds liquid hydrogen per hour. Today, daily production is measured in ıs. By next spring, the figure may doubled.

At the moment, three companies in the business of making liquid drogen on a large scale. **Air Products** . has built and operates a large nt for the Air Force at West Palm ach, Fla., and a moderate-sized nt at Painesville, Ohio. **Stearns- ger Manufacturing Co.** operates a derate-capacity plant at Bakersfield, lif. And **Linde Co. Division of ion Carbide** is building a large plant t will begin operation at Torrance, lif., next spring.

Production and cost figures on the Products and Stearns-Roger opera- ns are classified. The Air Force feels t revealing them would give a po- tial enemy valuable information on erica's war potential.

This creates an amusing paradox. the Linde product will be sold to SA, the civilian space agency. Pro- ction and cost figures for this plant— out as large as the Air Products ility in West Palm Beach—are a tter of public record. An Air Force kesman says classification of such ormation is under constant review l some of its hydrogen figures may released soon.

The creation of this new industry is an example of industry-government cooperation. Because it boils at 70°F above absolute zero, large-scale storage of the liquid has been a poser. Scientists of the Atomic Energy Commission and the National Bureau of Standards discovered principles underlying a process for storing the liquid without undue loss. Based on the scientific breakthrough, Air Products, Stearns-Roger and Linde developed mass-production methods. And **Pratt & Whitney Division of United Aircraft** has learned to handle the fluid in preparation for use as rocket fuel.

• **"Ultimate" chemical fuel**—The interest in hydrogen is mainly the result of its role as the ultimate chemical fuel. More specific impulse is provided by burning hydrogen than any other fuel—whether in oxygen, fluorine or any other oxidizer. The reason is elementary chemistry. Hydrogen, the lightest element, has one electron per atom available for chemical reaction. Since its atomic weight is 1, hydrogen has one reaction electron available for each unit of atomic weight.

When heavier atoms are used as fuel, there is no proportionate increase in the number of reaction electrons. Nor is there a proportionate decrease in the binding energy of the electrons, which would increase their reactivity.

Liquid hydrogen also has a role in *Project Rover*, NASA's nuclear propulsion development. Because of its light weight, hydrogen is best suited for use as a propellant gas to be heated by the *Rover* space-borne nuclear reactor.

The first plant with a capacity of more than 15 pounds per hour was put in operation by the Bureau of Standards at Boulder, Colo., in 1952. The liquid produced was kept in high-vacuum insulated, refrigerated dewars holding about 500 gallons (300 pounds). The refrigeration was necessary because the hydrogen molecule exists in two forms: one in which the two atoms are spinning in the same direction (orthohydrogen) and one in which they are spinning in opposite directions (parahydrogen).

Gaseous hydrogen at room temperature contains about 75% orthohydrogen and about 25% parahydrogen. But when cooled to the boiling point of –423°F, this mixture is unstable. At this temperature the two forms do not reach equilibrium until 99.8% of the molecules shift from ortho to para form. The diagrams on page 22 illustrate the transformation.

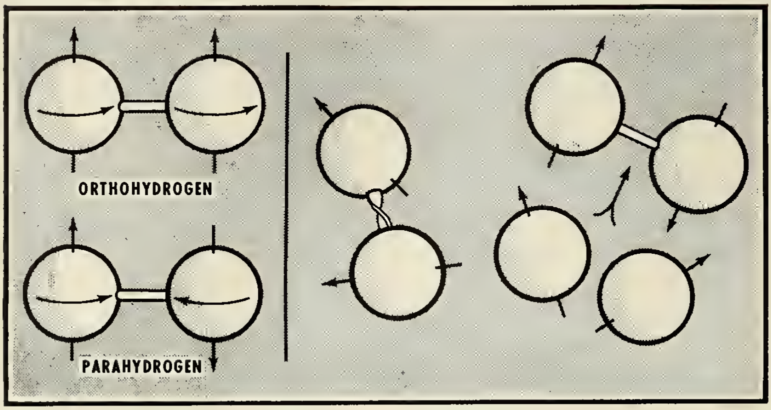
• **Long time transformation**—But the transformation from ortho to para requires a long time under ordinary conditions. It takes about a month for 25% para to convert itself to 90%. The conversion releases heat, because parahydrogen is in a lower energy state than ortho. It is more stable. This might be compared to some types of twin-engine airplanes in which the engines spin in opposite directions to make the plane more stable in flight by equalizing torque.

Because of this continuous release of heat, liquid hydrogen produced by older methods needed to be continually refrigerated. Even so, it was constantly boiling off. Many scientists searched for catalysts that would speed up the conversion, so that the product would be more stable.

The first major break came in 1953, when workers at the **Los Alamos Scientific Laboratory** succeeded in modifying a small hydrogen liquefier for the regular production of 85% para liquid at a rate of 25 liters (3 pounds) per hour. A short time later, the hydrogen liquefier at Boulder was modified to produce 240 liters per hour of 90-95% parahydrogen.

Meanwhile, under Atomic Energy Commission sponsorship, the Cryogenic Engineering Laboratory at Boulder began a catalysts research program directed by D. H. Weitzel. The most effective catalyst, they discovered, is hydrous ferric oxide. Its high conversion efficiency makes it possible to design ortho-para converters about 1/40

handling hazards are minimized . . .



HYDROGEN molecule exists in two forms shown at left: ortho, with spins of atoms parallel, and para, with spins in opposite directions. At right is sequence showing change of ortho molecule to the more stable para form.

the size of those used in the early work at Los Alamos and Boulder. This makes it possible to hold to manageable size the converters for the very large scale new plants.

• **12,000 pounds a day**—The Linde plant at Torrance, Calif., due to be completed next April, will have the capacity of producing 12,000 pounds per day. Linde, which is putting its own money into the venture, won't say how much the plant will cost. NASA has agreed to buy from Linde as needed on a sliding scale beginning at 70 cents a pound. If as much as 10,000 pounds a day are purchased, the price will average about 50 cents a pound, a Linde spokesman said.

Air Products Inc. began operating the first plant for continuous production of liquid hydrogen at Painesville, Ohio, in the summer of 1957. Stearns-Roger started up another plant the following winter at Bakersfield, Calif.

Part of the much larger Air Products facility at West Palm Beach went into operation in the fall of 1957 and the complete plant became operational early this year. It is the first plant with on-site generation of the gas used for liquefaction. As for production, the Air Force will say only that it is several tons per day.

Since the Air Force owns the plant and merely pays Air Products an operating fee, it would be difficult to give the cost of liquid hydrogen even if the figures were released. One officer has said that, depending on how you calculate, the cost is somewhere between $1.50 and $5 per pound. The Air Products contract for building and operating the plant is reported to be in the neighborhood of $20 million.

• **Vacuum-jacketed line**—A 2000′ vacuum-jacketed pipeline connects the Air Products plant to an area where Pratt & Whitney tests the liquid hydrogen-lox engine that will be the second stage of the *Centaur* space vehicle. The pipeline is capable of transferring up to 400 gallons per minute (14,400 pounds per hour). Presumably, this transfer capacity is much greater than the Air Products plant's production. The line is used to supply pump test stands where 50,000 gallons (30,000 pounds) of liquid hydrogen may be consumed in one test.

The plant storage system consists of 28,000-gallon tanks (the number of these is classified). Vacuum-insulated trailers also are available for transporting 6000-gallon loads of hydrogen by highway to points in California and elsewhere.

The cold liquid, once thought to be extremely hazardous, now is considered only a moderate danger. Precautions are necessary but Air Products' safety director, Franklin Himmelberger, says it is less flammable than propane, commonly stored in tanks in rural homes.

P. C. Vander Arend, Air Products' chief scientist, has given this outline of the safety assumptions made in design of the plant: All equipment containing hydrogen gas or liquid, except for the compressor building six stories high and a quarter-mile long, is located outside, where leaking lightweight hydrogen will dissipate rapidly upward. All equipment containing hydrogen gas or liquid is kept at a pressure above atmospheric, to avoid contamination with oxidants. The same is true of cold boxes containing heat exchangers, adsorbers and liquid baths.

A rather extensive alarm syst tells when pressures drop below s limits and shuts down the compress if the conditions are not corrected. operator in a central control room a continuous visual and instrum check on plant operation. And entire liquefier and storage system closed. Under normal conditions, li hydrogen gas escapes into the atr sphere. Safety relief valves are pi into tall stacks, which are tigh covered except when the excess is ing vented.

• **Not too hazardous**—Engine working with liquid hydrogen ag that spills are not dangerous so l as there is no source of ignition. few gallons spilled will evaporate mediately. When hundreds of gall are spilled, the ground freezes, the liquifies and a cloud of ice crys and water vapor forms. Althou warm hydrogen is much lighter t air, a large mass of very cold gas n have about the same density as and lie along the ground until it pi up heat. However, the adjacent outside the cloud has less than 0. hydrogen. Thus any explosion and will be confined to the volume of cloud.

A spill that is ignited immediat will burn smoothly in air without ploding. The fire creates an extrem strong updraft, so that damage usually confined to material direc overhead. Thus, C. D. Robin of P & Whitney advises, test stands sho be designed with no important equ ment overhead.

Leaks in a liquid hydrogen syst can usually be detected by the cl of ice crystals and water vapor arou it. But if the leaking hydrogen is bu ing, it may be harder to detect. hydrogen flame is invisible in daylig

Air Products recently invited engineers to its Allentown, Pa., he quarters for a series of lectures a demonstrations on safe handling cryogenics. Himmelberger told conference the three chief dangers handling liquid hydrogen are conta nation by oxidants, spills, and leaks the vent system. He recommended su preventive measures as periodic purg of vessels and pipes with inert gas, co stant monitoring of all equipment a powerful fans for quick evacuation all air from any room or building i which hydrogen may leak.

A constant alert is necessary, course, against the danger from spar flames and lightning. Hydrogen ma an explosive mixture with air when concentration is anywhere from 4 74%. "No smoking" must be the r anywhere near hydrogen equipment.

Engine Controls Demand A New Art

Components are improving too slowly to keep pace with new environmental demands; efforts to simplify servo loops underway

by Frank G. McGuire

Los Angeles—"The controls field gone about as far as it can go h the materials and skills it has to rk with today—and we've pushed transducer and sensor business as rd as anybody." These words by ger M. DiJulio, Chief Engineer at rvomechanisms, Inc., about sums up state of things in the field of engine ntrols, as seen by a number of comnies.

Components are being slowly but ely improved in reliability, performce, etc., but the problem is that they being improved *too* slowly. In ee years, say the controls people, 'll need much more performance n we have now in our control sysns. "But," they complain, "we'll be ced to make a system to operate at nus 400° F, and the same system ll have to operate at over 1000° F.

Other companies, specifically **Marardt Corp.** and **Bendix-Pacific Division,** are not trying to achieve seven-league steps as much as they are incrementally improving reliability and performance of present, proven components and loops.

Even though the performance and reliability have improved, there is a continuing effort to simplify the servo loops that make up a system for missile control. This is difficult mainly because of the basic nature of operating components. Many smaller items, such as a capacitor or two, have been deleted and some circuits have been simplified, but on the whole, no large-scale elimination or consolidation has occurred.

Certain important features have, of course, been designed into recent control systems, including that of **Aerojet's** *Titan* engine, which will continue operation even if the missile's hydraulic system suffers a complete failure.

Additionally, *Titan* is held to the launcher for a pre-determined period after full thrust is achieved, insuring that any malfunctions which occur immediately after ignition will automatically cause the engine to be shut off. The hold-down period, believed to be over five seconds, has been credited with saving at least one vehicle that was prevented from leaving the launcher at the last second, then was later flown successfully.

The unit is what might be termed a ground-based engine control, and is composed of a sequencer which compares the parameters of the engine operation with optimum parameters previously fed into it. If the actual engine operation does not fall within tolerable limits, the sequencer shuts off the engine before the missile leaves the ground. If all is well, explosive bolts are actuated, which free the missile for flight. The device's function is based on the premise that most mission-aborting malfunctions occur soon after ignition.

• **Thrust control**—In this area, the usual method is to sample chamber pressure through a transducer, and feed the error voltage through the control system into the servo loop, which regulates the turbopumps that either increase or decrease fuel and oxidizer flow until chamber pressure matches the pre-set level on the potentiometer of an electrical reference device.

Other methods of controlling thrust through propellant flow to the gas generator vary in complexity from a drilled orifice involving no moving parts, to the other extreme, with many electronic and mechanical devices in the system. Parametric requirements of the vehicle, calling for an accuracy between 0.1 and 5.0%, usually decide the method selected for thrust control.

With an open loop system, as normally used, each component must be made and tested to great accuracies, which is often uneconomical. If a closed system is used, the tolerances are more liberal, since the control sys-

Instrumentation Better Than Computation

"At this time, our instrumentaion is much better than the comutational art, and a lot better than ircuits themselves. To be more pecific, we can detect the motion of he sensing element in a transducer p to the limit of its internal hyseresis, where the properties of the naterial itself suddenly become a evere limitation. This is well below he confidence which you can place n things like precision gears, bearngs and machined parts, synchros, nd that sort of thing.

"We've developed some sophisicated and tricky methods to comensate for things like temperature nd accelerations. But there's still broad band of uncertainty that ou can't trim out.

"This begins to suggest that a new art might be required here. This new art will be computation to higher accuracies. The first thing that comes to mind is digital computation . . . but the sensing of basic phenomena is an analog thing—and there isn't an acceptable transducer on the market today that will sense this analog physical quantity and put out a usable digital signal.

"Something basically new and different is required. It will not come necessarily from the controls people or the computer people, but will probably come from some physicist who studies the very nature of matter itself."

Roger M. DiJulio
Chief Engineer
Servomechanisms, Inc.

control for guidance accuracy . . .

tem can then account for any deviations. Since October 1953, when it was first proven possible by flight test, the thrust-controller has added considerable effectiveness to the missile.

With this thrust controller, which permits pre-planned trajectories to be actually flown in practice, the Army's *Redstone* has repeatedly followed the pre-programmed trajectories with a cutoff point within 100 milliseconds of its predetermined 110-second flight time. Accuracy in this case is within 0.1%.

One of the prime reasons for thrust control is accuracy of guidance, not merely for engine considerations of running at rated thrust. A great simplification of guidance problems results from closer control of thrust. The missile is programmed on a time basis, and the timing comes out right only when a precise trajectory can be flown as previously planned. If the thrust varies from the plotted ideal, the timing is off, and thus the angle is off and the vehicle's position in space is different than required for the mission—therefore the end-point of the warhead or other payload is not as planned.

In order to correct for these variations, a much greater complexity of guidance systems would be required than is now needed for a closed loop thrust-control system where engine output is constantly monitored for compliance to the plotted level. It is therefore easier to make this a function of the propulsion system rather than the guidance system.

In solid propellant rocketry, there is not as much application for thrust-control devices as yet. The problems in this area rest mainly within the propulsion field, rather than the controls field. **Grand Central Rocket Company** has work in progress on a hybrid system that would control thrust levels by regulating the liquid oxidizer as it enters the combustion chamber with the solid fuel. **Thiokol Chemical Corp.** has indicated the possibility of introducing a combustion-modulating chemical that would disturb combustion to a controllable extent. Lowering of chamber pressure through escape ports at the side of the motor casing would also provide some means of thrust control.

Whatever the method used to actually raise or lower the thrust level in a rocket engine, the controls people indicate that present methods of exercising control and determining the amount needed would still be used.

• **Propellant utilization**—One of the most difficult problems confronting the engine controls people today is that of propellant utilization (PU) and liquid-level control. The difficulty lies in the accuracies needed, the environmental conditions encountered and the tactical requirements. Liquid-level control is a relatively old subject, but when applied to the measurement of rocket fuel/oxidizer levels, it becomes an entirely new field of endeavor.

Usually, the fuel/oxidizer combustion is done through stoichiometric requirements, so, that the PU system must insure that they are being consumed at an equally proportional rate. The most important consideration, therefore, is that the fuel/oxidizer must deplete simultaneously. Otherwise, combustion stops when the missile is lightest and near the end of powered flight, throwing the guidance system way off. It is therefore essential that both tanks empty precisely simultaneously.

The problem: continuous, pre
control and measurement of two la
masses of liquids, with great term
accuracy, in a vehicle travelling
12,000 mph and under terrific accel
tions, vibrations and temperature
tremes, and noise levels in excess
100 db. So, there are several sch
of thought on how it should be h
dled.

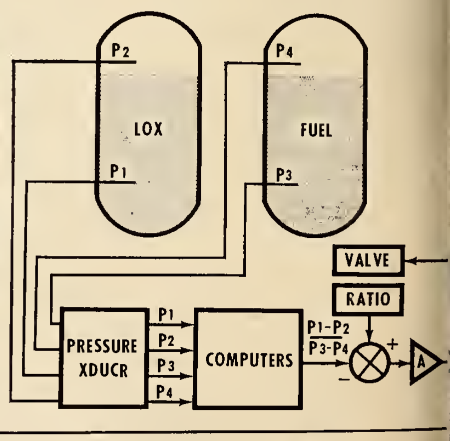
Some systems employ dip-stick t
approaches where a capacitive pr
or resistance probe is put into the ta
Other systems use the difference
pressure between top and bottom
the tanks, but this is merely an i
cation of the weight of the colu
There are difficulties in transla
column weight to significant data
total fluids.

Variations in tank diameter due
manufacturing tolerances are such t
even if the weight of a given colu
is known, there's no guarantee that
total amount is known. In addition
knowing the ratio of weight/volu
it is necessary to know where the le
is, so that in a variable-diameter tan
corrected ratio can be used.

Servomechanisms, Inc. is at w
on a method of computing the mas
not the cubage or pressure differenc
then translating this information i
control signals which operate a pu
or valve to control flow of one of
constituents. Some missiles require
type of control and some do no
those that don't usually being the sh
range missiles that can be "tuned"
tests to deplete fairly uniformly;
open loop method. Long-range vehi
not only have to be tuned, but
controlled.

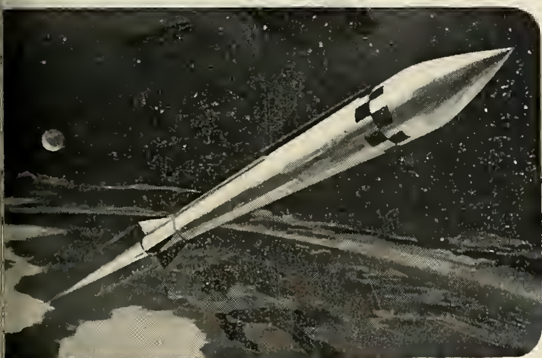
The other end of the PU spectr
is the loading of propellant aboard
missile. This can easily affect the c
trol of the vehicle in flight. Liq
oxygen tanking computers fill tanks
1/10 of 1% accuracy, by rapid fil
to 98% of total, then slowly topp

ABOVE: Servomechanisms' Type AQC 600 propellant utilization control system assures that the fuel and oxidizer are depleted simultaneously. This system measures the pressure ratio remaining in the tanks and controls flow. RIGHT: Schematic of the system.

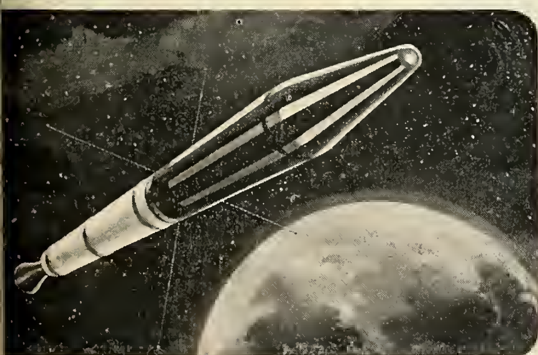


Historical Achievements at JPL

JATO UNITS...The nation's first successful jet-assisted takeoff (JATO) units were originated and developed in 1941 at the Jet Propulsion Laboratory, and sparked the development of future rocket vehicles.



THE CORPORAL...this country's first ballistic surface-to-surface guided missile, now an operational weapon of the U.S. Army, was pioneered and developed by the Jet Propulsion Laboratory.



EXPLORER I...The United States' first successful earth satellite, launched January 31, 1958, was developed by JPL in collaboration with the Army Ballistic Missile Agency.

THE WAC-CORPORAL...fired in flight from a V-2 rocket, established a world's altitude record of 250 miles in 1949. The combination was known as the Bumper-Wac.

THE SERGEANT...A second-generation solid propellant missile developed by JPL for the U.S. Army. The SERGEANT is now being readied for production.

PIONEER IV...America's first successful moon-space probe, launched March 3, 1959, was developed by the Jet Propulsion Laboratory in collaboration with the Army Ballistic Missile Agency and the National Aeronautics and Space Administration.

jpl

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new system to do two jobs . . .

off and maintaining the desired level in face of evaporation. At launch, this computer is dropped to the pad and reused.

Servomechanisms is currently at work on a system which will do both jobs: control ground fueling and also airborne depletion of fuel/oxidizer tanks. The airborne device will gain negligibly in weight, since most of the changes from present equipment involve only wiring.

These systems are small and light and are basically independent of the type of liquids being used in the missile, because there is no direct contact between the sensor and the tank contents.

Complications in loading occur similarly as in utilization: tank diameter changes, fuel densities with varying temperatures, and varying densities between fuel and oxidizers. Even different batches of the same fuel have slightly different densities.

Then there is the problem of sheer size in the plumbing that must handle vast amounts of liquid. How can a vehicle like *Saturn* be adequately and accurately calibrated for fuel loading? The first stage alone holds three million pounds of propellants. There will be at least three, and possibly five, different fuels and oxidizers used in the vehicle.

The accessory requirements are just as stringent. Vibration requirements for transducers on *Saturn* first-stage are over 125 g. This is in addition to the temperature requirements needed for a vehicle using eight engines in the first stage.

• **Hydraulics or pneumatics?**—The use of hydraulics or pneumatics in a system, depends, of course, on the requirements involved. Principal advantage of hydraulics being their good response characteristics, while their disadvantages lie mostly in temperature and nuclear radiation limitations. Gases suffer from a lack of response characteristics, but have few temperature or radiation worries.

The application of hot-gas pneumatic servos is getting considerable attention from Bendix-Pacific, which is using "clean fuels" as a hot-gas source. Company engineers feel that solid propellant gas generators, while having many advantages, introduce contamination to delicate systems. "Although solid-propellant people maintain their gas generators are very clean, and this is true in most senses, we find just enough contamination in them to justify using bottled cold gas where possible," explained a Bendix engineer. In reliability, also, Bendix sees the bottled gas as an advantage. It is viewed as competitive weight-wise with hot-gas systems, even for explorations as far as Mars. "It depends on how much you want to run the thing," says Bendix, "because cold-gas is superior to hot-gas up to about 1000 I_{sp}. Beyond that, the hot-gas systems seem to be favorable, except that they are not easily used in an on/off/on situation."

Response characteristics favor hydraulic systems, which perform at about 270 cps in an arrangement whose equivalent pneumatic system would perform at about one to five cps. Adding some sophisticated feedback to the pneumatic system would raise response to about ten cps, says Bendix, indicating that a factor of 25 to 30 makes the difference quite broad.

Marquardt Corporation, working mostly with pneumatics, has achieved responses of 18 cps, for example, then connected the system with external RC-type networks that reduced response to 3 cps. The change results from looking at the loop response or the complete system response. In contrast with Bendix, Marquardt has used hot-gas sources from either liquid-propellant or solid-propellant gas generators, but is not currently utilizing cold-gas bottled supplies to any great extent.

Work in the pneumatic system field is concerned mostly with improving "stiffness" of the system response, performance of individual components, and the old bugaboo, reliability. Few companies admitted to a search for one great stride or "breakthrough" in the field of controls.

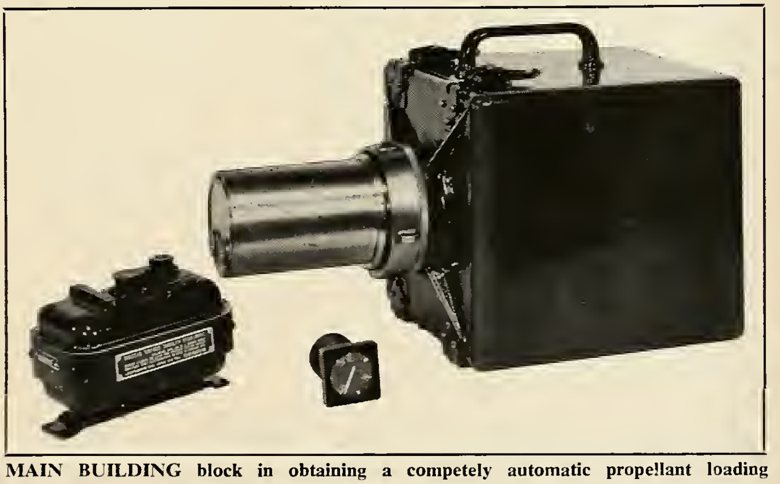
Marquardt is working on the adaptation of new principles in gas systems, as well as component and loop improvements. Advanced work at Bendix is also in gas controls, although company spokesmen feel that hydraulics are adequate for anything now or in the future, ". . . but to stay competitive, we have to reduce size and weight and increase performance."

• **Pressure switch**—An example of individual component improvement is that afforded by Servomechanisms, Inc.'s new pressure switch; devices which have been the bane of design engineers' existence. They've been notoriously unreliable, unpredictable, hard to make, environment-sensitive, etc.

The switch recently designed by SMI operates on a novel principle which does not depend on the storage of energy, the release of energy, or the triggering of mechanisms. It depends on a very discreet electrical phenomena which is either black or white. The switching takes place over an extremely narrow range of pressure change, and with extreme rapidity.

The unit is very reliable and rugged, as illustrated by the description of one of its tests: "We can set it to within a fraction of a psi of the switch point, hammer nails with it, and the circuit will not switch . . . go up on the other side of the range, set it again to within one psi of a switch point, hammer some more nails, and the circuit still will not switch."

The accelerations and shocks are in the thousands of g's, but the unit still detects motions in the pressure element down to tens of micro-inches. The logic is all electronic, solid state, and the unit is encapsulated into a capsule about 1½" diameter and 2" long. One part has an elastic motion,



MAIN BUILDING block in obtaining a competely automatic propellant loading system is the LOX tanking computer system.

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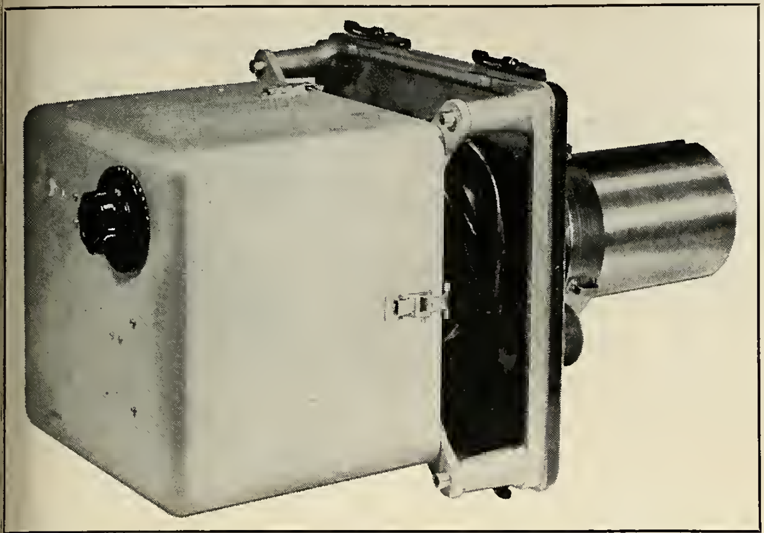

SERVOMECHANISMS' SMI Type AC 2019 computer with protective cover removed.

but there are no other moving parts. Operating with an on/off differential of 0.1% (it has achieved 0.03 of 1%), the switch will be used on the *Saturn* vehicle to sample chamber pressure in each of the first stage's eight engines, then signal a black box to release the vehicle if pressure is as planned. Otherwise, engine-cutoff devices will be actuated. As in most devices of this nature, fabrication of the devices is but a fraction of the time and cost involved in quality inspection, testing, and calibration.

• **Testing and accuracy**—Candidate for the title of most frustrating problem is that of proving just how accurate or reliable a device is. The standards are limiting, and there is a major obstacle in determining absolute accuracy. As phrased by one frustrated engineer: "We're talking about accuracies of 1/10 mm of mercury or less. We'd love to have a couple of hundredths of a millimeter, but we just can't get it." The problem is industry-wide . . . and is not just a technical problem. It has become necessary to organize the entire company, from front door to shipping dock, to handle that kind of accuracy. Sloppiness cannot be tolerated anywhere in the process.

Astronomical increases in performance will be required in the near future. Some of them can't be met right now. Frequently, say industry spokesmen, the specifications are written against what can be done, rather than what the requirement is.

One firm indicated that customers frequently come and say: "We need a gizmo to do this . . ." and is told; "You can't get it." "Then, we add a little increment to what is possible right now, and this makes us run for it."

It is estimated that systems managers could use another order or two of magnitude in the accuracy of propellant utilization, thrust control, and other segments of the controls field. The belief, however, is that the rest of the missile system is not that accurate, so the additional money we put into fantastically accurate devices is sometimes wasted. Tanks are not perfectly cylindrical, guidance is not precise enough, etc.

Then there is the argument that tolerances of a missile's components add up to a total probable reliability. Too many sloppy components, and the system will not perform. Therefore, each component must be much more accurate than the overall vehicle must be.

"It is sometimes necessary," said one Bendix engineer, "to compromise the design of one component to offset the weakness of another. In other words, you don't design the best servo valve, you design the best servo loop."

Complained SMI's DiJulio: "Everything we do now has a basic limitation . . . 'How accurately can we machine things?' 'How accurately can we measure them when they're made?' 'How stable are they?' 'Will they stay put until the vehicle gets there?' 'Can we get a production organization to make it?' and 'Can we get a production organization to determine that they've been made correctly?' So this problem backs up until you're down to the last girl on the production line . . . who never heard of the things you're talking about."

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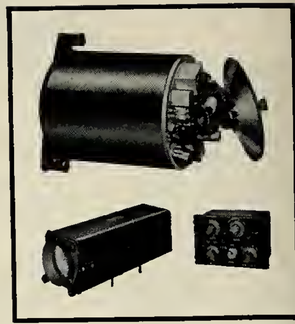

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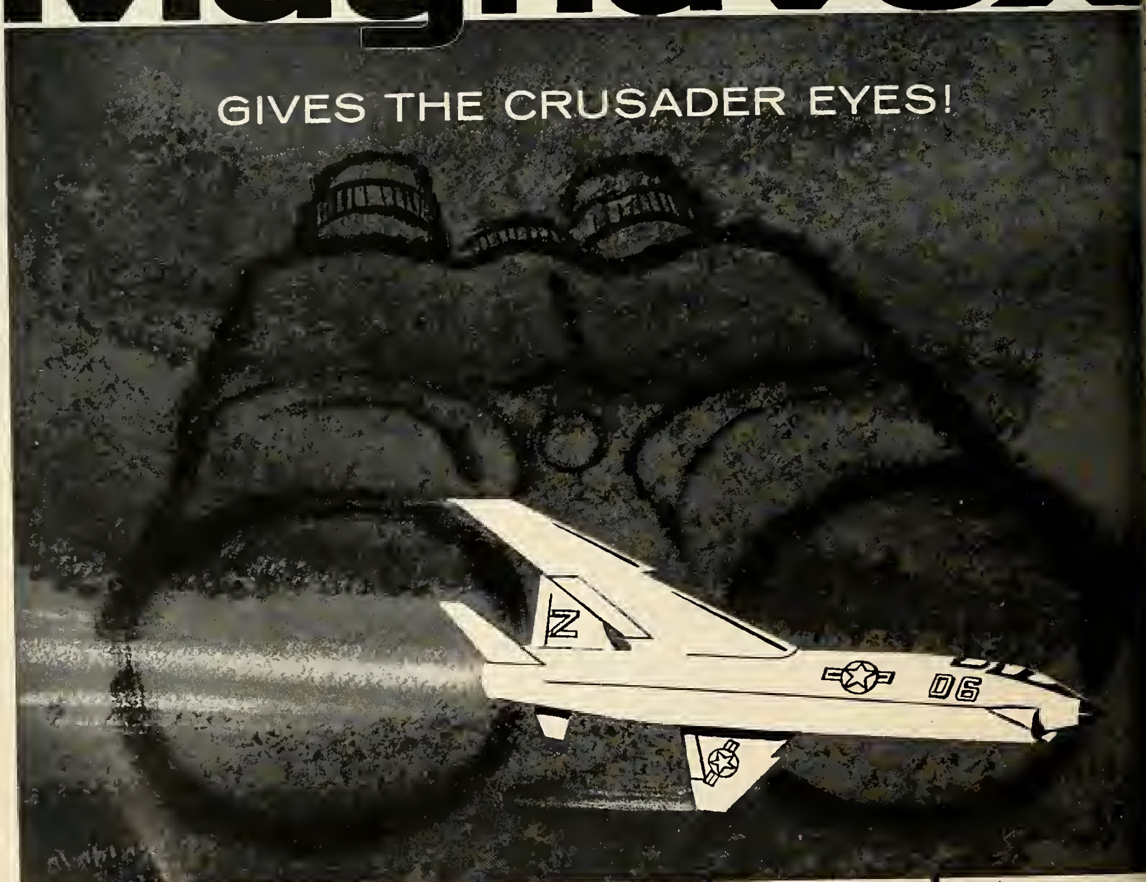

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APU's—the Muscles for Missiles

Gas-turbines are first choice for missile auxiliary power units; batteries are a strong second; exotic sources still are some years away from reality

by Hal Gettings

WASHINGTON—A vital, but often neglected, part of a missile system is its auxiliary power unit (APU). These units supply electrical, hydraulic—and sometimes mechanical and pneumatic—power to the various operating mechanisms of the missile. They drive control surfaces, energize transducers, guidance, telemetering, and other accessory equipment. Their development and production is presently a $25 million business.

Differentiated from primary power—the missile's propulsion system—the auxiliaries perform a function just as vital to the mission's success. Whether a test vehicle or an operational type, each missile and space vehicle must carry a separate internal power source. This source may take one of several forms. It may be a fuel cell, thermoelectric generator, nuclear unit, or some other exotic form of power.

At present, however, two less glamorous sources are carrying the bulk of practical applications: gas-turbine APU's and batteries.

• **Gas-turbine**—The gas-turbine unit claims several advantages over the battery. Most important, it is more efficient in size and weight per unit of power output. Batteries have undergone a steady improvement, however, and they find use in many missile applications. A comprehensive report on their development and important place in the missile business will be covered in next week's issue of m/r.

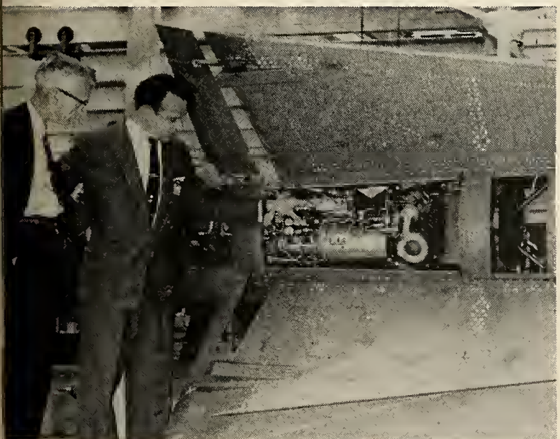
Gas-turbine APU's use both solid and liquid propellants as a hot-gas source. Both have their advantages and limitations and, at present, neither is considered sufficiently superior to make it universal.

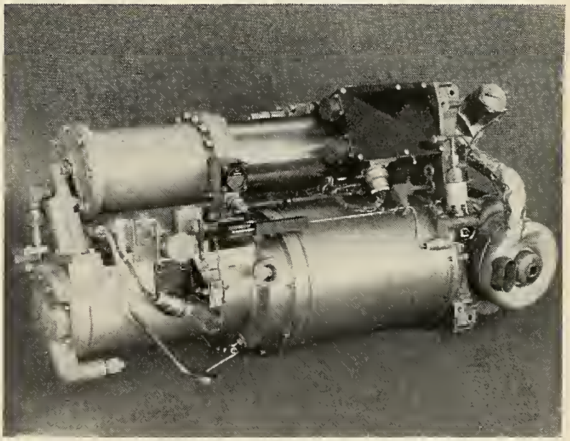
Current production of short-duration APU's is dominated by solids for their ease of handling and storage capability. For run durations of over two minutes, liquids are expected to dominate production for the next year.

Current research and development is aimed at solid-propellant units for over 30 hp and durations of up to 20 min.

According to an **AiResearch** spokesman, APU's can be expected to become more elaborate with each passing year. Power requirements and durations will continue to increase. He predicts that liquid propellants will be able to fill the need for units running for six months or more. Beyond one year, solar and nuclear-powered APU's will have to fill the need.

Generally, the liquid units are bulkier, more complex, and less reliable than the solids. On the other hand, their packaging design is more flexible and they are more controllable. Progress has been made in sealing the liquid container so that fueled units may be stored for two years and possibly longer.





LEFT: installation of APU in *Nike-Hercules*. RIGHT: new and simplified APU developed by AiResearch uses only half the valves and parts of conventional units. Operating on either ethylene oxide or hydrazine, the unit can be modified for use with solid propellants. Designed as an approach to a standard power source, the current model weighs 85 pounds and produces five horsepower for 7.5 minutes.

trouble with crash programs . . .

• **No emphasis**—Some auxiliary power manufacturers feel that proper emphasis has not been placed on this phase of missile development. They contend that the APU should be a part of the overall system design and not just packed into the missile frame somewhere along the line. Conversely, both **Thompson Ramo Wooldridge** and AiResearch—and possibly others—have made steps toward developing a line of standard units that would fit a large percentage of applications.

Since missile development is usually pushing the state-of-the-art, APU designers often find themselves working on a crash basis to build a unit for a particular missile. Consequently, new and unproven units are often pushed into production, or a missile development may have to wait for the APU.

Ideally, the APU development should go through an orderly process of feasibility study, research and development, breadboard, test and evaluation, and production. Such a logical time-consuming process would, of course, produce a good power unit for a now-obsolete missile.

This dilemma can be solved to an extent, however, by looking ahead to requirements for one to two years from now and doing the necessary research. In other words, start sooner. The problem here, naturally, is financing. Much could be accomplished by government backup of institute research programs in components and critical areas.

• **Areas of investigation**—Some of the areas to be investigated for improvement include evaluation of propellant characteristics, turbine reliability and efficiency, comparison of relative merits of various types of APU's versus application, materials for high-speed high temperature use, and standardization of environmental test requirements.

Many factors affect the design of gas-turbine APU's: type of control, outputs, run duration, package and space requirements, porting location, and others. They must be extremely rugged and reliable and be storable for an extended time. The primary problem of course, is the precise control of power output. Pressures, frequencies, power level are all critical.

Strangely enough, most units are not designed for high turbine efficiencies. Usual figures run in the range of 30-50%. Better design could easily raise these to 70-80%. The output of one air-to-air missile APU was recently experimentally modified to produce more than double its previous output by a simply nozzle design change. NASA engineers at Lewis Research Center recently conducted an investigation of a 4.5" two-stage turbine for APU use and obtained efficiencies of 65% and better.

Efficiency is usually sacrified, however, for reliability considerations. The smaller, more efficient, nozzle is more critical and subject to erosion and clogging. Especially in short-duration operation units, the gain in efficiency is usually not worth the cost. For long-duration operation (over 10 minutes) more attention is paid to higher-efficiency design.

Some work has been done on using primary propulsion gases to drive the power generators. Big problem here, however, is the difficulty in handling the extreme temperatures involved. At least one such system has successfully operated; others may possibly be in use.

Research has also gone into the possible use of hot-gas servos—a sys tem whereby direct use is made of e ergy from a secondary or primary pr pellant. Such a system could be us in place of hydraulic power but wou be no substitute where electrical ener is needed.

Claiming to be the largest man facturer of APU's in the business, **Ga rett Corporation's AiResearch Man facturing Division** started work in th field in 1950. Current work include units for *Terrier*, *Falcon*, *Nike-Herc les*, *Nike-Zeus*, *Polaris*, *Quail*, and a unspecified Navy missile. They a working on two WADC contracts f advanced space APU's—one using solar energy source and the other nuclear unit.

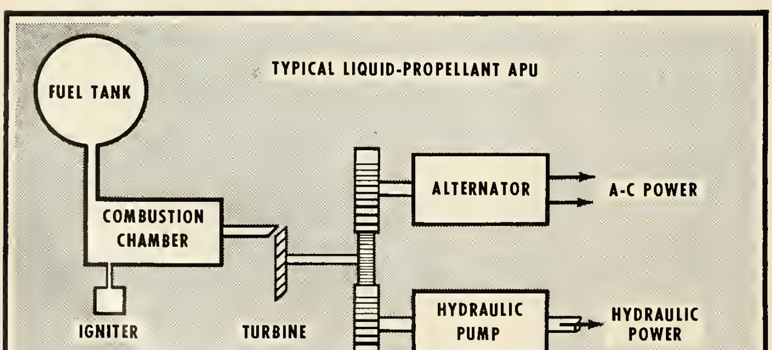
Thompson Ramo Wooldridge h several units now in operational mi siles and others under developmen They are producing a solid-propella unit for the advanced *Terrier* BT- which is actually a double system. Th hydraulic side produces approximatel seven horsepower and the other abo one kilowatt.

• **Hydrazine APU**—Their long-du ation hydrazine APU for the *Boma* produces approximately 40 horsepowe hydraulic and eight kilowatts electr cal. This unit features completely seale fuel tanks which can be stored u wards of two years. TRW last wee introduced the first in a propose series of solid-propellant multi-outp electrical units which can be stored fo as long as five years. They have als produced a solid-propellant turb hydraulic pump, capable of about 1 horsepower output, for an unspecifie missile. About half of TRW's uni use solid and the other half liqu propellants.

Vickers Incorporated, in an exte sion of their work on hydraul equipment, has just developed a uniq hot-gas driven motor pump for u as an APU. This unit operates at mod erate rotational speeds (6500-18,20 rpm) and produces ½ hp at 1500 p and up to 66 hp at 3000 psi. The mo tor has reportedly been successfull tested using a hydrogen-oxygen fu with combustion temperatures of ov 5000°F. Because of its high tempera ture capability, the unit may be ru from either propellant-generated gase or directly from the prime propulsio system.

The *X-15* manned missile uses tw 40 hp hydrogen peroxide APU's whic produce both hydraulic and electrica power. These units, built by **Genera Electric,** have an operation cycle u to 30 minutes and a designed life o 150 hours. Turbine speed is 51,20 rpm. Hydraulic pad speed is 3925 rp and alternator pad speed 12,000 rpm

Aerojet-General's Turbomachiner



VICKERS hot-gas motorpump. Unit shown, smallest in series, is capable of 3.9 hp and weighs only 2.5 pounds.

Division, devoted entirely to APU work, has produced a hydrazine-fueled unit which develops approximately 30 hp. This unit, scheduled for the *Titan,* holds frequency and voltage variations to 0.25%. It has been test run for periods up to 1¼ hours.

A different type of APU used for extremely short-duration maximum-force power in many missile applications is the cartridge-actuated device (CAD). This device, which uses the controlled power of an explosion, can produce 50-100,000 ft-lbs per lb of weight. They are actuated mechanically (by a firing pin) or by heavy currents (two amps or more). They are used to activate batteries, engage and disengage gear trains, open and close switches and valves, separate components, shear cables and membranes, and unlatch aircraft missile launchers.

Other firms important in APU business include **Hughes, Raytheon,** and **Sundstrand.**

BIAX Units Expected to Replace Semiconductors

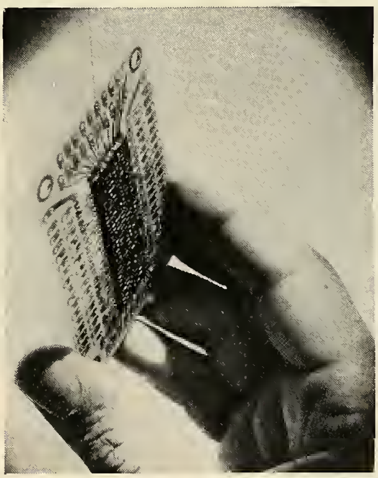
Los Angeles—A new microminiature computer element capable of operational speeds up to 20 megacycles per second has been developed here by **Aeronutronic Division** of **Ford Motor Company.** So small that more than 5000 can be held in a man's hand, the elements are expected to result in faster, smaller, and cheaper computing equipment.

Called the BIAX, the units are small (50 x 50 x 85 mils) bars of ferrite magnetic material presently being produced as memory elements and logic devices.

Several advantages are claimed for the BIAX elements over the semiconductor devices they reportedly will replace in the next generation of computers. They operate over a wide temperature range—from below freezing to 125°C. They have low thermal conductivity and are not affected by radiation. Units are relatively inexpensive to produce and reduce the number of solder connections in a typical computer by a factor of 10-100 and the number of connectors by a factor of ten or more. According to the company, an extremely high packing density may be achieved with the tiny units: 200 flip-flops and 3000 gates—the equivalent of 15-20,000 semiconductors—in one-tenth cubic foot.

The basic concept of BIAX is that of flux interference between orthogonal magnetic fields. This is accomplished by means of two 20-mil orthogonal holes through the elements. The flux interference takes place in the magnetic material between the holes. Because of the orthogonality, no normal magnetic coupling occurs between conductors associated with the two holes.

The spacing between the holes determines whether the flux interference is destructive or nondestructive. Nondestructive elements are used in memory applications and the destructive element in logic circuitry. In the memory elements, one of the holes acts as the storage axis while the other acts as the nondestructive interrogate axis. The logical element uses the same hole technique except that the holes are extremely close together.



TYPICAL BIAX array for an electronic digital computer memory unit, this printed circuit card contains more than 300 BIAX elements.

In memory element applications, BIAX provides a very rapid random access memory unit. Elements have been interrogated over 100 billion times at a ten mc rate with no loss in output signal.

Aeronutronic has five military contracts for equipment using the BIAX technique. Work is classified and no details are available.

tanford Plans to Build 142-Ft. Radar Dish Antenna

Palo Alto, Calif.—Stanford Uni-ersity and the Stanford Research In-itute will build a radar dish antenna tall as a 15-story building for studies the cosmos.

The 142-foot antenna will be the rgest of its type in this country and cond in the world only to the 250-ot dish at Jodrell Bank, England, e university announced last week. he Air Force Cambridge Research enter is providing financial support r the 1½-million-dollar project.

A million-watt radio transmitter—rgest ever built in the 20-60 cycle equency band—will be capable of uncing signals off the Sun and Mars. he gigantic research tool will be used make accurate measurements of anetary distances, explore the sur-ces of the Sun, Moon and planets d measure the rotation speed of enus.

ovel Technique May ass-Produce Transistors

Baltimore—A new technique de-loped by **Westinghouse** may pave the ay toward completely automatic mass-oduction of transistors and other miconductor devices.

Using long thin crystals of ger-anium, the devices are formed as a ntinuous series of dots along the sur-ce of the crystal. After electrical nnections are made, the strip is then t into sections, forming individual miconductor units. These are then aled in plastic or metal containers.

Westinghouse believes the entire ocess can be done automatically by achine at high speed and with highly liable results.

missile business...

By WILLIAM E. HOWARD

It won't happen overnight, but the Army holds promise of becoming a considerably bigger market for basic and applied research work. Chief agitator for broadening industrial participation is Lt. Gen. Arthur C. Trudeau, chief of Army R&D. For some time now Trudeau has been calling for a step-up in basic research, which presently is funded to the tune of 5% of the Army's $9 billion budget. Applied R&D gets 45%.

In anticipation of a bigger program . . .
Trudeau's office is now in the process of preparing—for industry—a classified document detailing long-range Army research goals and problem areas, in which private research is needed. This document won't be ready for several months—perhaps not until next year. However, it should be an extremely useful guide when it appears—and well worth ordering in advance.

Even if Army research funding is not increased . . .
industry's share of the total may be greater. The Army is showing a tendency to break more and more research out of government arsenals. Maj. Gen. August Schomberg, deputy Chief of Ordnance, says that today his agency is spending about 20% of its money in-house, with 80% going to industrial plants and non-profit institutions.

Areas in which Trudeau sees a real need . . .
include "unexplored" alloys—to find those that will be stronger, more heat-resistant and lighter—and electronics. The Army is looking for surveillance drones to penetrate enemy air space and be capable of sending back information via infrared, radar, photographic film or television. And it is re-emphasizing aircraft that are "low and slow" and can take off like a helicopter. This area may be wide open for propulsion techniques that are being developed for rockets.

Just off the press is a new Air Force booklet . . .
telling about the broad applied research interests of the Air Research and Development Command—and how individual companies can go after contracts. The booklet (obtainable from ARDC at Andrews AFB) is called: "Applied Research Planning Document Release Program." As the title implies, this publication is a reference guide to applied research areas and contains applications for getting planning documents in specific areas such as propulsion, electronics, and metals.

These documents—like the Army's—are classified . . .
and companies must show a "need-to-know" to get them. This may present a problem for firms seeking to break into the defense research field. The documents are classified because they actually define the military problems involved and why the particular service wants to solve them. As such, they are a fair indicator of our technological progress and would be useful to Moscow.

Small business vs. big business over defense contracts . . .
is heading for a showdown in the next session of Congress. The tussle will come over S. 2487 introduced by Sen. George Smathers (D-Fla.), chairman of the Senate Small Business Procurement Subcommittee which investigated "abuses" by large contractors. Smathers contends several large contractors are guilty of pirating engineering know-how from small firms and are making more and more components themselves, rather than subcontracting items.

Coming up before Senate Armed Services Committee . . .
Smathers' bill would provide for more careful screening and contract review by the Small Business Administration of agreements letting private industry use government-owned production equipment; require a fair market rental on such facilities; keep SBA fully informed of major contracts for subcontract opportunities; limit prime contractor profit on subcontracts to actual work performed; and require breakout of components and large segments of weapon systems from prime contracts into open competition. Biggest objector to this proposal very likely will be the Defense Department. It may be an interesting battle.

MISCELLANEOUS

$1,000,000—Giannini Controls Corp., Pasadena, for precision free and rate gyroscopes. (Two contracts, one from Bendix Products Div., Mishawaka, Ind., and from The Martin Co.)

NAVY

$71,237—The Aro Equipment Corp., Bryan, Ohio, for MD-1 and MD-2 oxygen regulators.

AIR FORCE

$73,360—Avco Corp., Research and Advanced Development Div., for research and development of an advanced design re-entry vehicle nose cone for the *Titan* ICBM.

$4,500,000—Kearfott Co., Inc., Little Falls, N.J., subsidiary of General Precision Equipment Corp., for production of attitude Coordinate Converter Systems and related equipment used to provide the *Bomarc* Interceptor with directional control signals. (Subcontract from Boeing Airplane Co., Pilotless Aircraft Division, Seattle.)

$980,680—McDonnell Aircraft Corp., for design and fabrication of an airframe part made of refractory metals to withstand space travel temperatures.

$500,000—Coleman Engineering Co., Torrance, Calif., for GAM-77 *Hound Dog* engineering, tooling and production of positioning and transportation trailers and associated hardware.

$225,000—Eitel McCullough, Inc., San Carlos, Calif., for transmitting tirode electron tubes.

$78,868—General Electric Co., Utica, N.Y., for study of disturbances in radio reception associated with passage of orbital bodies.

$57,200—Sonotone Corp., Elmsford, N.Y., for various electron tubes.

$50,000—Leach Corp., Compton, Calif., for development of instrumentation system to help probe the earth's upper atmosphere.

$30,075—Telechrome Mfg. Corp., Amityville, N.Y., for telemetering transmitters.

$25,256—Westinghouse Electric Corp., Elmira, N.Y., for electron tubes.

ARMY

$3,989,999—Kaiser Steel Corp., Los Angeles, for construction of 305-foot self-propelled tower for erecting and servicing *Satur* missiles.

$3,641,280—H. B. Zachry Co., San Antonio, Tex., for range instru mentation facilities, White Sands Missile Range.

$2,512,495—John H. Sellen Construction Co., Seattle, for construc tion of *Bomarc* facilities at Paine AFB.

$2,496,759—Donald M. Drake, Portland, Ore., for construction of *Bomarc* facility at Adams AFB.

$2,456,792—Montgomery, Ross & Fisher, Los Angeles, for construc tion of a *Bomarc* facility at Vandenberg AFB, Calif.

$1,952,873—Lawless and Alford, Austin, Tex. for construction o *Nike-Hercules* facilities at Bergstrom AFB.

$1,674,830—Browning Construction Co., San Antonio, Texas, fo construction of *Nike-Hercules* facilities at Dyess AFB.

$1,657,000—George A. Rutherford, Inc., Albuquerque, N.M., for con struction of a *Nike-Hercules* facility at Walker AFB, Roswell, N.M

$450,000—Telecomputing Corporation, Los Angeles, for the manu facture of nuclear warhead testers.

$198,271—Sperry Utah Lab. Div., Sperry Rand Corp., N.Y., fo radar set.

$104,806—Western Electric Co., Inc., N.Y. for electron tubes.

$84,037—Radioplane, Div. of Northrop Corp., Van Nuys, for dron system, low-speed.

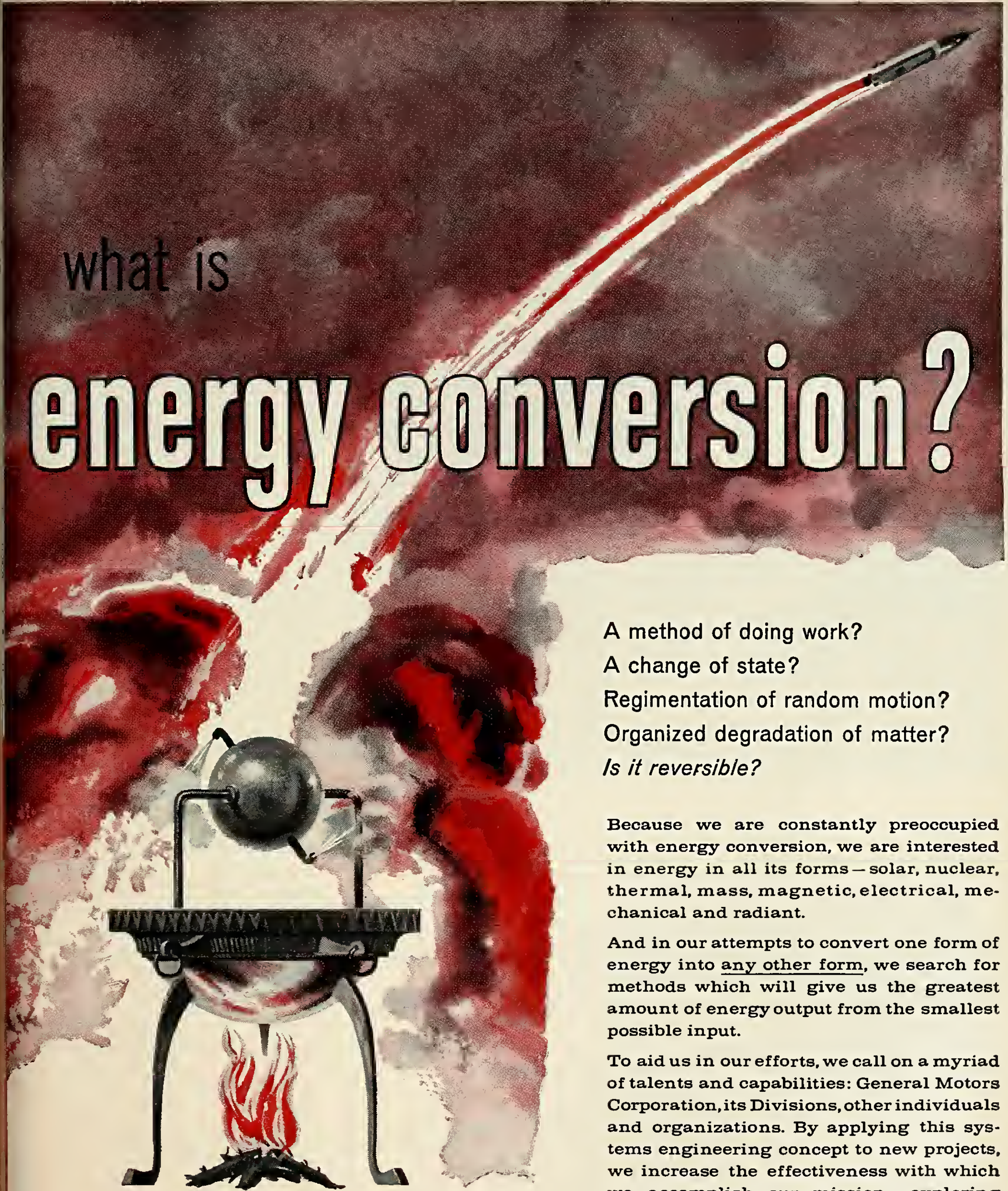
$75,000—General Electric Co., Syracuse, N.Y., for research and de velopment leading to the establishment of designs for solid stat reciprocal and non-reciprocal filters, transformers and delay line and the fabrication samples.

$72,713—McCullough, Inc., San Carlos, Calif., for electron tubes.

$67,095—Radio Corp. of America, Electron Tube Div., Harrisor N.J., for electron tubes.

$55,249—General Electric Co., Schenectady, N.Y., for electron tube

what is energy conversion?



A method of doing work?
A change of state?
Regimentation of random motion?
Organized degradation of matter?
Is it reversible?

Because we are constantly preoccupied with energy conversion, we are interested in energy in all its forms—solar, nuclear, thermal, mass, magnetic, electrical, mechanical and radiant.

And in our attempts to convert one form of energy into any other form, we search for methods which will give us the greatest amount of energy output from the smallest possible input.

To aid us in our efforts, we call on a myriad of talents and capabilities: General Motors Corporation, its Divisions, other individuals and organizations. By applying this systems engineering concept to new projects, we increase the effectiveness with which we accomplish our mission—exploring the needs of advanced propulsion and weapons systems.

Energy conversion is our business

ALLISON

Division of General Motors, Indianapolis, Indiana

(continued from page 15)

E. I. du Pont de Nemours Co. Inc. i planning to give major attention t high-temperature metals at its new re search center now a-building at Balti more . . . At St. Louis, **Monsant Chemical** is starting construction of plant to produce ultra-pure silicon—fo semiconductors . . . Solid-state physics theory of metal binds, the structure o plastics and other research will be ex panded into a new facility being erecte by **Union Carbide Research Institut** near Tarrytown, N.Y. It will be read late next year . . . **Avco** has come u with a small plasma generator for flam spraying ceramics at 15,000°F. Prod uct is similar to devices developed b **General Electric's** Rocket Engine Sec tion and by **Giannini Plasmadyn Corp.,** which developed the first pro duction plasma sprayer.

AF, Navy Cutting Off Boron Fuel Production

Production of boron-type fuel appears to be all but dead. The Ai Force has cancelled the schedule opening next month of a $45 millio plant at Model City, N.Y., wher **Olin Mathieson Chemical Corp.** wa getting ready to produce high energ fuels developed at a cost of $55 million

The Navy also is ready to shu down its $37 million **Callery Chemica** plant at Muskogee, Okla., the onl other DOD plant concerned with high energy compounds. Earlier this summe the Navy cancelled a boron prograr with **Metal Hydrides,** Beverly, Mas The AF also cancelled the **Genera Electric Co.** J93-5 boron-fueled je engine being developed for the B-7 at a cost of $10 million. B-70, whic may be scratched, will now use cor ventional fuels. (See story on p. 48.)

Actual cents-per-hour wage ir creases to be sought jointly by th IAM-UAW in the missile/aircraft ir dustry next year will be decided at "price tag" conference of the tw unions later this year. A 15-cent pe hour hike may be under consideratior

Latest scientific apparatus to b subjected to miniaturization—the mas spectrometer—will make a truly sig nificant transition. A unit being de signed for a 35-inch satellite by **Con solidated Systems Corp.** will occup only one-half cubic foot and weigh 1 pounds. Standard spectrometers use in oil refineries weigh four tons an require an entire small room. Th smallest previous model was a desk type unit weighing 115 pounds. Tw of the new spectrometers will b orbited in a NASA satellite to gain a accurate analysis and measurement o the exosphere between 150 and 60 miles above the earth. Launching is scheduled for 1961.

Army's new satellite-tracking station, atop Madkin Mountain at Redstone Arsenal, went into operation last week. The installation will track ABMA satellites launched under the direction of NASA.

Antennas include two 108 mc colinear arrays, a steerable 20 mc beam yagi, and three simple dipoles. The 108 mc units measure 20 x 20 feet and stand 27 feet high. One is polarized horizontally and the other vertically.

The station also includes receiving and recording equipment, digitizers, automatic teletypewriter to transmit tracking data to the ABMA Computation Laboratory, and an automatic graphic recorder. The antennas, from their 1250-foot mountaintop site, can track satellites anywhere above one-degree elevation.

Two *Minuteman* Silos Being Built at Cape

Launching facilities for **Boeing** *Minuteman*—including two underground silos—will be built at Cape Canaveral during the next nine months under a $5.3 million contract.

The reinforced concrete silos will be approximately 90 feet deep and 26 feet in diameter. Both launching complexes will also include domed blockhouses, instrumentation and launch support buildings, underground checkout and transformer rooms and two 1480-foot service tower tracks.

In addition there will be assembly facilities consisting of one inspection and assembly support building, two missile assembly buildings and two engine receiving and inspection buildings. Specs also call for two engine storage and one missile storage building, some hangar alterations and extensive exterior electrical work. Contractor for the Corps of Engineers is the **George A. Fuller Co.,** Atlanta.

Bendix *Eagle* Team

Contractor lineup for the Navy's long-range air-to-air *Eagle* missile now includes in addition to **Bendix Aviation,** the prime: **Grumman Aircraft Engineering Corp.,** Bethpage, L.I. (major sub for airframe, propulsion system, launching and support equipment); **Sanders Associates,** Nashua, N.H. (seeker); **Litton Industries,** Beverly Hills, Calif. (tactical computer); **Air Arm Division, Westinghouse Corp.,** Baltimore (airborne intercept radar). Bendix's Research Laboratories Division, Detroit, will develop electronic guidance and its Pacific Division, North Hollywood, Calif., will design and produce subsystems and perform missile assembly and tests.

people

Packard Bell Computer Corp. ha named **Kenneth F Jackson** technica assistant to the d rector. Jackson, wh holds several patent for missile autc pilot devices, form erly was special a sistant to the pres dent of the Waug Engineering Co.

JACKSON

William O. Boschen has been ap pointed to the Board of Directors c Avien, Inc. Boschen also is vice pres dent and general manager of Avien. Be fore joining Avien in 1954, Bosche was eastern regional manager Minnea polis-Honeywell's Aeronautical Divisior and manager of Aircraft Export, Av quipo, Inc., New York.

Douglas Aircraft Co. has appointe three *Nike* Systems project engineers t missile testing activities, **W. J. Binghan**, project aerodynamicist on the *Nike Her cules*, has been named *Nike* projec engineer (field station testing); **J. L. Cub**, chairman of the *Nike Hercules* and *Nik Zeus* test planning and evaluation com mittee, named *Nike* project engineer a White Sands missile range; and **L. I Marshall**, test planning coordinator fc the overall *Nike Zeus* field test progran has been appointed *Nike* project enginee at Point Mugu to work out details c future *Nike Zeus* tests on Pacific Missil Range.

Cliff Sanctuary, a member of th original radar re search team unde **Sir Robert Watson Watt,** "father c radar," has joine Del Mar Enginee ing Laboratories a assistant chief el gineer for elec tronics. Sanctuar served with th British Air Ministry at Bawdsey Researc Station, England, where he participate in electronics development programs an in the initial phases of the British earl warning radar system. Before joining De Mar, he was chief engineer of Decc Radar, Ltd., Toronto, Canada.

SANCTUARY

Baldwin-Lima-Hamilton Corp., Phila delphia, has an nounced election c **Frederick A. Fielde** as vice presider and general manage of the corpora tion's Loewy-Hydro press Division, Ne York City. Genera sales manager an assistant genera manager of the di vision since 1955, Fielder succeeds th late **Erwin Loewy.**

FIELDER

Control Data Corp. has announced promotions of the following men who were among the founders of the company when it was established in 1957. **Seymour R. Cray,** formerly associate director of engineering becomes engineering director of the Computer Division. **William R. Keye** has been elected vice president for Research and Engineering. Prior to joining CDC, he held engineering positions with Radio Corp. of America, Airborne Instruments Laboratory, Inc., Engineering Research Associates, and Remington Rand Univac where he was director of Product Design for commercial computer programs.

Gilbert N. Rosa has been elected a memher of the board of directors of Statham Instruments Inc., Los Angeles manufacturer of transducers. Rosa's elevation to a directorship, according to the company, is part of a long-range expansion plan.

ROSA

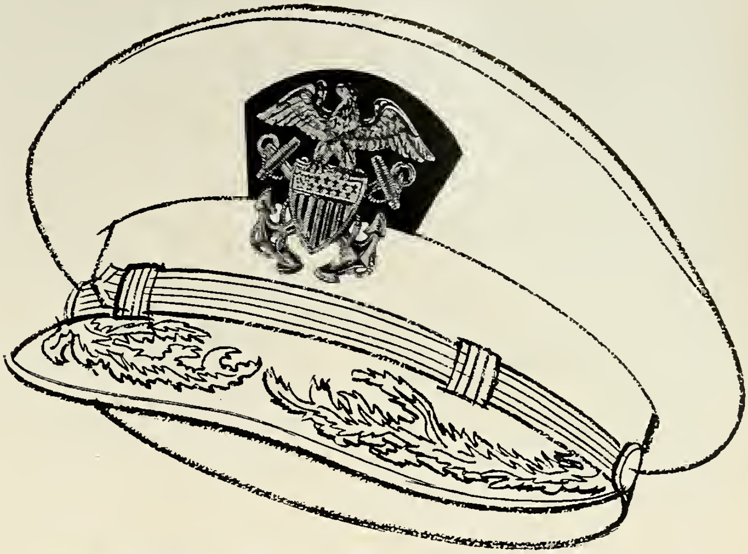
Aerojet-General Corp.'s Liquid Rocket Plant, has announced that **Herman L. Coplen, Jr.,** left the Systems and Control Department which he headed to join the Advanced Research Projects Agency in Washington, D.C. He will specialize in space research and in hallistic missile evaluation. Coplen, 43, joined the company in 1943 in Azusa, was active in the development of liquid fuel assist take off rockets for the Air Force F-84 and the B-47 and pioneered many programs now vital to the Space Age.

COPLEN

Andrew C. Bayle has heen elected vice-president—Engineering hy the directors of the Waltham Precision Instrument Co. (formerly Waltham Watch). Before joining Waltham Precision Bayle spent several years at Vectron, Inc. where he was chief engineer and assistant to the president.

Appointment of **William F. Hurst** as Director of Quality Control at the Leach Corp. Compton facilities has been announced. Hurst will he responsihle for all quality control activities at the Inet and Special Products Division, including the development and management of a total quality control plan. He was formerly director of Quality Control at Hallamore Electronics Co.

HURST



propulsion engineering . . .

By M/R STAFF

Suppress combustion instability . . .

in solid propellant motors by one of these three methods: Damping, acoustic interference, additives. This is the gist of a paper by E. W. Price, presented at the 9th International Astronautics Congress. Price discusses the three most effective and practicable methods of suppressing instability. "Damping" refers to viscous damping and temperature damping. "Acoustic interference" makes use of geometries that preclude easy excitation of natural modes of the combustion chamber. "Additives" considered by Price are suppressants such as aluminum oxide or carbon which block excitations.

The paper also discusses . . .

the various ways in which combustion instability shows itself and the conditions under which it occurs. Price also discusses the mechanism of combustion instability, the phase relations that permit excitation and methods for detecting instability.

European hydrogen peroxide capacity . . .

expands with the announcement of an addition to **Elfa, Ltd., Electrochemical Works** at Aarau, Switzerland. The new facilities are "Americanized" in that they incorporate designs and techniques used by **Food Machinery and Chemical Corporation's Becco Chemical Division** plants at Buffalo, N.Y., and Vancouver, Wash. It is an electrolytic process. Elfa does not have European missile industry or U.S. missile bases in mind as immediate markets—output will go to the textile, paper, and chemical industries for use as a bleach, plasticizer and chemical process intermediate. Output will be far below the 90%+ H_2O_2 needed for missiles, but the capability will be there if needed.

Synthetic lubricants . . .

for use at high temperatures are among the potential uses that **Union Carbide Corporation** sees for its new *iso*-decanoic acid—a mixture of isomers. Other potential applications are as a plasticizer, defoamer or corrosion inhibitor. Its boiling point (760 mm) is 254°C. It sets to a glass below –60°C. Price right now is 32¢ per pound in tank car lots.

Metallic lithium and derivatives . . .

formerly shipped from **Lithium Corporation's** Minneapolis plant will be shipped from Bessemer City, N.C., beginning in January. Lithium Corp. plans to save $500,000 to $1 million a year by moving everything to its North Carolina facility. The Bessemer City unit, now valued at $7 million, will be expanded; research labs and pilot plants will be added.

Investigating boron?

Boron derivatives are not entirely out of the fuels picture and some firms are either continuing their investigations or starting new ones in the hope of finding a way to salvage work already done. The Oak Ridge National Laboratory makes new types of fundamental studies possible by releasing research quantities of boron containing 92% B^{10} which can be traced through reactions. ORNL also announces availability of special boron compounds made up with B-10.

Russian missile industry chemists . . .

have the same interests and are working on the same projects as are U.S. missile chemists. Examples: T.V. Antipina and E.N. Avdonina are studying the influence of boron fluoride on the catalytic activity of aluminum oxide and alumosilicates. N.A. Slavinskaia, S.A. Kamenetskaia, and S. Ia. Pshezhetskii are studying the effect of ozone on combustion of hydrocarbons.

Project *Tepee* May Cost Less, Outperform BMEWS

WASHINGTON—Project *Tepee*—the Navy's missile warning system—could make the vast multimillion-dollar BMEWS system obsolete.

However, it would not necessarily eliminate the need for *Midas*—the early-warning satellite.

Tepee, now under R&D, is considered capable of detecting the firing of Soviet missiles seconds after launching. That would give about 30 minutes warning time.

BMEWS will be able to detect oncoming ICBM's when they are about 2500 miles away. That will mean about 15 minutes warning.

At best, therefore, BMEWS would only provide a back stop for an operational *Tepee*.

RCA's BMEWS is expected to cost more than $1 billion. It probably will be operational in about two years.

The Navy estimates that *Tepee* is comparatively much cheaper and far smaller than BMEWS. It possibly could be operational in less than three years.

Tepee—A development of Dr. William J. Thaler of the Naval Research Laboratory—is based on the use of ionospheric backscatter from high-frequency radar transmitters.

Navy scientists found that backscatter comes not only from the ground but also from plasma clouds resulting from the launching of a missile or nuclear explosions.

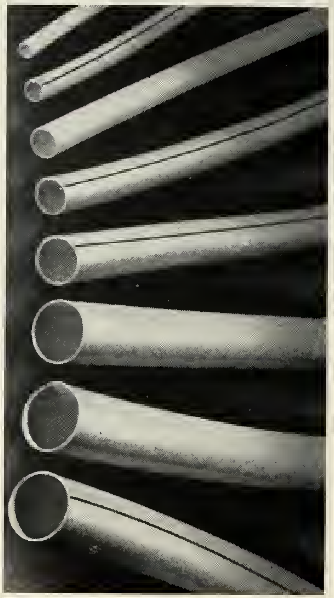
• **Success reported**—Thaler and his associates already have detected missile launchings and nuclear explosions over intercontinental ranges by using breadboard equipment.

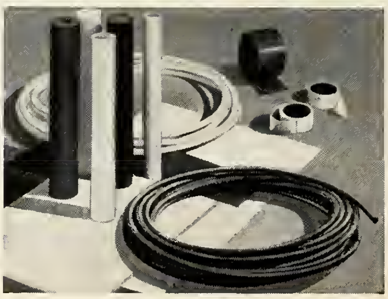
Moreover, the Navy has strongly indicated that it has detected Soviet missile launchings with *Tepee*. However, it stresses that the entire program is only in the R&D stage.

Thaler says that no breakthroughs are needed to perfect his system. He said the work ahead is mainly in the field of improving the quantity and quality of the information that can be obtained through the use of *Tepee* so that ICBM's can be tracked.

Scientists at Stanford and Yale Universities, **ACF Industries** and several other laboratories have joined in the research work. So far only about $2.7 million has been spent or budgeted for the program.

Tepee does not necessarily affect the attractiveness of **Lockheed's** *Midas* because the use of a satellite for early warning also provides a possible launching platform for trying to intercept a missile once it is launched.



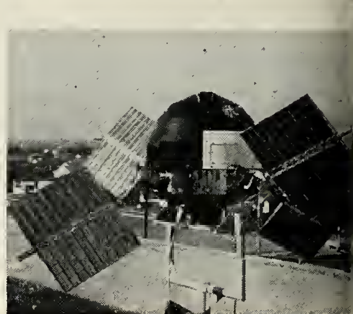


Explorer VI Gives NASA New Tracking Capability

WASHINGTON—The successful c eration of *Explorer VI*'s 8000 sol celled power system gives NASA t capability of tracking deep space prob over 50 million-mile distances.

A fall launching of *Atlas Able* is now scheduled as the first attem to utilize the Space Technology Labor tories' power unit on a deep space m sion.

Early data established *Explorer V* 142 lb. payload's apogee to be 26,4 statute miles, and its perigee 156 st tute miles. The period of orbit is hrs., 46 min., during which the satell so far has travelled a total of 91,1 miles. The orbit's angle of inclinati



is 47° and the lifetime of the orbit now predicted to be much more th one year.

Boosting *Explorer IV* into its hig ly elliptical orbit was a three-stage *Th Able III*. A five-pound solid "kic rocket, which would have been utiliz if the perigee had proved insufficie may be used later to sustain the li of the orbit.

The payload, developed under t direction of STL, carried 15 major e periments designed to tell scientis about the environment encounter over the long orbit, and to test prop gation techniques over long distanc in space. Of particular interest was 2½ lb. scanning device designed relay a crude picture of the eart cloud cover.

Companies contributing resear and hardware to the *Explorer VI* e periment, as listed by STL, included t **Atlantic Research Corp., Engineer Magnetics, Gilfillan Bros., Hallamo Electronics Co., Hoffman Electron Inc., Motorola Inc., Radiation In Rantec Inc., Space Electronics Cor Stanford University, University of Ch cago,** and the **University of Minnesot**

Pentagon Calls Halt to HE Boron Fuels Program

WASHINGTON—Research and deve opment work will be continued i high-energy boron type fuels despi a decision by the Defense Departme to abandon plans for quantity produ tion. However, indications are th this work will be dropped when cu rent contracts run out.

The Air Force has research an development contracts which are co tinuing with **Olin-Mathieson Chemic Corp., Callery Chemical Corp.; AF Corp.**, a corporation owned by **Ame ican Potash Company; Food Machi ery & Chemical Corp.** and **Nation Distillers**; and **Aerojet-Stauffer Chen ical Co.**

The difficulty with the fuel, a cording to informed sources, is that is literally too hot and too expensi to handle. Original plans called f using it first in aircraft and later i ballistic missiles. As matters no stand, improvements in hydrocarbo fuels—and in chemical fuels producin a higher energy which are less crank to handle—have resulted in by-passin boron—at least for the time being.

As a result, the Air Force will n permit Olin-Mathieson to open i newly completed Model City, N.Y plant which cost about $45 millio Similarly, the Navy will not allow th almost-completed Callery Chemic plant in Muskogee, Okla., to ope The Callery plant cost the Navy f land, plant and equipment abo $35,355;000. Since 1955, the Air For has spent about about $55 million t develop boron-type fuels. The Na estimates its costs for research and d velopment, which started in 1952, about $122 million. The Navy's figur include plant and equipment. How th AF and Navy plants will be use hasn't been decided.

• **Changing Signals**—Pentagon o ficials are using the boron story illustrate the current difficulty in pr viding firm research programs. Abo eight months ago, President Eisenhow in a message to Congress cited th boron high-energy fuel program as major importance. He said the pr gram had a top national priority. No at least for the foreseeable futur there will be no quantity production the fuel.

The big question is why more tha $200 million was spent before the d cision came to write production o Answers may finally be forthcomi when a report now being prepared t **Arthur D. Little Company** for th Secretary of Defense is made publ in mid-September.

Advertisers' Index

when and where

AUGUST

Institute of Radio Engineers, Western Electronic Show and Convention, Cow Palace, San Francisco, Aug. 18-21.

AFOSR/Propulsion Research Division, Directorate of Aeronautical Sciences Office of Naval Research, Office of Ordnance Research and National Aeronautics and Space Administration, Symposium on "The Dynamics of Ionized Cases," Northwestern University, Evanston, Ill., Aug. 24-25.

American Rocket Society, Gas Dynamics Symposium, Northwestern University, Evanston, Ill., Aug. 24-26.

Institute of the Aeronautical Sciences' National Specialists Meeting, A Symposium on Anti-Submarine Warfare, (classified), San Diego, Calif., Aug. 24-26.

USAF's Ballistic Missile Division; Space Technology Laboratories Inc., Fourth Symposium on Ballistic Missile and Space Technology, Los Angeles, Calif., Aug. 24-27.

International Commonwealth Spaceflight Symposium, Church House, Westminster, London, England, Aug. 27-29.

The Benevolent Tyranny of Congress

There must be a moral involved in the recent bill passed by both houses of Congress, a bill which requires Congressional authorization *by program* for procurement of missiles, rockets and aircraft. The moral is a little elusive but it probably concerns itself with the fact that Congress in its own way exercises a benevolent tyranny over the Army, Navy and Air Force. Congress giveth and Congress taketh away. And when an indulgent tyrant is goaded to exasperation his benevolence more often than not turns a little sour in hunting a remedy.

The Armed Services are still shuddering over the one-vote margin which defeated a nonsensical bill that would have prohibited any retired officer from being employed by a defense industry. What legislation will eventually be enacted to cover some fairly loose military-industry practices in that area is still in doubt.

But on the missiles, rockets and aircraft front the military is now faced with a vertical financial envelopment which is going to make previous budget troubles—by comparison—seem like capturing Piccadilly Circus on a sunny Sunday afternoon.

For years the Armed Services Committees of both houses have been complaining about the reprograming activities of the services. In so many words, this reprograming means getting money for one thing and spending it for another. There are, of course, restrictions. The Army cannot, for instance, take money for tactical missiles and spend it on reconnaissance aircraft. But they can take the money appropriated for one tactical missile and spend it on another. Just as the Air Force or the Navy can, for example, cut back one program and extend another—within the same category, say missiles or aircraft. Money cannot be shifted out of Research and Development—but it can be moved all over the lot within R&D.

Now by the insidious and dangerous practice of enacting a rider to the Military Construction bill—dangerous because it is almost always done in haste and without proper consideration—Congress has enacted a measure designed to prevent such shifting by requiring a program presentation of missiles, rockets and aircraft production and procurement each year.

How will this work out? Under almost any arrangement it seems certain to double the time spent by the military and defense officials who defend the budget annually before the Congress.

Heretofore the Department of Defense has appeared before two committees in defense of its budget—the Appropriations Committees of the House and the Senate. Now DOD and the Services must first appear before the Armed Service Committees of each house, get an approved program and then, in effect, take this program to the two Appropriations Committees to get the money.

This procedure has long been required for the military construction program because military construction takes place in some congressman's district, an event near and dear to his heart. Congress imposed the same restriction on the National Aeronautics and Space Administration. Each of these, however, involves a much smaller program with infinitely less detail than the multibillion-dollar missiles, rockets and aircraft program with all its complexities.

The exact procedures have not been spelled out and probably will not be until after December 31 when the Army, Navy and Air Force have been directed to tell the House and Senate Armed Service Committees what their programs are and how much each will cost. It is likely also that the actual effect of the new law will not be felt until the 1962 budget. Then the Pentagon will be faced with these difficulties, among others:

The sending up of a budget asking for a specific number of missile, rocket and aircraft wings, groups, squadrons, companies or perhaps flotillas, for a given period. How detailed this must be—no one knows for sure.

The problem of modernization and spares, since they require long lead time.

The fact that the President's budget would then cover only that part of the program to be financed that one year.

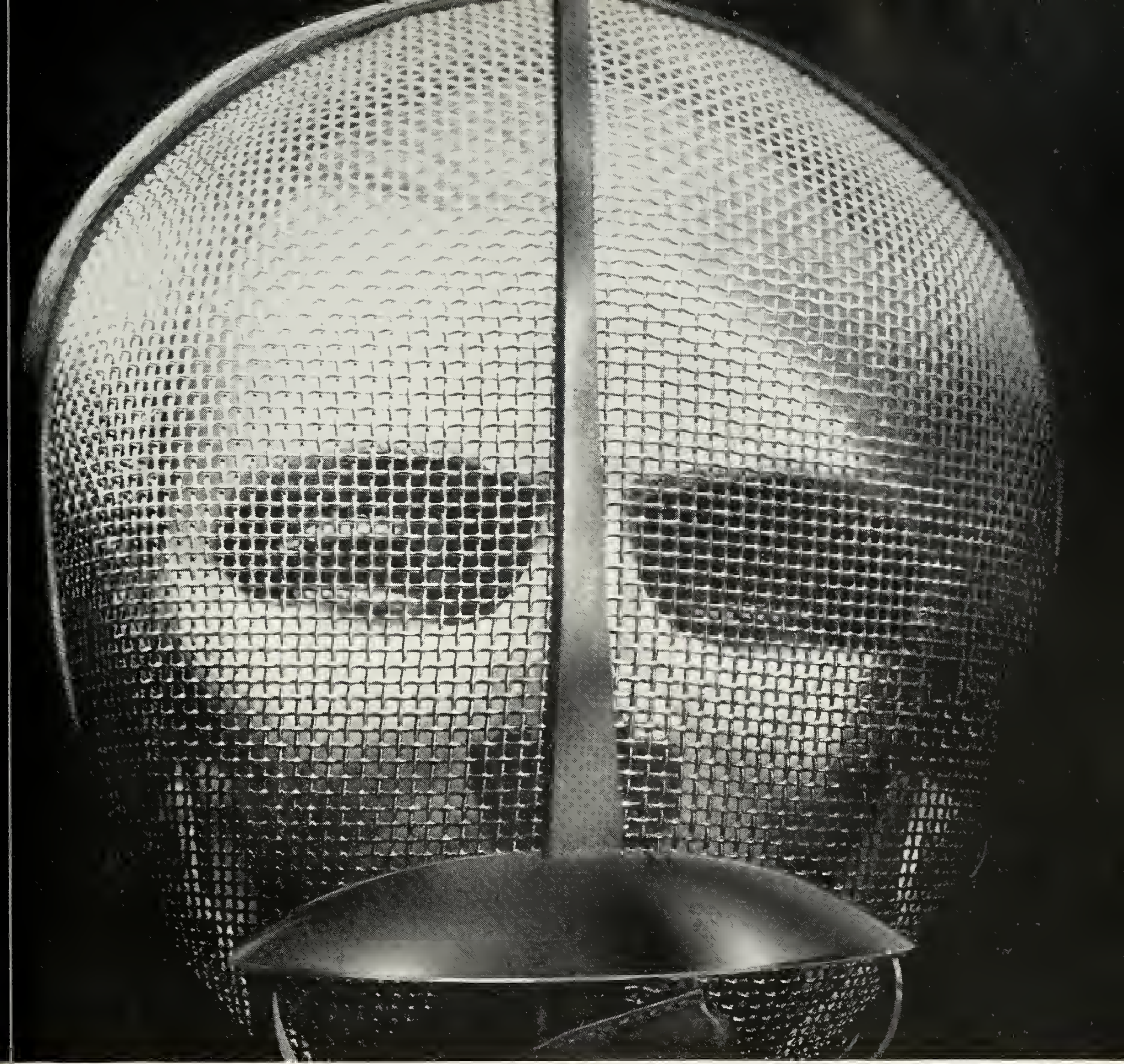
The problem of timing, because the program must be authorized before money can be appropriated; otherwise the money will be eliminated as "out of order," as it recently was in the NASA program.

Applying pressure to get the authorization bill out before the end of the fiscal year—because otherwise the continuing resolutions which allow the Pentagon to continue to operate might not be legal without the authorization.

Trying to figure what changes in budget format will be necessary because the rider covers only production and procurement—not development. However, development testing is now included in P & P funding.

What is to be gained from all this? It's a little like the moral involved—somewhat unclear. Certainly it adds time and another complexity to an already unbelievably drawn-out and complex missile, rockets and aircraft procurement and production program.

CLARKE NEWLON



SPACE
APPLICATIONS
OF

ELECTROLUMINESCENCE

In space things are either black or light. This almost total absence of degrees of intensity between light and black presents unique problems in illumination. Electroluminescence techniques applied in the initial systems considerations—of both space and airborne vehicles—are being studied. The resulting hardware represents significant developments in a new field.

A larger staff is being organized to augment existing personnel and facilities. Senior and junior staff positions are open for scientists and engineers who have experience in the areas listed on the right.

Optics
Light Transmission
Basic Phosphor Chemistry
Electroluminescent Panels
Insulating Materials
Human Factors Engineering
Thin Dielectric Formulation
Electrical Measurements and Evaluation

Graduate scientists and engineers with applicable backgrounds are invited to submit a resume to:

Mr. R. A. Martin, Supervisor
Professional Placement Staff
HUGHES RESEARCH AND DEVELOPMENT LABORATORIES
Culver City 62, California

HUGHES