SEPTEMBER 7, 1959

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missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS

ECIAL SECTION

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CONTRIBUTORS
British Astronautics ....G. V. E. THOMPSON
Propulsion ....MICHAEL LORENZO
Industry ....JAMES J. HAGGERTY, JR.
Soviet Affairs ....DR. ALBERT PARRY
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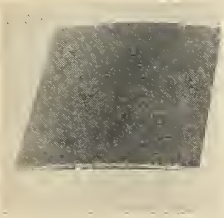
COVER: Adapter rings, or aft closures, like these for *Nike*, along with nozzles are a critical weight problem in solid rockets. But new techniques are providing answers. See p. 13.

BRITISH *Blue Streak* IRBM is being touted by some U.K. scientists as the basic vehicle for a major space effort by that country. This development is reported from London. p. 11.

OVERLOOKING the Pacific in Orange County, Calif., is site for a proposed center to be built by Aeronutronic Div. of Ford. A survey of the county's growth begins on p. 18.



BERYLLIUM sheet formed by extrusion and cross rolling shows highly developed crack pattern after bend ductility test. A report on progress in beryllium R&D starts on p. 22.

missiles and rockets®
MAGAZINE OF WORLD ASTRONAUTICS

SEPTEMBER 7 HEADLINES

ASTRONAUTICS ENGINEERING
U.S. Reg. Pdg.

SPECIAL SECTION

NEW MISSILE PRODUCTS

THE MISSILE WEEK
U.S. Reg. Pdg.

DEPARTMENTS

the missile week

Washington Countdown

IN THE PENTAGON

A seaborne anti-missile missile . . .
system is seen by Navy officials as a natural for installation on battleships or cruisers. Tentative studies are underway. A prime advantage of seaborne AICBM's would be the interception of oncoming ICBM's over empty oceans rather than population centers.

• • •

The land-based AICBM . . .
Western Electric's *Nike-Zeus*, will undergo future tests over an expanded area at White Sands Missile Range. The range is being spread over an extra 1500 square miles of New Mexican desert to make sure that debris from the tests will fall in uninhabited areas. *Zeus* will be fired only at simulated ICBM's at White Sands.

• • •

***Polaris*-boosted satellites . . .**
are a good possibility within the next few years. The Navy sees **Lockheed's** *Polaris* as an efficient booster for putting 50-pound military payloads into orbit.

• • •

***Minuteman* repair shop . . .**
sites are expected to be picked by the Air Force within the next two months. The repair shops—located at convenient spots around the country—will be used for both assembly of the **Boeing** *Minutemen* and periodic check-up of the birds after they are installed in their hardened bases.

• • •

An October Retirement . . .
for Defense Department Comptroller William J. McNeil is reported to be in the works. Two high-level officials considered top prospects to succeed the head Pentagon money man: DOD Assistant Secretary for Logistics Perkins McGuire, and Air Force Assistant Secretary for Financial Management Lyle S. Garlock.

• • •

Vital ICBM Statistics Dept. . . .
Minuteman will weigh about 75,000 to 80,000 pounds—180,000 pounds less than *Atlas*, 140-,000 pounds less than *Titan*.

ON CAPITOL HILL

Greater unification . . .
of the military services to end missile-space wrangles may well become a political campaign battlecry in Congress by next year. Sen. Clair Engle (D-Calif.) turned up the heat under the issue late last month with his call for one military service. The new, cutting report from the House Military Operations Subcommittee calling for merger of the Army and Air Force brought the issue to a rolling boil.

• • •

Politically-trained ears . . .
opened wide for both Engle's speech and the subcommittee report. Meantime, forthcoming decisions from the Pentagon on Army and other space programs (M/R Aug. 31) could easily make the issue hotter than ever. You can definitely jot this matter down under: To Be Continued.

AT NASA

Air-space sickness . . .
is one of the big problems that NASA engineers have still to lick before the first U.S. astronaut goes into orbit. Some way must be found to stabilize the Project *Mercury* capsule during re-entry. Otherwise, America's first spaceman isn't going to be interested in much besides a paper bag.

• • •

New Nul-G capsules . . .
may be purchased by NASA for testing human reaction to living in a weightless environment for long periods. The capsules—proposed in a design study by **Lockheed**—also might be used for training future astronauts.

• • •

Polar orbit tracking . . .
stations are planned soon by NASA. One will be on the University of Alaska campus. Two more will be in North Dakota and Newfoundland. Rather than build a fourth station in Europe, NASA will share a secret AF station already in existence.

AROUND TOWN

"Smart money" . . .
is being put on the rumor that the Pentagon will lift its ban soon on Gen. Thomas Power's book—"Design for Survival." The SAC commander's book is understood to be a stark warning that the power of America's missile-bomber deterrent forces is deteriorating.

• • •

Some of the reports . . .
that are being passed as "the latest" in the nation's capital:

. . . Russia can be expected to step up building of nuclear-powered submarines capable of launching missiles.

. . . The United States is somewhat closer to development of a truly maneuverable space craft than previously believed.

. . . Military men are urging that Laos be given modern equipment including missiles to meet the current Red invasion.


BERYLLIUM
in PROJECT
MERCURY

Industry Countdown

MANUFACTURING

One thousand *Polaris* . . .

missiles—or more—may be **Lockheed's** initial production run. It would take 640 just to arm the presently proposed 40 fleet ballistic missile submarines (16 per sub). More will be needed for spares, training and evaluation flights, etc. Any program for launching *Polaris* from surface ships, land or airplanes would jack up the production figure accordingly. Cost-per-bird is estimated at $500,000 —making it potentially a $500 million run.

• • •

Beryllium use in missiles . . .

is increasing. More than 80% of DOD beryllium is going into the missile program. Expected consumption in FY 1960 is 35,000 pounds. In FY 1959 DOD contractors used 12,000 pounds of the lightweight hard-to-work $60-a-pound (refined) metal—5000 pounds in the April-June quarter. (See p. 22 for analysis of structural beryllium.)

• • •

Half the nation's molybdenum . . .

output is being bought by missile builders. Jetavators, liners and nozzles are the principal moly components. It also is in these areas that probably the hottest competition exists between metals and non-metals.

• • •

Anti-friction bearings . . .

are being researched by **Corning Glass.** The company is working with its crystalline ceramic "Pyroceram" to develop bearings capable of operating at temperatures between 1000°F and 1600°F.

• • •

Boost of $20 million . . .

for materials research in FY 1960 has been ordered by Dr. Herbert York, DOD R&E chief. Extra funding, in addition to $50 million already scheduled this year, may be continued in FY 1961 if all goes well. Thermal protection and composite materials are getting $2 million of the new funds.

PROPULSION

Radically new and secret . . .

approach to solid-rocket motor cases is being explored by **Bendix Aviation.** The aim is to achieve strength-to-weight ratio of over 2-million inches under a Navy contract. If the approach proves out, motor case technology (which has yet to reach a 1-million-inch ratio) would leapfrog ahead.

First hot firing of *X-15* . . .

LOX/liquid ammonia engine Aug. 28 proved "exceptionally gratifying" to the Air Force. The **Reaction Motors** XLR-99-RM-1 50,000-thrust rocket was operated at three-quarters throttle for 46 seconds during static test at Edwards AFB. A total of 11 XLR-99's will be delivered to support the *X-15* rocket plane.

• • •

Controlled nuclear pulse . . .

engine for space vehicle has received a $1-million extension from DOD. The *Orion* project initiated a year ago by ARPA is under feasibility study by the **General Dynamics'** John Jay Hopkins Laboratory for Pure and Applied Science, San Diego.

ASTRIONICS

Phone calls via satellites . . .

is a new NASA project called *Echo.* **Bell Telephone Laboratories** is constructing a station that will attempt to bounce signals off of satellite reflectors in the first step of a feasibility study for relaying telephone calls.

• • •

Navy is stacking its space "chips" . . .

heavily on the *Transit* navigational satellite program. Nearly all of the Navy's space R&D is now focused on this project. **Applied Research Laboratory** of Johns Hopkins University is the contractor.

• • •

WE HEAR THAT—

BMD and STL may part . . .

company—at least physically. The BMD would build its own headquarters rather than remain a **Space Technology Laboratory** tenant at Los Angeles. The Air Force is officially denying the report, at present . . . A fabric with better heat resistance properties than stainless steel has been developed by **Raybestos-Manhattan,** Passaic, N.J. It is asbestos based, coated with **du Pont's** new "Viton" synthetic rubber and reinforced with "Inconel" wire . . . NASA is still convinced it will be able to net returning *Mercury* astronauts in the air. Planes have about 30 minutes to get to the capsule after the parachute opens . . . Fewer electron tubes were sold last year. The total of $569 million for power, special purpose and receiving tubes was $16 million less than the previous year—the first significant decline in their history, according to the U.S. Department of Commerce. . . . **Lockheed Aircraft Corp.** will open a new "top-level corporate office" in Paris in addition to maintaining its Geneva office.

More About the Missile Week on page 44

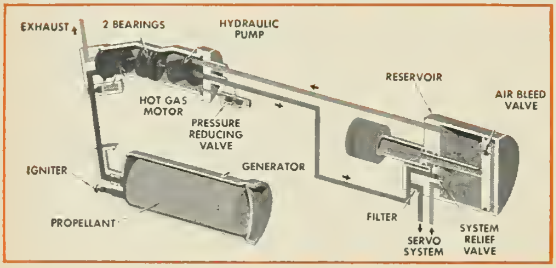
FLIGHT HARDWARE...NOW

VICKERS HOT GAS AUXILIARY POWER SYSTEMS

for missiles and spacecraft

CONCEPT

Vickers piston motors — as used in virtually all existing commercial and military aircraft — are now modified to operate efficiently on propellant-generated hot gas, or bleed gas from the main propulsion system. Minimum weight is achieved by mounting the hot gas motor "shaft-to-shaft" with a Vickers piston hydraulic pump in a common housing. The motorpump, a simple gas generator, hydraulic reservoir, filter, and relief valve are integrally mounted to form a complete Auxiliary Power System in a compact package.



DEVELOPMENT

Production line Vickers hydraulic motors have been operating on hot gas for over 2 years. Units have run on gases as hot as 2300°F without modification.

The present flight hardware was built and tested after an intensive prototype development effort. Test program motorpumps have accumulated over 100 runs each for 1 minute of operation cycle. Since the current development program is aimed at meeting known APS requirements, no limits have been established on the operating cycle duration for this type of equipment.

CONCLUSIONS

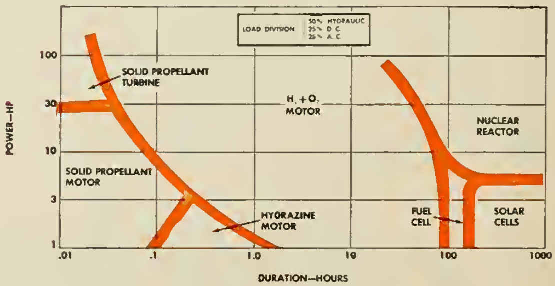
Performance and reliability goals for this concept have been met successfully. A complete hot gas APS package in the 2 - 8 horsepower range, shown above, is available within 90 days. Customer specifications for these and larger systems are invited. Write for Bulletin A-5223B.

APPLICATIONS

Because of the increasing scope of APS applications, Vickers conducted a series of studies to establish criteria for APS selection. Recent study results (published in March, 1959) indicate that for short duration operation, hot gas motors offer the best weight advantage in the 1 to 30 hp range. See curve below.

Attractive reliability and early delivery resulting from extensive use of proven hardware may extend the application of these systems to an even greater range of second and third generation missiles and spacecraft. Additional advantages include: low speed equipment (up to 10,000 rpm), convenient ground checkout, growth potential, and no alert time required.

OPTIMUM WEIGHT NON-PROPULSIVE POWER SYSTEMS



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8386

At Commonwealth Symposium . . .

British Clamor for Major Space Role

But there's mixed reaction to a proposal that Blue Streak and Black Knight be combined in a vehicle to replace the officially-approved NASA Scout

by Donald E. Perry, Managing Editor

LONDON—For the first time—nearly two years after the orbiting of *Sputnik* —the British scientific community, as represented by the powerful British Interplanetary Society, is clamoring for a major space program of its own. The result may be a vigorous competition to eliminate the present "Made in Russia and/or U.S.A." exclusive labels associated with world space experimentation.

Hanging in the balance is the fate of one very important American effort: NASA's *Scout* program abroad. British science now wants to overcome the government's "passive" participation whereby instruments are merely carried into space by means developed *outside* the Commonwealth.

To implement this desire, the U.K.'s *Blue Streak* and *Black Knight* are the touted vehicles. This is contrary to the government's announced policy in May when it signified its desire to use *Scout* as a research vehicle.

Scout, with its prospects of sending a 150-pound payload into orbit, is—many British scientists feel—not good enough. Using *Blue Streak* as the first stage and *Black Knight* as the second, these Britishers envision a 2000-pound useful payload.

The embryo for future British astronautics efforts was formed at the first Commonwealth Space Flight Symposium held recently at Church House, Westminster, here. The Symposium preceded the annual Congress of the International Astronautical Federation.

• **No race suggested**—The tone of the symposium was that the U.K. wants a *major* space program of its own—but not a "race" with the U.S. or U.S.S.R. What is desired is that space exploration be considered as having "no finishing line and an infinite distance to be covered."

The words are those of G.K.C. Pardoe, chief Coordinator of the Ballistic Missiles section of **de Havilland Propellers, Ltd.,** who advocated a space flight program based on *Blue Streak.*

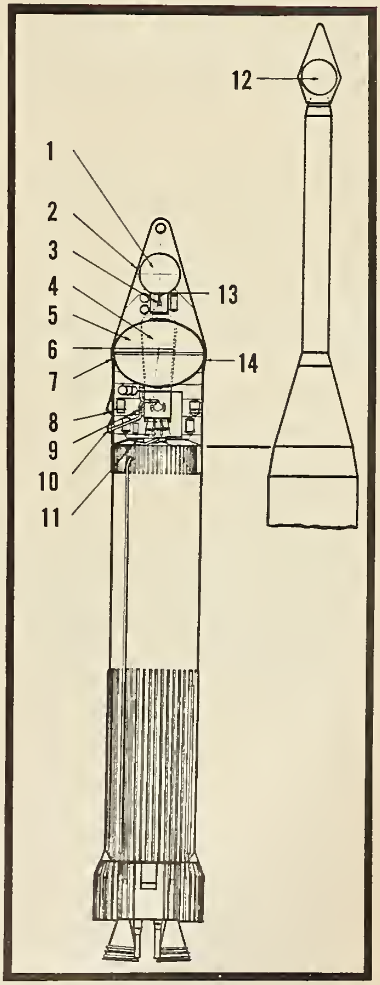
Hitting mildly at U.S./U.S.S.R. policies, Pardoe commented: "The best returns do not always come from the most exciting investments, and by equipping ourselves with a means of moving in terrestrial, cislunar and translunar space, we should be covering the zones of interest . . . of direct value to the earth's inhabitants for many years to come."

The important thing, he said. is to get into space and gain experience in the basic problems involved. The real zone of direct interest for decades to come is between here and the moon, he added.

• **Doubts expressed**—Some observers, including some Britishers, felt, however, that *Blue Streak's* possibilities left something to be desired. Said John E. Allen, head of Aerodynamics, Projects and Assessment Department, **A. V. Roe and Co., Ltd.:**

"(*Blue Streak's*) performance would be becoming obsolescent by the end of the 1960's and a vehicle to succeed it will have to be sought . . . now."

Many U.S. observers pointed out that the guidance flight test of *Blue Streak* is not due for another year at



BRITISH SPACE VEHICLE developed from a modified *Blue Streak* IRBM with the option of using a modified *Black Knight* as the second stage. (See story on page 12.) Specific details include: (1) payload; (2) nose cone; (3) ground connections and release mechanism; (4) kerosene tank; (5) H.T.P. tank; (6) tube through inner tank for electrical and other services; (7) external frame with release mechanism and fairing; (8) electrical ground connectors; (9) second-stage probe separation; (10) ground connectors for propellants: (11) working platform; (12) second-stage payload position; (13) final separation; (14) separation line.

least and that reliability still is an unproven factor. Under present plans, U.S. sources say, there is a schedule of less than a half-dozen flights per year and the U.K. can not hope to achieve maximum reliability under such a minimal firing program.

Be this as it may, existence of *Blue Streak* as a potential main stage vehicle for European countries is a factor not to be discounted. Pardoe commented that nations which do not possess a main stage booster facility could well consider planning space programs using *Blue Streak* because "the design team of the vehicle would be on their doorstep."

But regardless of such "sales pitches," there are many in the British aircraft industry—and in government —who remain to be "sold."

Allen. delivering a paper on "Britain's Place in Interplanetary Exploration," commented that "economic considerations hardly justify an expensive (say £20 million per annum) space programme at the moment." He recommended a "pilot" experiment of two years duration to provide, among other things:

- Creation of a type of Space Flight Research Association.
- Relatively inexpensive hypersonic flight experiments.
- A Commonwealth Spaceflight Year 1960 to stimulate understanding of spaceflight and discuss possible activities.
- Studies for a hypersonic, very-long-range airplane that would be fast enough to be used as a satellite launcher.

The Wedding Would Have Its Problems

LONDON—A substantially unaltered *Blue Streak* missile would give the United Kingdom the capability within two to three years of placing a payload of some 1000 pounds in a 300-mile circular orbit around the earth.

Design considerations for the vehicle were set forth in a paper by G. K. C. Pardoe, Chief Coordinator (Ballistic Missiles), **de Havilland Propellers, Ltd.,** in a paper presented here at the Commonwealth Spaceflight Symposium.

Pardoe recommended use of the Royal Aircraft Establishment's test vehicle—*Black Knight*—as a possible second stage for *Blue Streak* to assure early availability.

Black Knight has a quadruple chamber rocket motor system using H.T.P. and kerosene as propellants. Each of the four chambers produce 4000 pounds of thrust at take-off for a combined thrust of 16,000 pounds. The vehicle's length is some 35 feet and its maximum diameter is 3 feet.

However, use of the long, thin structure on top of *Blue Streak* would dictate careful investigations into the design of the adaptor between the two stages. New dynamic bending loads would be brought to bear on the forward tank section of *Blue Streak*, possibly demanding some structural changes.

Black Knight also would produce different flexural characteristics during first-stage burning which in turn would require some changes in the autopilot system.

Use of a liquid-fuel second stage would, of course, produce the problem of in-flight ignition, but Pardoe believes H.T.P. and kerosene should provide comparatively trouble-free ignition.

With a payload of 1000 pounds the geometry would have to have a low density. The H.T.P. tank has a considerable amount of wetted area which will be directly exposed to kinetic heating during early main-stage boost. To avoid insulation and minimize the input of heat on this wetted area, an attitude control device might be required so that the rear end of the tank faced the sun during coasting phase.

Pardoe said that while there is great merit in using the basic *Blue Knight*, it does fall short of ideal size and thrust characteristics in relation to its main stage.

PROPOSED basic vehicle for a British satellite effort is the *Blue Streak*.

He recommended an alternative: modifying tankage into a "doughnut" configuration. Two hemispherical tank domes would be separated by a parallel section of tank based upon the limiting volume (and therefore weight) which could be lifted by *Blue Streak*.

The same maximum diameter as *Blue Streak* would thus be produced in the second stage to allow for H.T.P./kerosene burning ratio.

Pardoe suggested that the more orthodox lateral separation diaphragm could be replaced by a longitudinal cylindrical-type diaphragm. Kerosene, being the smaller volume, could be contained within this central tube and H.T.P. would be in the outer torroidal container.

Higher pressure would have to be maintained in the kerosene tank to avoid stress on the central tube. However, since pressure in both tanks is relatively small, this should present no problem.

A transition bay in front of the *Blue Streak* tank could contain the inertial guidance system as well as encompassing the *Black Knight* propulsion bay. Small ancillary rockets would be required in the second stage.

The short configuration of the launch vehicle would involve few changes to its servicing tower, thus cutting down development costs.

• **Three choices**—Pardoe's proposal for producing a space vehicle embraces three areas. The first approach—simple but with limited capability—would be to use a solid rocket system as the second stage to place, say, 1000 pounds in a 300-mile orbit. On the other extreme would be a more elaborate liquid propulsion second stage, based on existing equipment, which would be able to place a payload of some 2000-pounds in a 300-mile orbit. Between the two measures is a half-way stage where *Black Knight* in its present form and immediate availability could put about 1000-pounds in a 300-mile orbit.

The British have contracted for three NASA *Scout* vehicles. *Scout* has a capability of placing about 150-pounds in space.

Soviets Announce They'll Attend IAF Congress

LONDON—Russia will be represented by at least a token delegation when IAF Congress meets here this week.

IAF officials received a surprise cable indicating that Prof. Leonid Sedov and Prof. Kyril Ogorodni would attend. possibly accompanied by one more delegate.

Nozzles are Top Weight Problem

Today they comprise some 30% of a rocket's dead weight, but the outlook for reduction appears favorable through various industry efforts

WASHINGTON—Rocketry in some respects is just one series of problems after another. Solve one, and another rears its head to challenge any further progress.

So it is with solid rocket motor cases. For months the big problem has been how to crack the notch sensitivity barrier and come up with a development series of rocket motor cases whose cylindrical walls had a minimum yield strength of 220,000 pounds per square inch or more (see M/R series, June 8. 22).

Now it looks as though this is about to be achieved—and all of a sudden something else takes over as the limiting factor on improving mass ratios. Now, nozzles are the number one weight problem in motor cases, with forward bulkheads and aft closures with their heavy thickened sections running a close second.

Weight reduction in the cylindrical section of the case itself is still important, but the potential there for improving mass ratios is far less than it is in other areas. And as always in this business, the customer is willing to pay for the answers he wants; more and more money is going into R&D in these areas.

Current mass ratios—propellant weight to total powerplant weight—range from 0.85 to a little over 0.90 in very exceptional cases—up from less than 0.80 during World War II. For a comparison with some kind of theoretical maximum, check these figures by Dr. Hal Ritchey, vice-president, **Thiokol Chemical Corp.:**

• **Desired ratios**—For that can of beer he wants to place on the moon, Dr. Ritchey has calculated a mass ratio of 0.814; for an egg (in the shell), 0.896; a candy bar, 0.956; and a packaged loaf of bread, 0.977. Actually, when you compare current rocket mass ratios with these figures, we're not doing badly.

Improvement in mass ratios since World War II has been due to two fairly elementary technologies:

—development of inside-out propellant burning techniques which cut temperature problems of motor cases to a minimum.

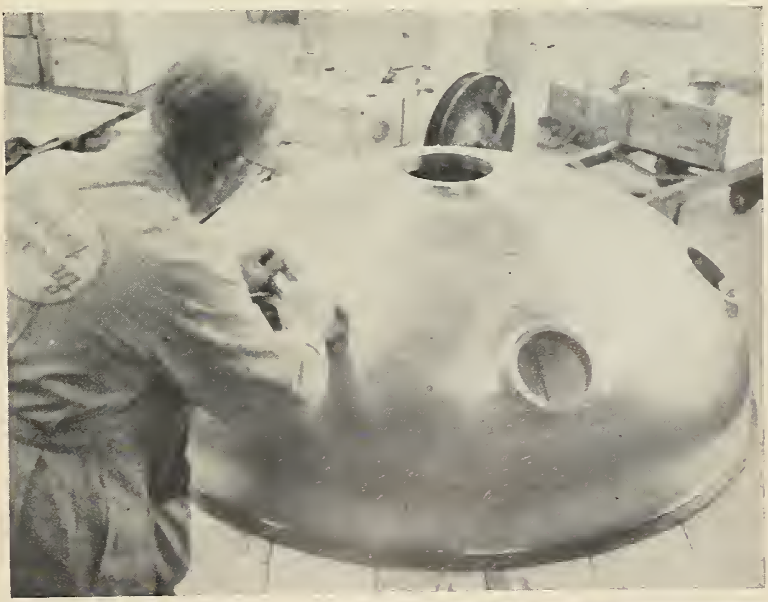
—creditable progress in development of high-strength, thin-wall metal motor cases and in low-density (plastic/glass) materials.

Though still far short of present goals, motor case technologies are approaching a point of diminishing returns. This isn't to say solid rocket makers have lost interest in a 240,000-psi minimum-yield strength steel motor case, for example. Far from it. Millions of dollars are still pouring into the effort to beat notch sensitivity and reach that elusive goal—and with some degree of success. There are programs under way that strive to attain 500,000-psi min-yield in the cylindrical part of a steel case; 200,000 psi in a plastic case.

• **Deadweight**—However, in all the sweat over cylinder wall improvement, other vital (and heavy) solid-rocket motor parts have been largely ignored—such things as the forward bulkhead, aft closure and nozzle. For example, in today's typical medium-size solid-rocket motor, of the four main components which make up all that dead weight, the motor case (the cylindrical section) may account for 20%; the forward bulkhead, 30%; aft closure, 20%; and nozzle, 30%.

This is for a rocket with a length-to-diameter ratio of about 2.5. Increase the ratio, and weight of the cylindrical section goes up proportionately.

Suppose our typical rocket motor has a mass ratio of 0.90 and that its



THOUGH the wall thickness of this forward bulkhead for a large solid-propellant rocket motor gets as low as .070 in., thickened sections boost the total weight.

MUCH OF the weight of rocket motors is represented by wing attachments and thrust elements with thick sections.

FINISH-MACHINED adapter rings for *Nike* booster case show how thick the metal can get. The aft closure represents one-fifth of the weight of a typical rocket motor.

cylindrical section has a min-yield strength of 200,000 psi. Even if we increase that strength level to 400,000 psi (a prodigious feat with current technologies), we only run our mass ratio up to 0.91.

However, if we can improve the performance-to-weight ratio of the other three factors by the same relative amount—2-to-1—mass ratio jumps to 0.94 without any improvement in actual case strength.

And it is in these areas that the coming bulk of solid-rocket motor case improvement is beginning to be concentrated.

• **Heavy fittings**—In forward bulkheads and aft closures, the main problem is the weight of fitments, bosses, etc. For example, some large solid-propellant motors have forward bulkheads fitted with a series of thrust reversal nozzles. Even though the basic wall thickness may be 0.070" or less (well into the 200,000-psi range), bosses for fitting nozzles may be 0.75" on their thinnest dimension, with the case wall around them tapering gradually down to the basic dimension.

In addition, the bulkhead itself must be attached to the case. If this is done by weldment, there's no material increase in weight in this area. But as often as not it's done with bolts, breechlocks, etc.—all of which require thickened (thus, heavier) sections. And these thickened sections may weigh more than all the rest of the forward dome.

With few exceptions, propellants are cast into solid-rocket cases before attachment of forward closure and/or nozzle; whatever remains to be fitted after the propellant is cast and the core mold withdrawn must be attached by some means other than welding. Heat of welding would be too likely to set off the propellants. Again, this means bolts, threads, breechlocks, keylocks, ringlocks—and inevitably a thicker, heavier section.

• **Peculiar nozzle problems**—The nozzle falls into a trouble-making realm of its own. Not only must it usually be fitted by similar means, but it suffers from a special set of environmental problems. A rocket exhaust is a high-temperature, high-velocity, highly abrasive and highly erosive flow; nozzles must be resistant to heat and/or provide a heat sink and must be physically and chemically tough to retain their critical geometry until burn-out. For these reasons, they are the heaviest part of a rocket motor for the volume they displace.

• **Plastic headaches**—Only in plastic motor cases have fitment and attaching problems been reduced to a near-minimum. The case, forward bulkhead and aft closure are made in a single operation, resulting in a one-piece motor. Metal attaching rings (usually aluminum) for nozzles and igniters are inserted in the plastic structure during fabrication. Even here there's room for improvement—such as reduction in attachment ring size and weight. And of course the same old nozzle problem remains. Some highly specialized rocket motor cases have 85% of their weight concentrated in the nozzle. Others, utilizing molybdenum nozzles, run the ratio up even higher.

Another headache with plastic motor cases made in a single unit is that casting fixtures must be inserted in pieces and assembled inside the case, then disassembled and withdrawn one-by-one after propellant casting. Though there's a weight saving in cases made this way, cost and complexity of propellant casting operations are substantially increased.

• **Solution still lacking**—The problem of attaching the various metal parts of a motor case to one another is an old one; but no one has yet provided a solution that is both reliable and lightweight. Bolted sections have been largely abandoned as unnecessarily heavy. The trend, where possible, is to weld—though reliability of production welding is still something of a problem. Welding is sometimes—but not always—possible with both the forward bulkhead and the aft closure, the nozzle attachment ring usually being large enough for most casting operations.

Another approach to both forward dome and aft closure attachment in metal cases is to spin or deep draw the case, including end closures, in two pieces; then to put them together at the middle with a circumferential weld; and finally to machine igniter boss and nozzle attachment ring out of sections left thick during drawing or spinning.

None of these systems, including threads, breech, ring and keylock systems, has so far proved very satisfactory. All are heavy and sometimes cause trouble when attempts are made to undo them—as may be necessary for disassembly for such purposes as propellant casting or later inspection of the propellant grain.

Anyone with a good, lightweight solution to this attachment problem can find a ready market for a development contract with any one of the many government agencies concerned with solid propellant rockets or the companies that manufacture them.

• **Nozzles promising**—Chances of reducing nozzle weight are better. Approaches to this problem are many and varied, ranging from techniques for electroplating any electroplatable metal to such unlikely materials as paper, wood and plastic, to the recrystallization of silicon carbide on graphite.

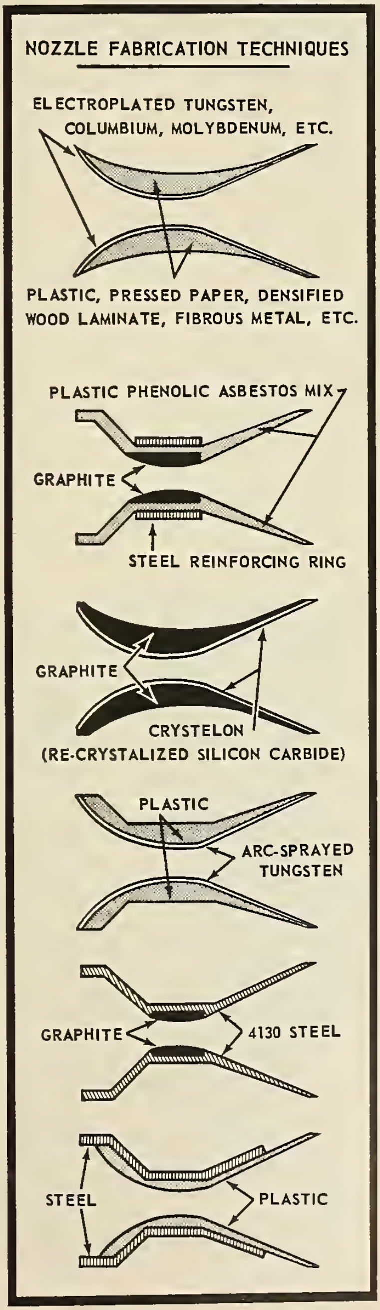
Thin metal sections by themselves do not offer the same advantages in nozzles that they do in motor cases. Under the rigors of rocket exhaust, they lack dimensional stability. But, more importantly, they have no ability to withstand the heat involved—either to absorb it in a heat sink or simply to stand up and take it. Possible exceptions are some of the refractory metals —of which molybdenum is one. However, moly's high density (over 12 times that of steel) makes it a poor candidate for a lightweight structure.

Non-metallics, however, are beginning to show real promise of nozzle weight-reduction. For example, a thrust-vectored nozzle made of molybdenum weighs something over 350 pounds, compared to less than 50 pounds for a comparable nozzle made of plastic and steel. Plastics not only have dimensional stability due to their bulk, but demonstrate very favorable characteristics in the presence of high-speed, high-temperature gas flow.

Currently, the most popular approach involves the use of phenollic-glass-asbestos-etc. aggregates which are first pressed into their general shape and then finish-machined to tolerance much in the manner that metal is machined. These are usually backed up by metal (4130 steel, for example), but the total weight is less than it would be for an all-metal nozzle with, perhaps, a graphite insert.

• **Other approaches**—One of the more successful current efforts in nozzle weight reduction lies in refractory coated graphite. **The Norton Company,** for example, machines a nozzle out of pure graphite and then vaporizes and sprays a thin coat of silicon carbide on the inner contours of the throat. This is then placed in a high-temperature furnace where silicon carbide reforms into minute crystals—smooth and as hard as a carbide cutting tool. The problem with this nozzle is strength; efforts are under way to wind it with narrow metal reinforcing strip. Other companies are conducting similar work.

Yet another approach to the nozzle problem comes out of **General Electric Company's** Rocket Engine Section where efforts are being made to find a suitable plastic nozzle material that can be arc-sprayed with a tungsten liner.



Ethyl Corporation's method for electroplating heretofore unplatable materials is new and has not yet been fully investigated. However, this, like plasma spraying, opens up a whole new range of possible basic nozzle structure materials.

Still other areas that offer a longer-term potential include fiber metallurgy where very thin (.0001" diameter) metal fibers are pressed into the desired shape and then resistance welded so that everywhere a fiber touches another, it is joined by a weld. A great variety of densities and strengths is possible with this method. Although it usually results in a porous material, this drawback can be overcome.

Another field, of course, is ceramics. Efforts right now are being made to combine ceramics with other materials, much as glass is combined with plastic in monofilament winding. Work on the development of ductile ceramics has made considerable progress recently and this may offer one of the better long-term solutions.

Better Method Developed To Measure Solid Changes

MENLO PARK, CALIF.—Scientists at the **Stanford Research Institute** have announced the development of an improved method of measuring creep and stress relaxation in solid propellants.

The research team of R. B. Beyer, C. F. Clark and B. C. Belt said last week they expect the new process to add significantly to knowledge of solid propellant aging.

The method reduces the observation time from two weeks to one day, and is accurate to 0.005 inch. Another advantage pointed out by the researchers is the determination possible at the initial portion of the test.

A more accurate distinction thus is made between the reversible elastic properties of the material and its irreversible creep formation.

A unique apparatus measures the stress relaxation by mechanically introducing an initial deformation. The stress decay is then measured and recorded automatically.

The project is sponsored by the Air Force's Wright Air Development Center and is chiefly concerned with the changes in solid rocket propellants during storing and aging.

Double-base Solids Still Standard Despite Inroads by Polyurethane

by Jay Holmes

INDIAN HEAD, MD.—Although *Polaris* and some other missiles use the new polyurethane binder, double-base composition is still the standard for a major part of America's solid-fuel program.

At the Naval Propellant Plant in this Potomac River community, the Navy's "in-house" staff manufactures double-base grains for almost all of the solid-fuel rockets used by the sea service—and a few for the other services.

Relatively small rockets use extruded and machined double-base grains. But the only safe method of making larger grains—such as the 3000-pound grain, the largest made here—is by casting.

There is still a chance the big *Polaris* grain may switch to double-base. Two years ago, when the Navy chose polyurethane, case bonding of double-base grains was a problem. Now that has been solved. NPP announced last December it is working with **Allegheny Ballistics Laboratory,** Cumberland, Md., on a double-base propellant for possible *Polaris* use. The experimental fuel is now in pilot-plant production and has undergone preliminary testing.

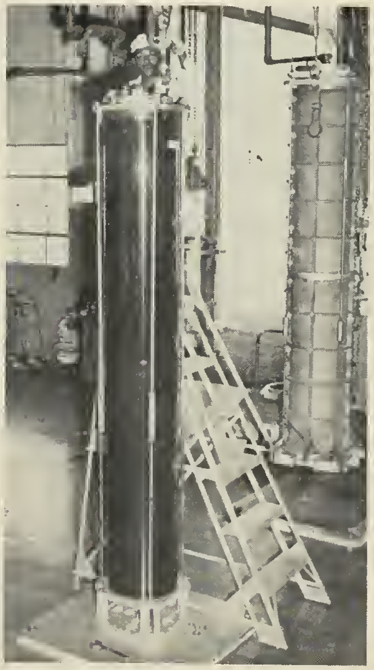
Double-base grains extruded here include those of the *Sidewinder* and *Zuni* and gas-generator propellants for *Sidewinder, Sparrow* and the Army's *Hawk.* Among the cast grains produced at Indian Head are those for the *Talos, Terrier, Weapon A, Boar* and *Bullpup.*

• **The process**—Recently, the Defense Department declassified the details of the grain casting process at Indian Head. Capt. G. T. Atkins, Commanding officer, outlined the operation for a visitor:

The grain normally is cast inside an inert plastic beaker—or inhibitor—which prevents the burning of the propellant on the outer circumferential surface. In the mold-assembly operation, the beaker is placed inside a tight-fitting corset of metal alloy or glass fiber. Cores are positioned longitudinally through the inhibitor and held in place with plates at either end. The cores form the perforations in the grain, which determine the amount of internal burning surface.

Casting powder then is poured into the assembled mold. The powder consists mainly of either nitrocellulose or nitrocellulose with some nitroglycerin. It is in the form of small, solid cylindrical granules about the size of a thin pencil lead in length and diameter. The powder is poured into the mold from overhead bins.

After auxiliary parts of the mold assembly are put into place, the mold is evacuated for about a day. This reduces total volatiles and excess moisture—which would decrease the coalescent properties of the mixture. Evacuation also reduces the moisture content of the casting solvent.



WORKER PREPARES to remove cores from cast solid grain at Indian Head plant.

• **Pressure differential**—The solvent—usually nitroglycerin with a small percentage of plasticizer and stabilizer, is introduced into the mold through one of the end plates. Air pressure forces the solvent through a tightly packed column of powder. The casting operation is complete when it reaches the opposite end.

The temperature must be kept very close to 70°F while the solvent is being introduced. If it varies too much, casting becomes very difficult. When temperature is too high, the cast powder will tend to gel too rapidly. When temperature is too low, the viscosity of the solvent becomes too high to permit it to move freely through the casting-powder granules.

The powder grain in the mold must be cured for several days at temperatures usually ranging from 100° to 200°F. During this period, the powder is transformed from a sticky mass into a solid plastic grain. After curing, the mold is removed to a rest house where it remains at room temperature for about 24 hours or until it reaches ambient temperature.

The grain is placed in a special hold-down stand while the core is being pulled from the mold after the mold parts are removed. The core, in either horizontal or vertical position, is normally removed easily, but it may need a slight initial shove. A plastic coating may lubricate the surface and make this easier.

Next the grain is cut to specified length and the ends are squared. For safety, this is done by remote control, with the operator watching the operation through a heavy glass window. During the cutting operation, water usually is played on the saw blades to reduce the hazards of excess friction.

If the grain meets the requirements of a thorough and rigid inspection, it is accepted for loading in a missile motor.

SPACE RESEARCH

BRISTOL SIDDELEY GAMMA ROCKET ENGINE POWERS BLACK KNIGHT- BRITAIN'S HIGHLY SUCCESSFUL SPACE RESEARCH VEHICLE

On 11th June, 19,000 lb of thrust sent Black Knight to the threshold of outer space—500 miles above the Woomera rocket range in Australia.

This was the third successful firing *(there have been no failures)* and much of the credit for Black Knight's trouble-free performance must be given to the Gamma.

The Bristol Siddeley Gamma 201 is a liquid propellant rocket engine. Four trunnion-mounted chambers burn kerosene with HTP and each chamber is fed by its own turbopump unit. The complete weight of the engine compartment is less than 700 lb (dry) and Gamma delivers 19,000 lb at altitude—16,400 lb at sea level.

Black Knight is a research vehicle and no military applications are planned. But the experience gained and lessons learned from this highly successful space probe will be invaluable in the development of Britain's IRBM—Blue Streak.

So impressive is Black Knight's performance with the Gamma powerplant that even more advanced applications are being actively developed. In fact, Black Knight coupled with Blue Streak is first choice to put Britain's projected space satellite into orbit.

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Orange County: Nowhere To Go But Up!

Missile firms have turned the former farming community into the nation's fastest-growing metropolitan area—and this is only the beginning

by Frank G. McGuire

LOS ANGELES—Discover Orange County! is the advice given in the county's Industrial News Directory, and a great many firms in the missile industry have done just that.

Orange County, the fastest-growing metropolitan area in the nation, had 6000 jobs in manufacturing employment in 1950—today it has 40,000. Lying between Los Angeles and San Diego Counties in Southern California, Orange County seems a cinch to catch most of the overflow of expansion from firms in those two heavily industrialized areas, but mostly from Los Angeles.

Over 160 miles of high-speed freeways criss-cross the county, and a number of airports serve it, including the large commercial airports of Los Angeles and San Diego. The state is planning a considerable expansion of the freeway network in the county.

The firms now located, or building, in Orange County read like a Who's Who of the missile industry:

Lockheed Electronics and Avionics Division (LEAD) is preparing to build a permanent headquarters facility on a 200-acre site in Newport Beach.

Autonetics Division of **North American Aviation** is a newcomer, with a 370-employe facility handling computer operations and engineering work on inertial navigation systems in Fullerton.

Aeronutronic Division of **Ford Motor Co.** is in various stages of construction and utilization of its group of buildings at Newport Beach.

Hughes Products Group also has a new home in Newport Beach for its Semiconductor Division, and turns out subminiature devices here. The entire research and manufacturing activities were moved from Los Angeles. Another Hughes unit, in Costa Mesa, turns out silicon and germanium diodes.

Hughes Ground Systems Group is another of the missile-industry entities moving into Orange County. Growing from 800 employes in 1957 to 5000 now, the group has recently occupied a brand-new plant of 850,000 square feet in Fullerton, housing administration, engineering and light electronic assembly operations.

Thompson Ramo Wooldridge has a $2 million component plant under construction for its Tapco Group. Scheduled for completion in February, the three-story plant in Anaheim will assume most of the Bell and Long Beach operations of TRW.

Interstate Engineering Corp., of Anaheim, has an entire "family" of firms in broadly diversified fields, and is heavily involved in the missile program.

Cannon Electric Company recently passed the 500-employe mark in expanding its new plant in Santa Ana. The ten-month-old plant produces Cannon's most competitive line—its military standard hardware.

• **Why Orange County?**—As is obvious from the list of firms involved, the growth in Orange County is largely in the electronics field. In past years, there has been a "latent resistance" againt the influx of industry to Orange County, mostly because of the disadvantages associated with "heavy" industry such as steel mills. It has apparently come as an awakening that it is possible to have the economic advantages of industry without the disadvantages —unsightly huge plants, smoke, heavy truck traffic, etc.

Much of the change in attitude is due to the campus-type architecture used in construction, and the research and development nature of many of the firms now going into the county. Even those producing considerable quantities of goods are doing so in attractive buildings, without the smokestacks, railroads criss-crossing streets, and other blemishes that the old-time residents associated with industry.

W. Worth Bernard, publisher of the *Orange County Industrial News,* says the county hopes to have enough industry to support an anticipated population of 2½ million by 1980. A study by **Stanford Research Institute** indicated this was in store, and some feel that the two-million mark may be reached by 1970. Today's population is 680,000; in 1950, it was 216,000.

B. F. Coggan, Vice President and Division Manager of **Convair-San Diego,** said: "This area (Southern California) is becoming the fountainhead of scientific manpower. The scientists are being brought here, not by the handful, but by the hundreds! . . . Because of this, the industrial growth of Orange County will be terrific." With its thousands of scientists qualified for teaching, the county has been suggested as the site for a Science Academy paralleling, in science, Annapolis, West Point and the Air Academy.

• **Beethoven and boats**—Recreational and other benefits of the area are numerous: three symphony orchestras, 12 golf courses, 14 bowling centers, Disneyland, Knott's Berry Farm, and the greatest small-craft harbor in the nation (last year, more boats were sold in California than new cars!).

The future may see three colleges serving the county. Chapman College in Orange, the new Orange County State College now being built in Fullerton, and possibly a county branch of the University of California, still in the works. The county has 18 high schools, increasing to 22 by the fall semester, and three junior colleges.

A detailed economic study of the county was undertaken by Stanford Research Institute at the request of the County Board of Supervisors, to guide planning in highway construction, flood control, recreation, airport planning, industrial development, and zoning.

The amount of land zoned for industry, or in the process of being zoned, is upwards of 45,000 acres in the county. Although some feel this is too much, it is estimated that such an amount will be needed to support industry for a 2½ million population.

In addition to those listed previously, a great number of firms have facilities in the county: **Giannini, Burroughs, BJ Electronics, Hallamore, General Electric, Interstate Engineering, A. O. Smith, Beckman Instruments Narmco, Electronic Engineering Co., Pacific Scientific Aeroproducts, U.S. Borax and Chemical Co., Pacific Laminates,** and numerous others.

Lockheed's facility will be one of the larger new ones. The site is a 200-acre tract close to the Orange County Airport, where construction will begin before the end of the year. Occupancy is expected by late next summer. The new plant facilities will have a capacity of up to 1000 research, engineering and administrative personnel and supporting groups. For the foreseeable future, LEAD expects to keep its temporary facilities as a manufacturing plant.

Until the new structure is ready, LEAD is gradually developing its new position by staffing the key administrative positions, and bringing in the necessary technical and scientific personnel. Concurrently, it is moving along with sale and development of its product line, which will be all military at first, then branch out into specialized industrial areas. LEAD expects to have about 400 employes by year-end, compared with 75 now.

Autonetics Division of North American Aviation (which has just built a 200,000-square-foot building in Downey) employs 370 people at its Fullerton flight control engineering department. The facility, which houses an analog computer installation for work on flight control problems, may be expanded even further by the addition of leased space. There are no plans afoot as of now to move any Autonetics operations outside the LA area.

Cannon Electric Company, with plants in Salem, Mass., and Phoenix, Ariz., has housed its production facilities for the military standard line to the Santa Ana plant in Orange County. The company's most competitive line, military standard plugs, are not specifically designed for missile use, but are used when standard equipment shows up in a missile system.

Built in October, 1958, the plant has a capacity of 750 employes, but still is not considered by the firm to be a significant move away from the Los Angeles area, since most of the company's eighteen product lines still come out of the Los Angeles headquarters group. Two lines are handled by Salem and two by Phoenix: the Guided Missile and Special Products lines are handled at Phoenix because it lies in different procurement area.

Most of the new space being utilized by Cannon is for manufacturing, but each facility has its own engineering section. Relative to the headquarters group, the newer facilities are small: Los Angeles, 340,000 square feet; Phoenix, 70,000, and Santa Ana, 112,000. The Los Angeles HQ group is spread throughout eight buildings occupying several city blocks, and one company spokesman told M/R that "we'd like to tear them all down and rebuild our facilities under one roof." Nevertheless, there are no plans for ever removing the executive offices out of Los Angeles.

The company recently bought a new building in Orange County that had been built by a die-casting company, but never occupied. Although it is now being used mostly for storage, Cannon believes it is the only die-casting facility in the county.

Aeronutronic Division of Ford, similarly to LEAD, is occupying a 200-acre site in Newport Beach. The division's $22-million research and engineering center, designed by **Wm. L. Pereira & Associates,** overlooks the Pacific Ocean, and consists of an ultra-modern 120,000-square-foot computer electronics facility which was occupied in July, a Space Technology Building of 120,000 square feet scheduled for completion by Jan. 1, and a Central Services Building scheduled for completion during the first quarter of 1960.

A 30,000-square-foot Environmental Test and Reproduction Building will be built by November, 1960, and a multi-story administration and a Tactical Weapon Systems Operations building are both scheduled for completion by mid-1960.

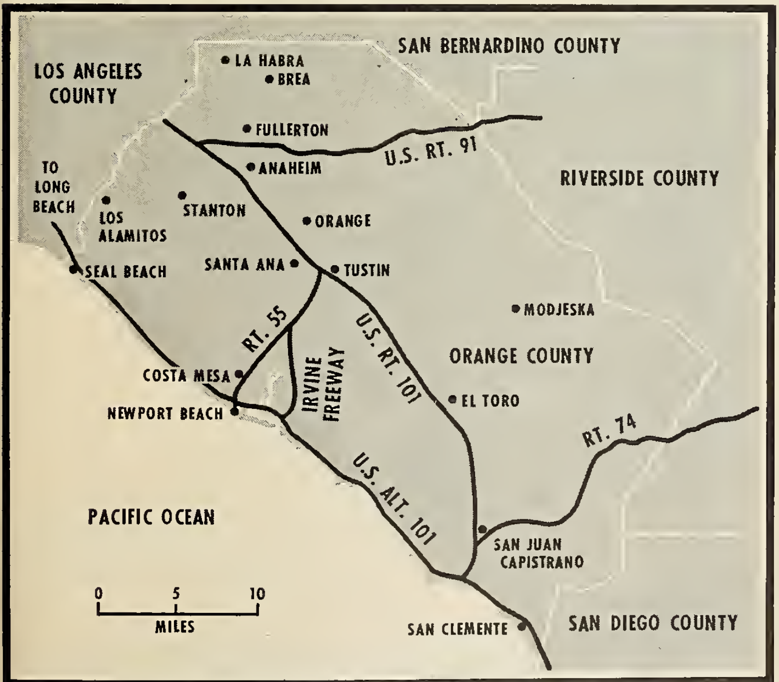
Beckman Instruments Systems Division in Anaheim handles assembly of the electronic data processing systems used in developmental testing of rocket engines. One of five Beckman divisions in Orange County, the Systems division also has a plant in Richmond, Calif.

Interstate Engineering Corp., (with a number of sub-organizations), produces missile and aircraft components, as well as instrumentation, in Orange County. A Navy prime contractor, **Interstate Electronics Corp.** produced instrumentation for the *Polaris* FBM system, including three instrumentation systems for the Atlantic Missile Range, and instrumentation for the USS Observation Island. Latter equipment includes photo apparatus, television, and electronic ranging gear.

Interstate Electronics, a subsidiary of Interstate Engineering, is also at work on development of a complete system for underwater firings from nuclear subs. Interstate Electronics has a staff of over 350 employes, with 70 of them engineers.

Supplementing and supporting the many companies listed here are dozens of small contractors and their plants in the county.

In the entire industry-laden area of Southern California, the prime location for just about any industrially "clean" industry appears to be Orange County, and things will probably remain this way for some time to come.



A LITTLE-KNOWN agricultural section as recently as 1950, Orange County today has a population of 680,000 and anticipates some 2½ million in another 20 years.

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Upstream 4000 PSIG Max.	Upstream 6000 PSIG
Downstream 3000 PSIG Max.	Downstream 4500 PSIG

Service: Air, Nitrogen, Helium

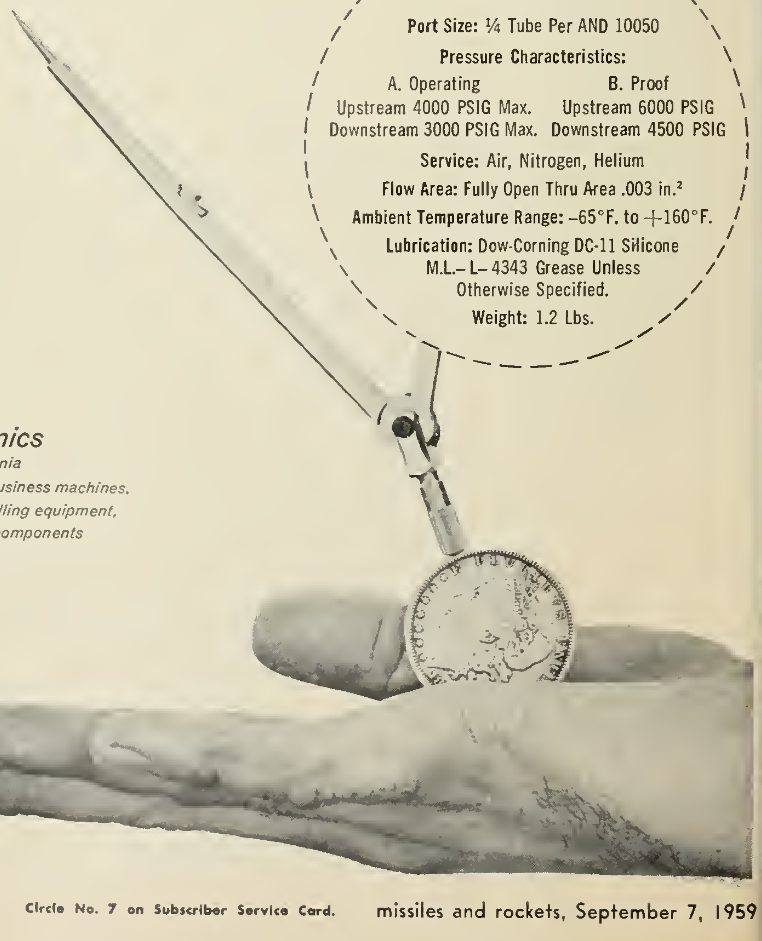
Flow Area: Fully Open Thru Area .003 in.²

Ambient Temperature Range: –65°F. to +160°F.

Lubrication: Dow-Corning DC-11 Silicone M.L.– L– 4343 Grease Unless Otherwise Specified.

Weight: 1.2 Lbs.

Clary is one of the nation's largest manufacturers of rocket and missile valves. Other devices include: ABSOLUTE PRESSURE REGULATOR that maintains an outlet pressure of 18½ to 20 PSIA with variations in flow rate from 3 to 350 SCFM under 30 to 100 PSIA inlet pressure and –65°F. to +350°F.; and DIFFERENTIAL PRESSURE REGULATOR that maintains an outlet pressure of 6 PSIG ±.25 with flow variations from 3 to 160 SCFM under 10 to 250 PSIG inlet pressure and –65°F. to +350°F.



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Report Pinpoints Red Launch Base

Czech article says new satellite and missile base is located above the Aral Sea—new details on Mechta are also revealed.

By Paul Means

WASHINGTON—The Soviet Union's new missile and satellite launching base—in operation less than a year—is northeast of the Aral Sea in the Republic of Kazakh, approximately 70 miles north and east of the city of Aral'sk.

The coordinates (47 N, 62.5 E) of the new Russian "Cape Canaveral" were publicly revealed for the first time in the June 9th edition of a Czechoslovakian aviation journal. The journal, *Kridla Vlasti,* also disclosed new specific information about the Soviet sun orbiter *Mechta.*

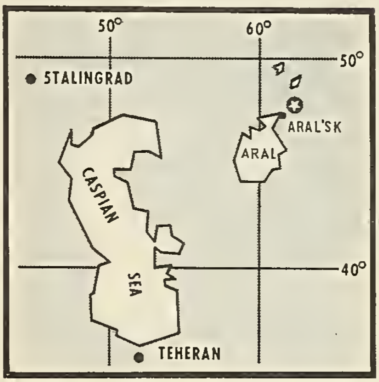
The Czech article was translated by the Central Intelligence Agency for publication in the Department of Commerce's Office of Technical Services bulletin last week.

According to reliable sources, the Czech article was accurate in its listing of the base's coordinates, which place it one degree east and one minute north of Aral'sk, but was inaccurate in its description of the location. The article reported the location to be in "an area northeast of the Ural lakes, on the dividing line between Europe and Asia"—about 700 miles away from the coordinate location.

The IRBM, ICBM, and space vehicle launching base has been in operation less than a year, according to M/R sources. *Mechta* was one of the first vehicles to be launched from the new base.

The old Soviet base was at Kapustin Yar at the bend in the Volga River near Stalingrad. (See M/R, Feb., 1958, p. 61). M/R in the 1958 article revealed that the Kapustin Yar base was within tracking distance of the Air Force radar stations at Samsun, Turkey, in the Elburz mountains north of Tehran, and at a third position north of Meshéd.

The Czech article said *Mechta's* first stage developed 600,000 lbs. of thrust. The main engine produced 440,000 lbs. of thrust, and two auxiliary solid motors—which were not ignited until the vehicle had reached an altitude of about 2000 meters—developed a thrust of about 80.000 lbs. each.



RED BASE'S location, according to the coordinates given in the Czech article, is northeast of the Aral Sea, about 70 miles from Aral'sk.

• **Two stages?**—Experts on Russian missiles speculate that the main engine of the *Sputnik* and *Mechta* vehicles may be a two-engine combination such as *Atlas,* with each engine developing 220,000 lbs. of thrust. This is substantiated by the Czech article's report that the booster was clamped down until full thrust was achieved.

The liquid propellant for all three stages, according to the article, was a hydrocarbon fuel with a boron additive, and liquid oxygen. The ratio of fuel to oxydizer, the same for all three stages, was 2.4:1.

The second stage, a modified IRBM, did not separate from the booster until 2.5 seconds after ignition, giving it time to achieve full thrust. The third stage separated in a similar manner.

The exhaust nozzles and combustion chambers were lined with tungsten. The rocket motors had a mixing chamber in front of the actual combustion chamber, making it possible for the combustion chamber to attain a pressure of 23.6 kg/cm^2 which, by expanding the exhaust orifice, dropped to 0.7 kg/cm^2.

• **Chamber cooled**—Though burning temperature was approximately 3200°C, the temperature of the combustion chamber walls and exhaust nozzles was kept below 600°C by using the rocket fuel as a coolant circulating through special channels around the combustion chambers.

Thermocouples regulated the flow of the coolant fuel, which when warmed was returned to the fuel tanks and re-mixed with the cold fuel.

The injection pressure of the fuel varied from 135 to 180 kg/cm^2, according to the thrust required to maintain a speed predetermined by an integrator working in conjunction with the stabilizing gear of the third starge.

The injectors for fuel and oxygen in the third-stage rocket motor were equipped with magnetic needle valves controlled by perforated program cards.

The fuel pumps, used in all three stages, were driven by steam turbines which in turn were driven by diverting burning gases from the combustion chamber. A special compressor was used at launch.

The article stated that all pre-launch functions were automatic.

The trajectory, according to the article, had been previously fed into perforated aluminum cards, which, with the aid of two electronic computers, directed the vehicle's third-stage guidance system. The ground station was located one kilometer from the firing base.

The flight path of *Mechta* was monitored, according to the article, by 13 ground stations in Russia (one main station and 12 secondary stations), equipped with Doppler, radar, and photo-theodolite instruments. All three equipment systems were set up on a common mounts which could rotate horizontally as well as vertically. The stations were interconnected by cable.

Exploring Beryllium's Potential

But Martin Co. metals researcher says beryllium technology must be greatly expanded before it can become a truly useful material. Progress is defined in overcoming extreme brittleness and in working the metal.

by Charles J. Giemza

BALTIMORE—Beryllium's unusual combination of mechanical and physical properties is generating interest in its potential application to missile and other airframe structures. Investigation so far, however, indicates the lightweight metal's utilization in structures will depend upon qualities beyond sheer mechanical superiority.

For before these advantages can be realized, it will be necessary to substantially enlarge beryllium technology.

The necessary transition from the basic material forms to an element of the structure must be accomplished without incurring a significant compromise of the material's virgin characteristics, presuming the original properties approach ideality.

Admittedly, it is possible to employ beryllium—as it is presently known—in structures where the design conditions are quite conservative. But this approach is hardly ingenious and produces no contribution. Indeed, it is an imposed limitation which may forestall a more rapid and complete development of structural beryllium.

Furthermore, the seriousness of possible catastrophic structural failures, if underdeveloped beryllium should be employed, cannot be minimized. The assurance of beryllium's structural integrity will be achieved only when the damaging factors are clearly established and—having been identified—are either reduced or eliminated through defined fabrication processes and design.

• **Re-entry vehicle design**—Efficient structural design implies that the structural material would be fully exploited. The comparison of beryllium's individual properties—density, strength, stiffness—to other materials' properties may be misleading. Even the combination of beryllium's properties may not be particularly advantageous in some design applications. Therefore, structural indices of strength-density or modulus-density ratios, while indicating an apparent advantage, provide no clue to beryllium's superiority.

About the Author:

Mr. Giemza is supervisor of metals research at The Martin Co., Baltimore. For his part in developing the nation's first beryllium structure meeting primary structural standards, Giemza received the Achievement of the Year Award from the American Rocket Society.

In one hypothetical design of a re-entry vehicle, advantage was taken of all mechanical and physical properties—strength, stiffness, density, specific heat, themal conductivity, oxidation resistance and creep resistance. The design—a composite, thermally protected beryllium structure—was superior (for the mission profile in question) to alternative designs made from other materials in these respects:

• Auxiliary cooling was not required.

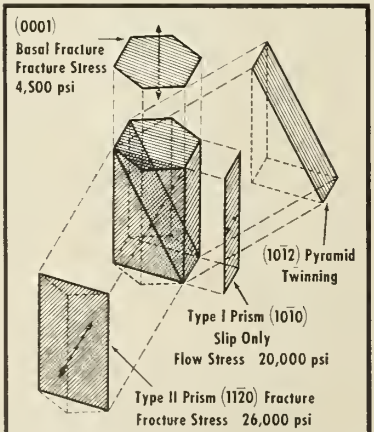


FIG. 1—Beryllium unit cell, principal slip and fracture planes.

• The beryllium composite structure was substantially lighter.

• Attainment of an arbitrary temperature (above the initial condition) occurred appreciably after that developed in the alternative designs—thus effectively extending the range and preserving a higher structural strength throughout the mission.

• A critical dynamic condition was eliminated.

Speculative design studies do not, however, solve the immediate problems which prevent the realization of these designs. Excepting the semi-structural and non-structural employment of beryllium, no practical design experience has been generated. Moreover, no commercial beryllium product has been developed which could be construed as a primary airframe structural material. Although these observations appear pessimistic, one must consider that the premature employment of beryllium would not provide a fair evaluation of its total potential.

If the time when structural beryllium becomes available is to be shortened, the comparatively modest beryllium development effort will require new emphasis. It would be timely, therefore, to review the factors which would have a bearing on the attainment of goals in the development of structural beryllium.

• **Crystallographic texture**—Because the developed properties and characteristics of beryllium depend on the arrangement of crystals in the polycrystalline aggregate, it is necessary to explicitly define the fabrication parameters and consequently the mode of fabrication which will impart the desired texture.

• **Forming**—Forming which is performed subsequent to the original fabrication—will alter what may have been an ideal texture. In addition, the rather poor formability of beryllium will require a thorough study in this respect. The possible alteration of the crystallographic texture by forming will require a specification of the de-

(continued on page 29)

missile hardware

When it comes to the problems of putting propellants and explosives to work on the actuating jobs in and around missiles, Beckman & Whitley offers a background gained in ten years of pioneering. Examples shown are just a few selections of solutions to typical problems.

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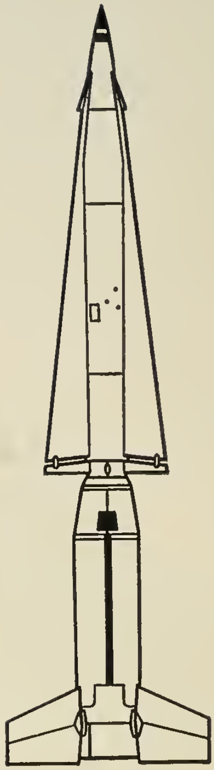
PROJECT	CONTRACTORS	DESCRIPTION	STATUS
SPACE VEHICLES			
ATLAS-ABLE (NASA)	STL, prime; GE/Burroughs, Arma, guidance; Rocketdyne, Aerojet-General, ABL, propulsion	Orbit 200-lb. vehicle around moon or send into deep space	Moon orbit attempt scheduled for October
CENTAUR (NASA)	Convair, prime; Pratt & Whitney/JPL, propulsion	Soft-land 730-lb. on moon	First test flight in fall, 1961
COURIER (ARPA-Army)	Army Signal Corps, prime	Delayed repeater communications satellite	R&D; satellite in advanced stage
DISCOVERER (ARPA-AF)	Lockheed, prime	Thor-Agena launchings of early stabilized satellites	6 launched; 3 in orbit and stabilized; ejected capsules not recovered
DYNA-SOAR I (Air Force)	Boeing and Martin/Bell, competing	Boost-glide orbital test vehicle	Late study stage
JUPITER-C (NASA)	ABMA/Chrysler, prime; Sperry, guidance; Rocketdyne, JPL, propulsion	Early satellite booster; small payload	Being phased out
JUNO II (NASA)	ABMA/Chrysler, prime; Ford Instrument, guid.; Rocketdyne/JPL, prop.	Early deep space booster; small payload	Being phased out
MERCURY (NASA)	NASA, prime; McDonnell, capsule	First manned satellite	Capsule testing being conducted
MIDAS (ARPA-Air Force)	Lockheed, prime	Early-warning satellite; detect ICBM launchings by infrared before birds leave pad	R&D
MRS. V (ARPA)	No prime announced	Manueverable, recoverable space vehicle; also known as DYNA-SOAR II	Early R&D
NOTUS (ARPA-Army)	G.E., polar communication system	Overall instantaneous repeater communications satellite program	R&D
NOVA (NASA)	Rocketdyne, prime; Rocketdyne, propulsion	Clustered 6 million lb. booster	Early R&D on 1.5 million lb. engines
ORION (ARPA-Air Force)	General Atomic	Space station launched by series of atomic explosions	Feasibility studies under way; tests may be attempted
SAMOS (ARPA-Air Force)	Lockheed, prime	Reconnaissance satellite; formerly Sentry	R&D; stabilization already achieved in DISCOVERER series
SATURN (ARPA-Army)	Army Ordinance Missile Command, prime; Convair/Pratt Whitney, propulsion	Clustered 1.5 million lb. thrust booster; liquid TITAN second stage; CENTAUR third stage	Static test early 1960; first booster flight one year later; operational about 2 years
SCOUT (NASA)	Chance Vought, prime; Minneapolis-Honeywell, guidance; Aerojet-General/Allegany/Thiokol, propulsion	Four-stage satellite launcher; 200-300 lb. payload in orbit	Operational next spring
SUZANO (ARPA)		Space platform to be used as base for staging and other missions	Feasibility studies
THOR-ABLE (NASA)	STL, prime; Rocketdyne/Aerojet-General/ABL, propulsion	Early deep space booster	Sun orbit shot in December
THOR-DELTA (NASA)	STL, prime; IT&T, guidance; Rocketdyne/Aerojet-General/Allegany,prop.	Put 65-lb. satellite in orbit around moon	R&D; first flight early 1960
TRANSIT (ARPA-Navy)	Lockheed and Johns Hopkins Laboratory, prime	Navigational satellite	R&D
TRIBE (ARPA)		Family of space launching vehicles	Planning
VANGUARD (NASA)	Martin, prime; Minneapolis-Honeywell, guidance; GE, Aerojet, ABL, Grand Central, Atlantic Research, Thiokol, propulsion	First planned satellite booster; small payloads	Being phased out; one bird left
VEGA (NASA)	JPL/Convair, prime; GE, guidance; Rocketdyne/JPL/GE, propulsion	Advanced space vehicle with ATLAS; second stage start-restart; can put 980 lbs. around moon	First flight in fall, 1960
X-15 (NASA-Air Force)	North American prime; Thiokol, prop.	Rocket plane; 3600 mph;	Powered flight expected this fall
MISSILES & ROCKETS			
ABLE (Navy)	Avco, prime	ASW surface-to-underwater; 500 lb. solid; conventional	Deployed on destroyer escorts

ASROC (Navy)	Minneapolis-Honeywell, prime	Surface-to-underwater; solid rocket torpedo; nuclear	R&D
ASTOR (Navy)	Westinghouse, prime	ASW underwater to underwater; rocket torpedo; nuclear	R&D
ATLAS (Air Force)	Convair, prime; GE/Burroughs, ARMA, guidance; Rocketdyne, propulsion	ICBM; more than 5500-mile range; liquid; nuclear	29 launchings of test vehicles all types: 14 successes, 7 partial; 8 failures; expected operational this month
ALBM (Air Force)	Douglas, prime	Air launched ballistic missile; more than 1000-mile range; solid; nuclear	Design study
ARM	No contract announced	Anti-radar missile	R&D
BOMARC (Air Force)	Boeing, prime; Westinghouse; guidance; Marquardt, A model/Thiokol B, propulsion	Air-breathing surface-to-air interceptor; A model liquid, B solid; 200-400 m. range, Mach 2.7, nuclear	A model operational; B under R&D
BULLPUP (Navy)	Martin, prime; Republic, guidance; Thiokol, propulsion	Air-to-surface; 4-mile range; conventional 250-lb. bomb	Deployed with Atlantic and Pacific Fleets; bigger model under R&D
CORPORAL (Army)	Firestone, prime; Gilfillan, guidance; Ryan, propulsion	Surface-to-surface; 75-mile range; liquid; nuclear	Deployed with U.S. & NATO troops in Europe
CORVUS (Navy)	Temco, prime; Texas Instrument, guidance; Reaction Motors, propulsion	Air-to-surface; pre-packaged liquid; radar homing; about 100-miles range	First successful test July 18, 1959
CLAYMORE (Army)	No contract announced	Anti-personnel missile	R&D
CROSSBOW (Air Force)	Radioplane, prime; Bendix, guidance; Westinghouse, propulsion	Air-to-surface; turbojet; radar homing; 200-mile range	R&D
DAVY CROCKETT (Army)	In-House Project at Rock Island, Ill., arsenal	Surface-to-surface; solid; bazooka launched; sub-kiloton nuclear warhead	R&D
EAGLE (Navy)	Bendix, prime; Sanders, guidance	Air-to-air; 100-mile range; nuclear; for launching from relatively-slow aircraft	Early R&D
FALCON (Air Force)	Hughes, prime; Hughes, guidance; Thiokol, propulsion	Air-to-air; 5-mile range; Mach 2; solid; conventional	GAR-1D & GAR-2A & GAR-3 operational; GAR-4 & GAR-9 under R&D
GENIE (Air Force)	Douglas, prime; Aerojet-General, propulsion	Air-to-air; unguided; 1.5-mile range; nuclear	Operational
GIMLET (Navy)	No contract announced	Air-to-surface; unguided; considered highly accurate	R&D
HAWK (Army)	Raytheon, prime; Raytheon, guidance; Aerojet-General, propulsion	Surface-to-air; 20-mile range; solid; conventional; designed to hit low-flying planes	Operational; units training for early deployment
HONEST JOHN (Army)	Douglas, prime; Hercules, propulsion	Surface-to-surface; unguided; 16.5-miles range; nuclear	Operational; deployed in Europe
HOUND DOG (Air Force)	North American, prime; Autonetics, guidance; Pratt and Whitney, propulsion	Airbreathing air-to-surface; 500-mile range; Mach 1.7; turbojet; nuclear	Nearly operational; to be launched from B-52G intercontinental bombers
JUPITER (Army)	Chrysler, prime; Ford Instrument, guidance; Rocketdyne, propulsion	IRBM; liquid; nuclear	Being deployed with Italian troops in Italy; 20 launchings: 14 successes; 5 partials; 1 failure
LACROSSE (Army)	Martin, prime; Federal Telecommunications Laboratories, guidance; Thiokol, propulsion	Surface-to-surface; highly mobile; 20-mile range; solid; nuclear	Operational; units being trained
LITTLE JOHN (Army)	Emerson Electric, prime; ABL, propulsion	Surface-to-surface; unguided; 10-mile range; solid; nuclear	Nearly operational; units training with it
LOBBER (Army)	No contract announced	Surface-to-surface; cargo carrier; 10-15 mile range; also can drop napalm	Studies
LULU (Navy)	No contract announced	Surface-to-surface; nuclear	R&D
MACE (Air Force)	Martin, prime; AC Spark Plug, guidance; Allison, propulsion	Air-breathing surface-to-surface; more than 650-mile range; turbojet & solid; nuclear	Being deployed with U.S. troops in West Germany
MATADOR (Air Force)	Martin, prime; Thiokol/Allison, propulsion	Air-breathing surface-to-surface; 650-mile range	Being turned over to West Germans; also deployed in Far East
MAULER (Army)	No contract announced	Surface-to-air; IR guidance; field weapon	R&D
MINUTEMAN (Air Force)	Boeing, prime; Autonetics, guidance; Thiokol, propulsion	2nd generation ICBM; solid; mobile; nuclear	R&D. Expected to be operational by late 1962 or early 1963

MISSILE A (Army)	No contract announced	Surface-to-surface; 65-70 mile range; solid	Design studies
NIKE-AJAX (Army)	Western Electric, prime; Western Electric, guidance; Hercules Powder, propulsion	Surface-to-air; 25-mile range; Mach 2.5; solid & liquid; conventional	Deployed in U.S., Europe & Far East
NIKE-HERCULES (Army)	Western Electric, prime; Western Electric, guidance; Hercules & Thiokol, propulsion	Surface-to-air; 80-mile range; Mach 3+; nuclear	Rapidly replacing NIKE-AJAX
NIKE-ZEUS (Army)	Western Electric, prime; Bell Telephone, guidance; Grand Central, propulsion	Anti-missile; 3-stage; 200-mile range; solid; nuclear	R&D; major components being tested; first tests against ICBM's to be in PMR; first launched Zeus fell apart in flight Aug. 26
PERSHING (Army)	Martin, prime; Bendix, guidance; Thiokol, propulsion	Surface-to-surface; solid; 700-mile range; nuclear	R&D; to replace REDSTONE
POLARIS (Navy)	Lockheed, prime; GE, guidance; Aerojet-General, propulsion	Underwater and surface-to-surface; solid; 1500-mile range; nuclear	37 launchings of test vehicle; 26 successes; 9 partial; 2 failures; launched from surface ship Aug. 27, 1959; expected operational late 1960
RAVEN (Navy)	No contract announced	Air-to-surface; about 500-mile range	Study
REDEYE (Army)	Convair, prime	Surface-to-air; 20-lb. bazooka-type; IR guidance; solid; conventional	R&D
REDSTONE (Army)	Chrysler, prime; Ford Instrument, guidance; Rocketdyne, propulsion	Surface-to-surface; liquid; 200-mile range; nuclear	Deployed with U.S. troops in Europe
REGULUS (Navy)	Chance Vought, prime; Sperry, guidance; Aerojet-General, propulsion	Surface-to-surface; turbojet & solid; 500-mile range; nuclear	Deployed aboard U.S. submarines
SERGEANT (Army)	JPL/Sperry, prime; Sperry, guidance; Thiokol, propulsion	Surface-to-surface; solid; more than 75-mile range; nuclear	Production. To replace CORPORAL
SHILLELAGH (Army)	Aeronutronics, prime	Surface-to-surface; lightweight; can be vehicle-mounted	R&D; expected to be operational mid-1960's
SIDEWINDER (Navy)	Philco, prime; Avion, guidance; Naval Powder Plant, propulsion	Air-to-air; IR guidance; 6-7-mile range; conventional	Deployment with Naval and Air Force units
SLAM (Air Force)	No contract announced	Surface-to-surface; low-altitude; supersonic; nuclear-powered ramjet; nuclear	Study-R&D
SNARK (Air Force)	Norair, prime; Northrop, guidance; Aerojet-General, propulsion	Surface-to-surface; 5500-mile range; solid and turbojet; Mach .9; nuclear	Deployed at Presque Isle, Maine
SPARROW III (Navy)	Raytheon, prime; Raytheon, guidance; Aerojet-General, propulsion	Air-to-air; 5-8-mile range; Mach 2.5-3; solid; conventional	Operational with carrier aircraft; earlier SPARROW I obsolete
SUBROC (Navy)	Goodyear, prime; Kearfott, guidance; Thiokol, propulsion	Underwater or surface-to-underwater; 25-50 mile range; solid; nuclear	R&D
SS-10 (Army)	Nord Aviation, prime	Surface-to-surface; primarily anti-tank; 1600-yards range; 33 lbs. solid; wire guided; conventional	Operational with U.S. and French units; battle-tested in North Africa
SS-11 (Army)	Nord Aviation, prime	Surface-to-surface; also helicopter-to-surface; 3800-yard range; 63 lbs.; wire guided; conventional	Operational. Under evaluation by Army.
TALOS (Navy)	Bendix, prime; Farnsworth/Sperry, guidance; Bendix/McDonnell, propulsion	Surface-to-surface; 65-mile range; solid & ramjet; Mach 2.5; nuclear	Operational this year aboard cruiser Galveston
TARTAR (Navy)	Convair, prime; Raytheon, guidance; Aerojet-General, propulsion	Surface-to-air; 10-mile range; Mach 2; 15 feet long & 1 foot in diameter; solid dual-thrust motor; conventional	Many test firings in Pacific; expected deployment 1960 as primary armament of guided missile destroyers; production
TERRIER (Navy)	Convair, prime; Reeves/FTL, Sperry, guidance; ABL, propulsion	Surface-to-air; 10-mile range; Mach 2.5; 27 feet long; solid; conventional	Operational with fleet
THOR (Air Force)	Douglas, prime; AC Spark Plug, guidance; Rocketdyne, propulsion	Surface-to-surface IRBM; 1500-mile range; liquid; nuclear	Operational; bases being set up in England, possibly Turkey soon; 42 launchings: 26 successes; 9 partial; 7 failures
TITAN (Air Force)	Martin, prime; Bell, Remington Rand, guidance; Aerojet-General, propulsion	Surface-to-surface ICBM; 5500-mile range; liquid; 90 feet long; nuclear	5 launchings test vehicles: 4 successes; 1 failure; expected to be operational late 1960-early 1961
WAGTAIL (Air Force)	Minneapolis-Honeywell, prime	Air-to-ground; low-level; solid; designed to climb over hills and trees	R&D
ZUNI (Navy)	Naval Ordnance Test Station, prime	Air-to-air, air-to-surface; solid; unguided rocket; 5-mile range; conventional	Operational



The man:

A U.S. Army missileman working with Nike Hercules missile equipment. The modern Army relies heavily on the special skills and knowledge of men like this who are trained extensively in military schools, and supported technically in the field by Army Ordnance Corps, Western Electric and Douglas field service men.

The mission:

Defense of U.S. cities. Army Nike Hercules units are already on duty at many key points...have the important assignment of guarding against enemy aircraft.

The missile:

Douglas-built Nike Hercules, product of a Douglas-Western Electric-Army Ordnance team, has successfully engaged supersonic drone targets at altitudes well over 60,000 feet. Other drone targets have been destroyed up to 100,000 feet, and at ranges beyond 75 miles.

Status	Combat ready
Range	75 miles plus
Speed	Supersonic
Warhead	Nuclear or conventional
Service	U. S. Army

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(continued from page 22)

gree of compromise or, alternatively, an initial fabrication history which would account for the effect of forming.

• **Joining**—Perhaps the most important requirement for transforming beryllium products into useful structural elements is the capability of being joined with no appreciable sacrifice in properties. The methods of joining which are available are: mechanical fastening, brazing, welding, and adhesive bending. Each method has certain advantages but all have disadvantages which will require solution.

Mechanical fastening will require a study of twinning damage, stress concentrations, joint configurations, drilling techniques and remedial treatments before and after assembly. Brazing will require study of intermetallic compounds, brazing alloys, protective atmospheres, joint configurations, brazing parameters, and crystallographic effects. Welding will pose similar but more severe problems than brazing. Adhesives will have a limited application and present no significant problems.

• **Design Information**—The anisotropic character of wrought beryllium and the damaging effect of many factors will require new criteria for characterizing beryllium's design properties.

• **Alloying**—Although alloying in itself may not prove feasible, it would provide a basis for defining the influence of impurity phases in heat affected regions and for developing filler metals for welding and brazing.

• **Crystal Structure**—Perhaps the most important single physical factor that has impeded the development of structural beryllium which would be superior to conventional metals for a given application has been the anisotropic character of the crystal structure. The atomic arrangement—a hexagonal close-packed system—is deficient in its ability to flow plastically for arbitrary stress states. Essentially, three atomic planes govern the brittle or ductile behavior of beryllium.

These planes, the direction in which flow or fracture occur, and the stress required to initiate flow or fracture are illustrated for a unit cell in Fig. 1. The $10\bar{1}0$ prism plane has been established as the principal slip system and, as measured in single crystal studies, requires about 20,000 psi to initiate slip. The 0001 basal plane and $11\bar{2}0$ prism plane are the principal sources for fracture—having fracture stresses of about 4500 psi and 26,000 psi, respectively, as measured for a single crystal.

Comparing the three stress levels, it is apparent that the low ductility of beryllium is dependent on the resolved stress to which the basal planes are subjected.

As the number of crystals increases, the stress state required for plastic flow or fracture will change—depending on the geometric relation of the crystals—because of the interaction among the crystals. However, plastic flow or brittle fracture of the polycrystalline aggregate would be governed by the three atomic planes at stress levels somewhat proportional to those for single crystals. If the resolved stress normal to the (0001) basal plane is maintained below a critical value for a given applied stress, then the plastic flow of the $(10\bar{1}0)$ prism planes will predominate.

The natural conclusion can then be drawn that it would be desirable to align the basal planes of all the crystals in the polycrystalline aggregate parallel to the applied force; then the stress normal to the basal planes would be zero. Practically, it would be impossible to obtain this ideal arrangement, but fortunately when a large number of basal planes are more or less parallel, then ductility is evidenced. In fact, sheet has been produced which has developed elongations in excess of 50% in the plane of the sheet.

• **Fabrication Process**—In the past, the study of beryllium crystal structures and related mechanical properties indicated the following: the mechanical characteristics of wrought beryllium are attributable, when all other influencing factors are held constant, to the crystallographic texture. More specifically, the mechanical properties, the characteristic response to a stress state, and the developed anisotropy of beryllium depend on the manner and degree of deformation. Such factors as grain size and impurities still required solution.

The employment of castings as a starting condition for wrought forms did not meet with success. Fortunately, a fine-grained structure was made possible by the introduction of semi-powder metallurgy techniques. The powder—produced by attritioning beryllium chips—develops an oxide coating which inhibits grain growth during processing. The influence of the second factor, impurities, was minimized by employing inert atmospheres and vacuum.

Having identified and partially resolved the important embrittling problems, it was possible to produce various shapes by hot-pressing (sintering under pressure); hot-pressing and extruding, and hot-pressing, extruding, and rolling. In general, while the processed metal was mechanically superior to shapes produced from castings, the material did not develop the qualities necessary for efficient structural design.

Paradoxically, isotropic material, produced by hot-pressing, and the highly anisotropic material, produced by hot-pressing and extruding, exhibited undesirable mechanical characteristics. The former developed only moderate strength $F_{tu} = 40 - 50{,}000$ psi; $F_{ty} = 20 = 30{,}000$ psi and low ductility (0 - 1%). On the other hand, extrusions, made with large reductions, developed highly directional properties. In the direction of extrusion, high strength ($F_{tu} = 100{,}000$ psi) and high ductility (10%) were developed. However, because of the highly aligned atomic planes, the transverse properties were very poor. Furthermore, the extrusions would not withstand, without fracture, even moderate eccentric loading.

When the semi-powder metallurgy techniques were extended to the fabrication of sheet (hot-pressing, extruding and cross-rolling), it was demonstrated that, in addition to the development of

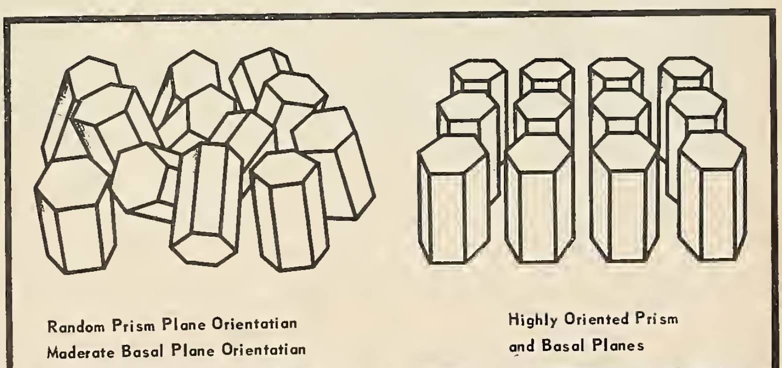


FIG. 2—Crystallographic texture in moderately and highly worked beryllium powder.

rather high strength, a phenomenal increase (in excess of 50%) in the ductility was obtained. Although the mechanical properties were exhibited in tests on small specimens, the results of these investigations established the practical significance of preferred crystal orientation. The preferred crystal orientation, termed "layer texturing," is identified, in the case of sheet material, with a predominant number of crystals having their basal planes parallel to the plane of the sheet. One deficiency arises, however, in that the anisotropy of the single crystal is manifested, i.e., the thickness direction of extruded cross-rolled sheet did not exhibit measurable plastic flow. Furthermore, beryllium sheet produced by this technique was sensitive to size embrittlement. The size embrittlement is simply a loss of ductility as the size of the element increases—which is in some manner related to the restraint developed in larger elements—thereby generating a resolved fracture stress sufficiently large to govern failure.

• **Hot-Upsetting**—Recently, a novel method based on semi-powder metallurgy techniques was developed for producing beryllium sheet which would better satisfy the structural requirements of airframes. The method, called "hot-upsetting," although elementary in character, resolved many of the problems of brittleness and may have a far-reaching influence in prescribing the manner in which beryllium is fabricated. The sheet produced by hot-upsetting develops a strength in excess of 70,000 psi (governed by the amount of hot work) and an elongation in excess of 10%.

In a comprehensive evaluation of the mechanical characteristics of wrought beryllium, sheets made by three methods—hot-pressing, hot-upsetting, and extruding and cross-rolling—were comparatively tested. Respectively, the processes imparted increasing amounts of texturing—the hot-pressed sheet represented an essentially isotropic condition; the extruded and cross-rolled represented the highly anisotropic condition; and the hot-upset sheet represented an intermediate state of preferred orientation.

Tensile tests showed that elongation in the plane of the sheets was essentially proportional to the degree of hot work. The hot-upset sheet exhibited a ductility intermediate to sheet produced by the other two methods (hot-pressed, 0-1%; hot-upset 10-12½; extruded and cross-rolled, over 25%). In plane stress tests, in which $\sigma_x = \sigma_y - \sigma_z = 0$, the inverse held true, i.e., the highly worked sheet exhibited the greatest embrittlement. In another evaluation, a measure of the bend ductility as a function of size or size embrittlement was made. Although the essentially isotropic hot-pressed sheet exhibited a uniaxial ductility of about 1%, its bend ductility was considerably superior to the extruded and cross-rolled sheet. However, the trend for size embrittlement increased with increasing sheet size and it was significantly inferior to hot-upset sheet.

The importance of bend ductility cannot be quantitatively established, at this time, for structural applications, but it is a well-known precept that ductility, while not accounted for in stress analysis, is an essential quality necessary for redistributing high local stresses and for withstanding the embrittling effect of complex stresses.

A characterization of the disposition of crystals is shown in Fig. 2 for sheet made by two techniques. On the left, a moderately oriented crystal structure represents sheet produced by moderate deformations such as hot-upsetting. On the right, the highly aligned structure is developed as in extrusion and cross-rolling.

A log-log plot illustrating the bend ductility of beryllium sheet produced by three different fabrication methods is shown in Fig. 3. The permanent deflection in inches is plotted on the ordinate, and a width-to-thickness ratio is plotted on the abscissa. A constant width-to-thickness may not behave in the same way. In addition to the plot of data, some typical bend ductility specimens are shown in Fig. 4 for extruded and cross-rolled and hot-upset sheet. The highly developed crack pattern of the ductile extruded and cross-rolled sheet is coincident with the alignment of the $11\bar{2}0$ prism planes.

The conclusion that can be drawn from the foregoing discussion of the three sheet fabrication processes can be summarized as follows:

1) An isotropic polycrystalline aggregate cannot develop satisfactory mechanical properties because of the lack of hot work.

2) A large amount of the hot work or reduction can be associated with a highly preferential grain structure and

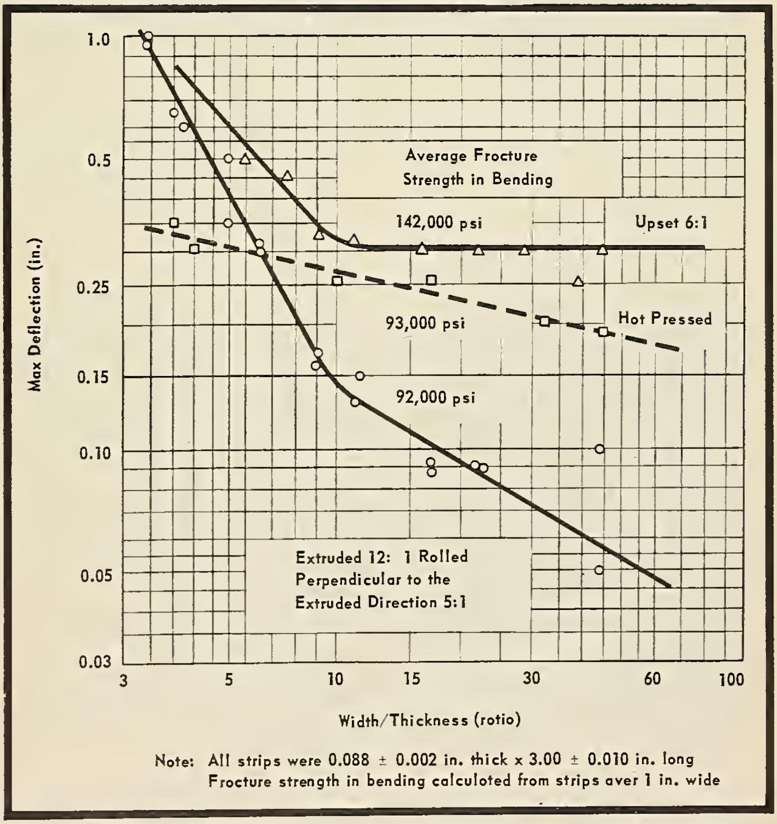


FIG. 3—Bend ductility of beryllium as it is influenced by size and the method of fabrication. A constant width-to-thickness may not behave in the same way.

therefore anisotropic properties. Although the mechanical properties developed by large reductions are apparently high in certain directions (as determined in a tensile test) under practical circumstances, even ductile beryllium becomes brittle.

3) The manner and degree of hot work which produce a prescribed texture are necessary antecedents to the development of a structural beryllium.

The structural superiority of hot-upset sheet—established in the comparative examination of sheets produced by several fabrication techniques—has been demonstrated in the preliminary sense. Although definitive fabrication parameters have not yet been established, it is expected that the texture requirements for structural beryllium are significant and essential.

• **Brittleness**—The factors which cause the embrittlement of beryllium have been identified, and a relatively large improvement has been made toward eliminating this deficiency. Even though a quantitative design value for critical embrittlement cannot be established, the incipience of brittle failure appears to remain an important consideration. If the causes which bring about embrittlement of beryllium are fully understood, then it should be possible through process control and design to circumvent the critical conditions.

A complete specification of the causes of embrittlement would include the following:

1) Grain Size: Semi-powder metallurgy techniques have eliminated this factor as an initial cause for embrittlement. However, subsequent brazing, welding and processing or prolonged exposure at elevated temperature may bring about grain growth.

2) Transition Temperature: The impact transition from brittle to ductile behavior occurs above 400°F and increases readily with increased impurities, cold work, and stress state. The impact strength of beryllium is much below the poorest structural alloys. Although impact strength has been a consideration for material selection, the value of this property in design applications has not been quantitatively established. However, it appears that finite strain rates rather than impact would govern in the intended applications.

3) Impurities: Impurities in the form of oxides and trace metals can produce significant embrittlement. The trace metals occur in form of impurity phases—alloys or intermetallic compounds, and their influence can be manifested as a reduction of ductility at lower temperatures or grain boundary weakening at elevated temperatures (about 900°F, depending on the material) as the result of possible precipitation of the impurity phases. Although the initial purity can be assured, the residual trace impurity content may produce a measurable effect when it is combined with other factors.

4) Notches: It appears that notch sensitivity will remain an important cause of embrittlement in beryllium. However, it will be possible to minimize the sensitivity to notch embrittlement by rigidly observing a defined fabrication history.

5) Stress State: Because of the low fracture stress of the basal planes, biaxiality and triaxiality may produce resolved stressed sufficiently high to cause failure at low applied stresses. The magnitude of this effect can be greatly diminished by the development of a prescribed crystallographic structure. An associated cause of embrittlement, the size effect (not necessarily related to the statistical occurrence of major flaws), can at the same time be reduced when the specified fabrication history is observed.

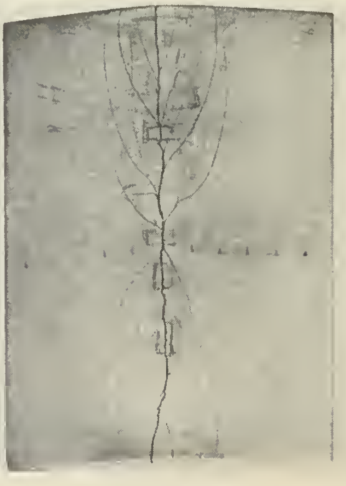
6) Twinning: The phenomenon called twinning is an alteration of the crystal structure generated by machining or forming below the recrystallization temperature. This factor can severely embrittle the most ductile beryllium. Generally, annealing and/or etching will restore the ductility of the metal.

• **Structure property tests**—The superiority of beryllium to other structural metals must also be weighed with its deficient characteristics. Strength and ductility determined by standard test techniques have been adequate indices for characterizing the structural merit of conventional metals. However, the behavior of beryllium is markedly influenced by factors which are normally considered unimportant. These factors have been briefly discussed relative to embrittlement. Now it becomes necessary to establish a standard for qualifying the structural utility of beryllium as a function of these factors.

The standard tensile test is an unconservative measure of beryllium's mechanical characteristics. As the gage width (size of the element) increases, ductility decreases; and, while the embrittling effect of size has not been carried out to gage widths beyond one inch (generally because of the high cost of specimens, about $100-200 each), it is presumed that large forms may develop only a fraction of the ductility measured in a tensile test. Size effect studies for tensile tests (conduced by the author) have shown the occurrence of this phenomenon in three separate determinations for beryllium sheet produced by three techniques.

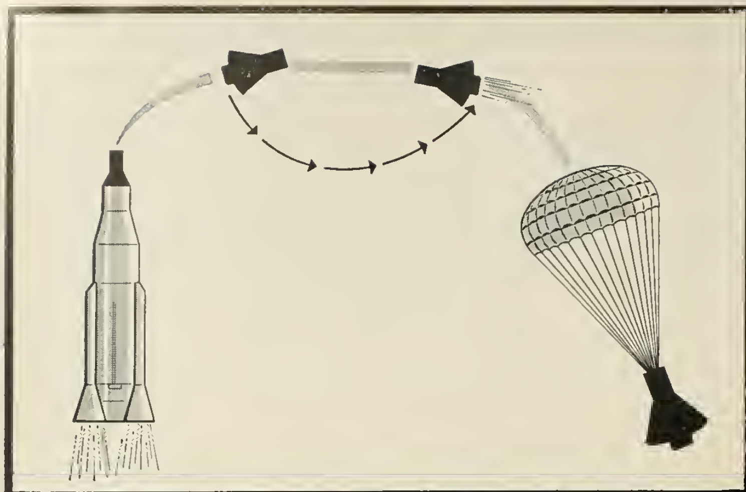
The potential value of beryllium in weapon systems structural components should be sufficient reason, in itself, for an intensive development program. With this development program, coupled with the advances which have been made recently in the beryllium technology, there is every reason to expect that beryllium will soon be classified as an important structural material.

Extruded
Cross-Rolled



Hot-Upset Sheet
6:1 Ratio

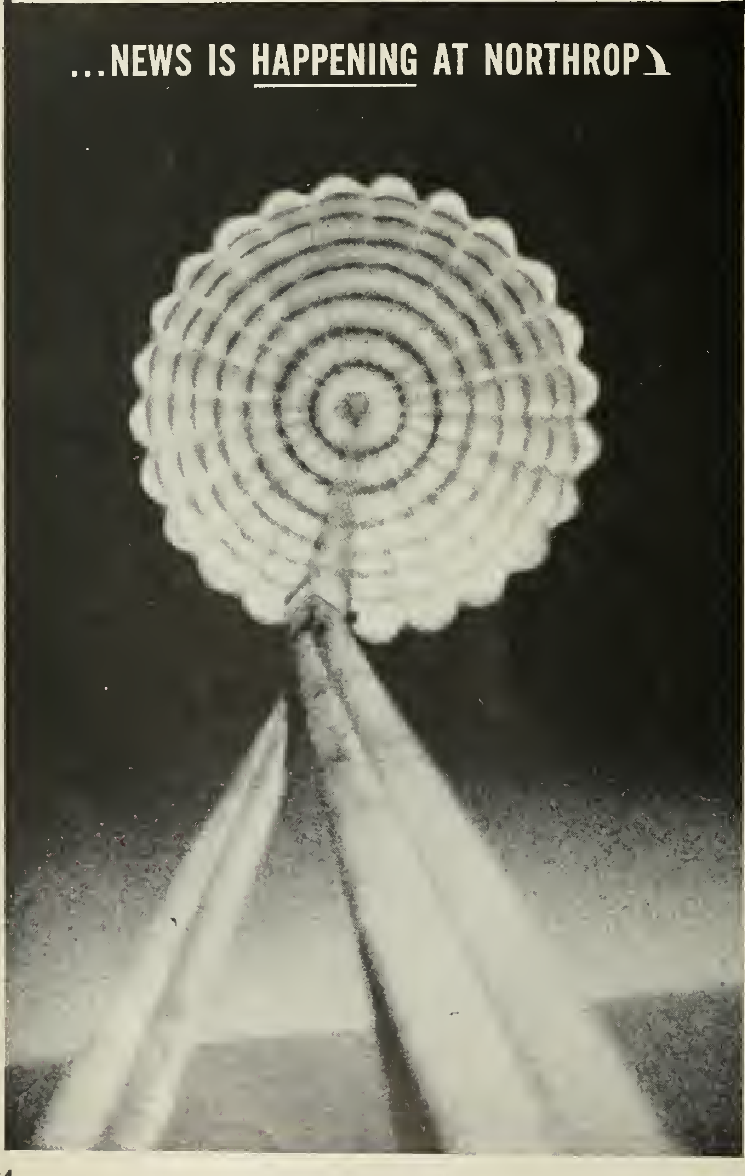
FIG. 4—Crack patterns in bend ductility test specimens of beryllium sheet fabricated by two techniques. Note highly developed crack patterns on the left.



1. NASA flight plans call for ICBM-launching. The manned Mercury capsule will reach orbital velocity at about 120 miles, separate from the missile and ride horizontally in orbit.

2. Hurtling at 18,000 mph, the capsule will circle the earth in 90 minutes. Going into its re-entry phase, the capsule will be rotated by attitude controls to come "home" bottom down.

3. A drogue parachute will be deployed at 70,000 feet, decelerate the capsule and stabilize it. The final descent chute will be deployed at 10,000 feet preparatory for surface landing. Just prior to landing, pneumatic bags stored in the rim of the capsule will inflate to assure stability if landing is in water.



NEW TYPE OF RADIOPLANE PARACHUTE AN INTEGRAL PART OF NASA'S PLAN FOR RECOVERING FIRST MAN IN SPACE

The leader in the development, testing and manufacture of recovery systems–Radioplane–was selected by McDonnell Aircraft Corp. to join the National Aeronautics and Space Administration's Project Mercury.

Today Radioplane is readying the capsule landing system. For the project, Radioplane will use the new Ringsail parachute–a parachute with two radical departures from conventional Ringslot style. For a new kind of performance, Radioplane designed the new crescent-shape-slot parachute. The Ringsail withstands and reduces by as much as 35%, parachute opening shock at high-speed deployment. Drag coefficient and inherent stability are increased.

To solve the problem of aerodynamic heat without loss of strength, Radioplane is presently developing a high-temperature-tolerant fabric for drag devices.

This landing system for Project Mercury exemplifies Radioplane's unique capabilities. Scientists and engineers in Radioplane's Paradynamics Group combine their experience in the recovery field with the newest in equipment to develop systems with the highest degree of reliability. They are continually solving the increasingly complex recovery problems of the space age – producing the most efficient answers – at minimum cost.

RADIOPLANE

Von Nuys, California, and El Paso, Texas
A Division of ***NORTHROP CORPORATION***

Circle No. 11 on Subscriber Service Card.

Space Temperatures Simulated in Chamber

One of the problems of the Space Age is development of materials that can withstand sudden and extreme temperature changes. Accompanying this is a need for equipment to test them.

Such a piece of equipment is the environmental chamber. This is a box-like unit in which temperature, air pressure and humidity can be carefully regulated to test airplane, missile and rocket components under conditions simulating those encountered in flight.

Recently the U.S. Navy asked **Webber Engineering Corp.** to develop a chamber that would test materials at 1000°F. This is hot enough to melt lead or zinc, and to consume a piece of cloth almost instantaneously.

Interior volume of the chamber was to be 27 cubic feet. Because of the heat extremes involved, heavy insulation between the inner and outer shells would be necessary. But if the insulating materials previously used for environmental chambers were employed, each wall would have to be 16 to 18 inches thick, drastically increasing the amount of floor space needed for equipment.

Webber's engineers found the reinforced insulating material needed in Foamsil, a light-weight, 99% pure fused silica foam developed by the **Pittsburgh Corning Corporation.** Tests proved that Foamsil could withstand up to 2200°F., 1200° above the Navy's specified ceiling. It also was tested successfully at 1500° for 96 hours and minus 2000 degrees for another 96 hours.

A shock test also was run, in which the temperature of the testing chamber was raised from 80 degrees ambient to 1000 degrees in 15 minutes. The level was then dropped to 100 below zero with no damage or breakdown in the insulating material.

Most important, it was determined that all the Navy's requirements could be met or surpassed by a chamber with Foamsil walls only six inches thick. These consisted of three layers of 17-inch by 22-inch by 2-inch blocks, bonded together and to the cabinet wall with a bonding material capable of withstanding the required temperature range.

The entire cabinet was insulated with Foamsil blocks, weighing a combined 945 pounds. Insulating cost was about one-fifth of that for a chamber with 18-inch walls of other available materials. In addition, a chamber with thicker walls would have required substantially more steel and additional labor to construct.

Foamsil also proved rugged and easy to handle. It has a compressive strength of 200 pounds per square inch, and it can be drilled, sawed or cut. It does not absorb moisture. As a result there was no condensation on the exterior of the chamber with low interior temperatures, and low transmission of heat to the exterior with high interior temperatures.

new missile products

By using Foamsil, Webber Engineering was able to keep overall dimensions of the pilot unit, including refrigerating, heating and control equipment, to four feet by five feet by six and a half feet.

As the result of developing the chamber for the Navy, the Webber company has manufactured a standard model incorporating temperature extremes of 1000 degrees and minus 100 degrees with an altitude pressure testing to 100,000 feet and humidity control from 20 to 95% and relative humidity in the 35 to 185°F. range.

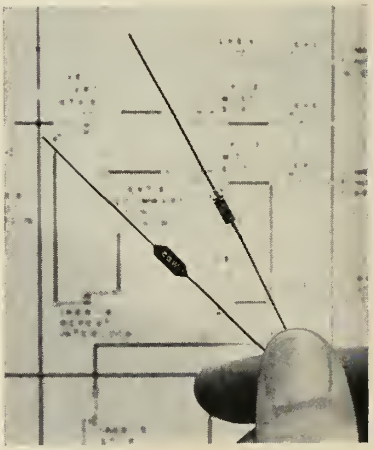
Circle No. 225 on Subscriber Service Card.

Oxide Film Resistors Made in 1/8 Watt Ratings

Oxide film resistors in new 1/8 watt ratings will be introduced by **Corning Glass Works** at the 1959 WESCON Show in San Francisco.

The new miniature components have been added to two lines of encapsulated resistors produced by Corning's Electronic Components Department at Bradford, Pa. Both the epoxy-coated N-60 resistor and the glass-enclosed NF-60 resistor conform to MIL-R-10509C, characteristic B.

The new units are the first 1/8 watt resistors to be made by Corning.



They are approximately 3/8 inches in length and 1/8 inches in diameter.

The epoxy-coated resistor was introduced in ½ and ¼ watt sizes at the Radio Engineering Show in March. Its coating is said to provide excellent insulation and moisture resistance.

In the new 1/8 watt rating, as in the currently available ¼ watt size, its glass case is joined to the resistance element in a true glass-to-metal seal.

According to the company, this makes the components absolutely impervious to moisture.

Both new 1/8 watt units have a resistance range of 10 to 100,000 ohms at 250 volts and 70C, with derating to 150C.

Circle No. 227 on Subscriber Service Card.

High Speed Digital Printer Transistorized

Potter Instrument Company, Inc., has announced the production of a high speed digital printer, Model 3303, completely transistorized and designed to be integrated into pre-flight checkout systems.

Built to conform to MIL-E-16400, the Model 3303 features print-out rates in excess of 10 lines per second and custom designed format with choice of number of columns up to 20 and type of characters or symbols.

Storage and programming electronics are offered in a separate housing that may be integrated with the printer onto a RETMA standard structure for rack mounting. Any character coding or single line control can be employed to control the printer.

Pressure sensitive paper is used to avoid the troubles usually experienced with ribbon and associated drive mechanisms.

Custom designs are available to satisfy specific system requirements. Physical dimension are: 8½" wide x 8" high x 15 7/8" long and 34 pounds in weight.

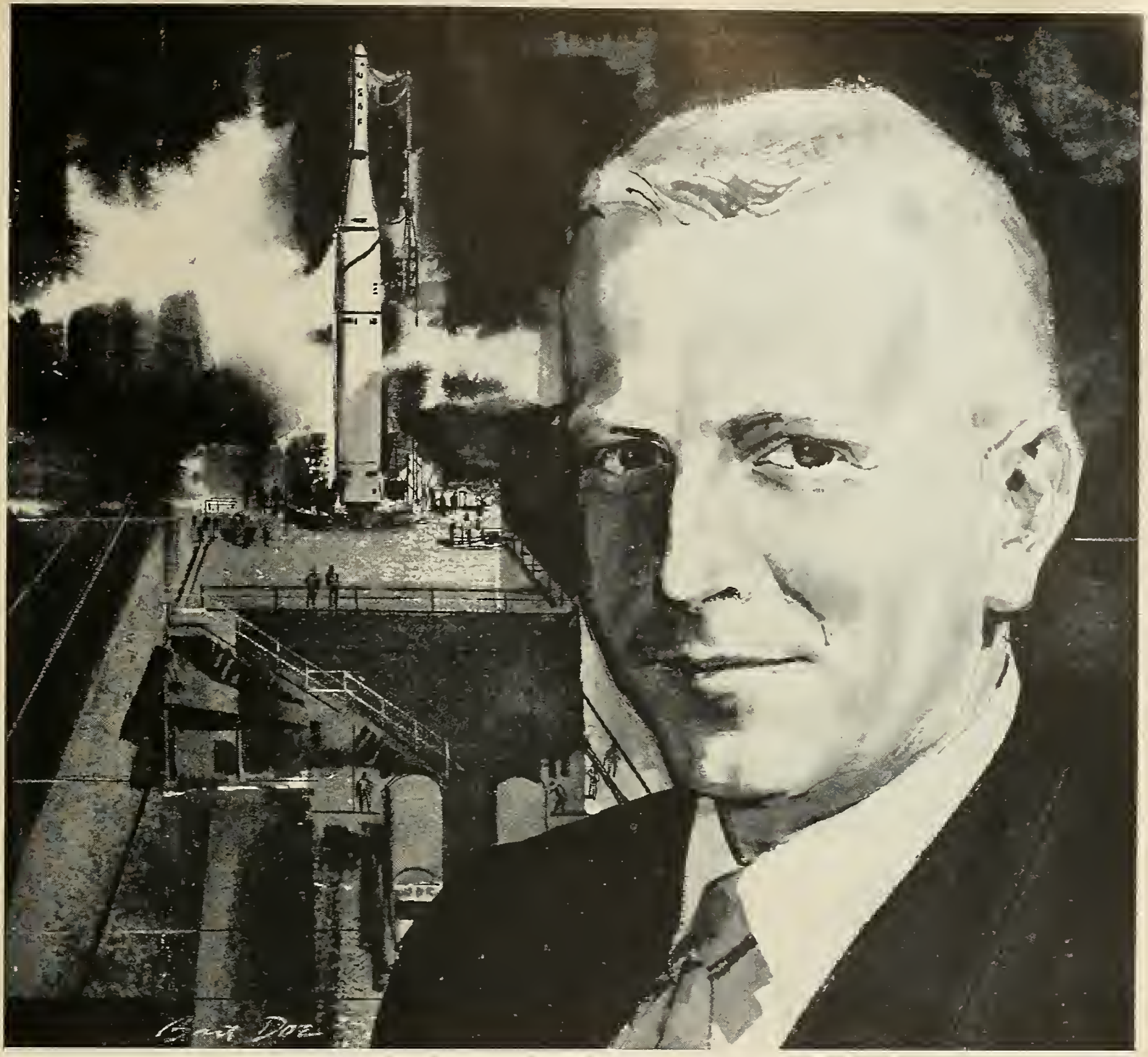
Circle No. 228 on Subscriber Service Card.

Line Shock Tester Costs Five Cents a Minute

Consolidated Electrodynamics Corporation, Rochester Div., has developed a compact shock tester which repeats either of a choice of two widely specified shock pulses in rapid succession.

Designed for on-the-line testing of high-volume production items, this new Hyge-6500 can perform a complete test cycle every minute. Unlike other units which require disassembly for a change of waveform, external adjustment permits change-over of the Hyge-6500 in just a minute or two.

Unit cost is kept low by limiting capability to the two shock test specifications most frequently encountered in volume production: MIL-E-5272A (11±1 ms Half-sine), and Ramo-



C. D. Boyce

October 1958, when the Thor-Able lunar probe soared 79,000 miles, was a time of quiet pride for Clay Boyce. Design engineer Boyce was responsible for successfully predicting the in-flight performance of the Aerojet second stage of the Able vehicle.

Clay Boyce has gone on to become an Aerojet Systems Division group leader, in charge of design and installation for the next generation of Able upper-stage vehicles for scientific and military applications. You'll agree, a mighty important assignment for a BSME still in his twenties.

Clay Boyce, with Aerojet since 1955, exemplifies the possibilities that exist at Aerojet for professionally gifted younger men to perform tasks of engrossing interest. We'd be delighted to hear from *you*. Write: Director of Scientific and Engineering Personnel, Box 296J, Azusa, California, or Box 1947J, Sacramento, California.

Aerojet-General® CORPORATION

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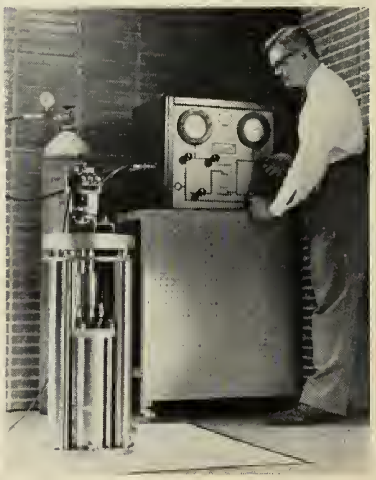
new missile products

Wooldridge (6±.5 ms Sawtooth). Purchase price is less than that of other testers limited to a single waveform. Use of compressed bottled nitrogen as the power source keeps operating cost down to an average of 5¢ per test.

The Hyge-6500 tests specimens ranging in weight from a fraction of an ounce up to 150 pounds . . . from transistors to motor generators. Internal deceleration eliminates the need for rail systems, so that wide, bulky specimens can be easily accommodated on the specimen carriage. The carriage is 12½" in diameter, and 2" thick with a natural frequency of 2000 cycles. Fixture mounting holes are standardized with those used in shaker testing.

Acceleration level for the half-sine test is from 10g to 100g. For the sawtooth test the level is 25g to 100g. Like change of waveform, acceleration level can be varied by a fast, simple external adjustment. Maximum specimen thrust is 15,000 pounds, the product of the maximum specimen mass accommodated and the maximum acceleration level attainable.

Elimination of external braking devices such as rail systems makes this Hyge-6500 compact enough to be built right into production lines. Base is only 13" square, while height is not quite



30". Simplicity of operation permits use of inexperienced help. Operating safety is assured by automatic pressure bleed-off after firing, and by manual operation of toggle valve to rebuild pressure for the next shot.

Circle No. 230 on Subscriber Service Card.

propulsion engineering

By M/R STAFF

Better than molybdenum . . .

is molybdenum silicide (Mo_3Si). Chemists and metallurgists know that the compound is better than unalloyed molybdenum at high temperatures: the silicide retains its strength better and shows greater resistance to corrosion. The reasons for this are now being uncovered by Prof. Erwin Mueller (renowned as the pioneer in work with the field emission microscope) and his colleague at Pennsylvania State University, Dr. E. C. Cooper. The two are studying surface migration of atoms under a contract with the Air Force Office of Scientific Research.

Migration rate of atoms . . .

is much slower on the surface of molybdenum silicide than on the surface of pure molybdenum, when traces of oxygen are present. Mueller and Cooper believe this is related to the strength of the silicide in this way: Materials which are not readily deformed often are ones from which dislocations cannot be removed at the surface—a result of slow atom migration and rearrangement on the surface.

High-temperature strength . . .

of molybdenum silicide may depend on the presence of oxygen and its action in blocking surface migration, reports AFOSR's Solid State Sciences Directorate, which administers the Mueller contract. It says that when the last trace of oxygen was removed from the apparatus in which the Pennsylvania State team studied the metal and its alloy, "the migration rate on the silicide greatly increased until it equaled that on molybdenum."

The most important point . . .

made by the study, AFOSR concludes, is that the discovery "emphasizes the need for further studies of the properties of metals in ultrahigh vacuums where the absence of normally present contamination may alter important physical properties."

"It may develop . . .

for example," the office suggests, "that molybdenum silicide is weak rather than strong, in a good vacuum at high temperatures." The implication here is that a material we now regard as ideal for certain applications may fail us completely under some space conditions.

Solid propellants . . .

were the subject of another recent AFOSR activity. The classified (confidential) 15th Annual Meeting of the Joint Army-Navy-Air Force Solid Propellants Group, Washington, D.C., brought together 750 people. Most of them were from working levels of research and development on solid propellants. It was the largest meeting of its type ever held.

Some solid propellants contractors . . .

who attended the meeting and contributed papers: Dr. Raymond Friedman, **Atlantic Research Corp.**; Dr. R. F. Chaiken, **Aerojet-General**; and Prof. C. J. Marsel, New York University. All hold Air Force research contracts. What they discussed and what their prime interests are cannot be revealed. However, Friedman is one of the nation's leading authorities on flame and combustion. He held a $250,000 grant from the Air Pollution Foundation for basic studies on combustion which other chemists might someday apply to the problem of air pollution resulting from incomplete combustion in automobile engines. Marsel, a prominent chemical engineer, was one of the first persons to have wide knowledge of plans for chemical fuel (boron) operation of the B-70. Under AFOSR rules, their studies must be fundamental and out of the ordinary.

Red Astronauts Not Yet Chosen

from an m/r correspondent

LONDON—Russia is planning several lunar probes soon but has not yet selected astronauts for her first manned space flights.

Furthermore, Academician Leonid Sedov told a news conference last week, Russia has not even fired a prototype of a manned capsule on a simple ballistic trajectory. This could indicate the Soviet "man in space" program is not ahead of America's Project *Mercury*.

Sedov, head of the three-man Soviet delegation to the annual congress of the International Astronautical Federation, agreed with NASA Deputy Administrator Hugh Dryden that international cooperation in space is very desirable. Sedov said his nation will cooperate with the U.S. in a major space exploration experiment or a series but the question should be settled first on the political level.

At the opening session of the conference attended by a record 600 delegates, Dryden declared that broad astronautics exploration is beyond the resources of any single nation and world cooperation is an immediate necessity.

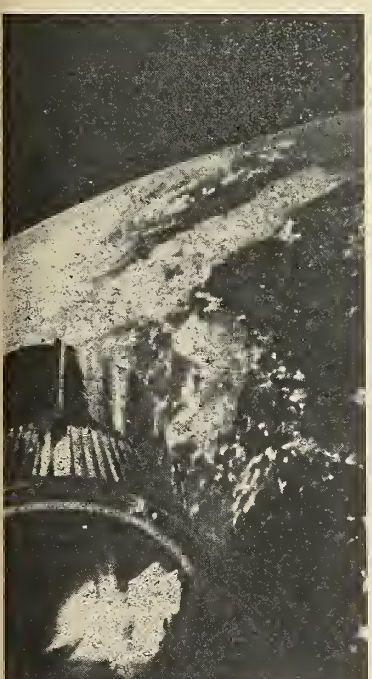
Americans again dominated the congress. The U.S. congressional delegation is reported headed for the Soviet Union next week to make an opening request for U.S.-U.S.S.R. astronautics cooperation.

Atlas Now Operational, Turned Over to SAC

WASHINGTON—The Air Force has quietly added the *Atlas* ICBM to its arsenal of operational weapons.

Air Force officials have disclosed that the big Convair missile was turned over to SAC at Vandenberg Air Force Base by ARDC on Aug. 31.

Defense Secretary Neil McElroy announced earlier this summer that *Atlas'* operational date had to be postponed until at least September because of technical difficulties. The Air Force has said the technical difficulties were solved and proved it by the recent series of successful *Atlas* firings from Cape Canaveral.



Atlas **RE-ENTRY vehicle looks back at Cape Canaveral shortly after separation from missile 295 seconds after lift-off Aug. 24. Florida east and west coasts run diagonally at upper right.**

U.K. Orders *Malkara* SSMs from Australia

LONDON—A "substantial" order for the Australian *Malkara* SSM has been placed by the British Ministry of Supply. The *Malkara* thus becomes the British Army's first anti-tank guided weapon.

Thirty *Malkaras* have been delivered for acceptance trials and 150 are understood to have been ordered some months ago. The ministry did not make it clear whether the order referred to now is in addition to these.

The weapon has had extensive trials on the Ministry of Supply range in Kircudbrightshire. It is cruciform-winged and is controlled by wires. The *Malkara* uses a solid fuel rocket. It weighs 200 lbs., is about 6 feet long and has a range of about 3,500 yards. It was designed by the Government Aircraft Factories, near Melbourne.

NSF Awards Grants for Gas, Plasma Research

CAMBRIDGE, MASS.—Fundamental research in plasma dynamics at M. I. T. and high-temperature gas dynamics at Harvard will be sponsored under grants from the National Science Foundation.

Dr. William P. Allis of M. I. T. said a $500,000 grant will lead to increased knowledge of electric plasmas and their uses.

Dr. Howard W. Emmons of Harvard disclosed that the $300,000 grant will support research into behavior of gases at high temperatures.

AMC Ballistic Center In Major Shakeup

Major reorganization is underway at the AF Air Materiel Command Ballistic Missiles Center, Beverly Hills, Calif. The change involves establishment of several new directorates. One combines the formerly independent staff agencies for procurement, and for production, into a single procurement and production directorate under Col. Samuel W. Bishop.

Former independent weapon systems organizations for *Atlas, Titan, Thor* and *Minuteman* have been merged under a single directorate of ballistic missiles headed by Col. John A. Kewitt. Col. Sherman E. Ellis is commanding the new directorate of satellite and space systems, which encompasses the old directorate of satellite systems and special projects.

The directorates of sub-systems and resources are being regrouped into a single directorate of equipment and installations under Col. William W. Snavely. This organization will include the functions of resources, installations, guidance, propulsion and reentry vehicles.

The Air Force is pressing development of a large packaged liquid rocket engine. It has awarded a contract to **Thiokol Chemical Co.'s Reaction Motors Division,** Denville, N.J., calling for refinements in present packaged state-of-the-art. Thiokol's *Guardian I* and *Guardian II* packaged engines are used in the Navy's *Sparrow III* and *Bullpup* missiles.

Rare-earth oxides research is being extended to July, 1960, by the AF Office of Scientific Research. The program at Ohio State's Research Foundation is expected to add considerably to the field of materials for high-altitude and space flight.

Minuteman Nose Cone Contract Won by Avco

The Air Force has awarded **Avco Corp.'s** Research and Advanced Development Division, Wilmington, Mass., a $36.6 million prime contract to develop an ablative re-entry vehicle for the *Minuteman* ICBM. Avco, prime for the *Titan* nose cone, will also develop advanced materials for *Minuteman's* rocket motor nozzles.

Ford Motor Co.'s Aeronutronics Division has an ARDC contract to use its BIAX computer elements in developing an electronic "logical evaluator set" for selection and retrieval of information from a large magnetic tape file . . . The AMC is buying $5.2 million worth of APN-59 radar sets from **Sperry Gyroscope** . . . In the first half of 1959, ARDC centers awarded $29 million in contracts; of the 1038 contractors, 669 were classified as small business.

Expansions and Mergers

A $1-million missile/space R&D facility is being built by **Solar Aircraft Co.** at San Diego . . . **Wirepots Ltd.** of England, potentiometer producer, has been purchased by **General Controls Co.,** Burbank, Calif. . . . Latest addition to New Jersey's growing electronics industry is **Oliver-Shepherd Industries**—a new company which will employ 250 persons at Nutley.

west coast industry

By FRANK G. McGUIRE

The name **Astrodyne** will be dropped, now that **North American Aviation** is full owner of the solid-rocket producer. The company will henceforth be known as the solid rocket operation of **Rocketdyne Division,** and will be as much a part of Rocketdyne as the Neosho operations.

The recruiting of personnel . . .

has been growing in intensity and audacity among the talent-starved firms of the missile industry. Several instances pointed out at the recent WESCON show by Arthur Hoppe of the San Francisco *Chronicle,* are actually ironical and humorous . . . though expensive for Uncle Sam. He ultimately gets the recruiting bill, which is estimated at $2 billion annually.

The recruiting that went on at WESCON was described by one electronics executive as "the greatest white-slave market in the world." Techniques ranged from that of **Republic Aviation Corp.,** (which handed out Chinese fortune cookies advising "A brighter future can be yours with Republic . . . ") to that of the unnamed company which is reported to have bribed the hotel telephone operators to mis-route calls intended for rival recruiting suites. One firm, also nameless, handed this writer a pack of recruiting cards with the suggestion that they be passed out to promising young talent!

Of the WESCON Attendance . . .

one in twenty was estimated to be a recruiting agent, and one-third of the remainder were supposed to be looking for new jobs. The pickin's are conceded to be much better in the smog-ridden, overcrowded Los Angeles area than in the San Francisco Bay area. In order of apparent importance to available engineers are the type of job offered, local living conditions, and salary—which is now pretty well standardized in similar technical positions.

Probably the most ironical instance . . .

cited about the recruiting scramble is that of one electronics company executive who sadly related: "We sent ten strong, eager and dependable recruiters out to an electronics show in Chicago recently . . . and do you know—only four came back! "

The X-15's interim powerplant . . .

will probably remain "interim" for a long time. Many here hold that the single-barreled XLR-99 engine won't be ready even by the end of 1960, although some optimists expect delivery by the middle of the year. The research craft's present powerplant consists of two RMI XLR-11 engines, each with four nozzles developing 2000-pounds-thrust. The resulting 16,000 pounds thrust is one-fourth that of the XLR-99—a 50,000-pound-thrust engine. The XLR-11, incidentally, was first tested at Edwards AFB ten years ago as the first operation in the base's rocket test facility.

Production-line economy paid off . . .

for Uncle Sam in the T-33 jet trainer program just terminated at **Lockheed.** The aircraft, described as a "transistion trainer between yesterday's aircraft and tomorrow's spaceships," was reduced in cost so drastically that the final aircraft, No. 5691, cost 1/25 of the first. Another example, also at Lockheed, is that of a $10,000 annual saving through reduction of console-lights for electronic equipment from 150 types to four.

Consolidated Electrodynamics Corp. . . .

is in the strongest financial position in its 22-year history, the firm says. Sales, new orders and backlog for the first six months topped all similar periods for the company and its subsidiaries, while earnings after taxes were $858,844, topped only by the record first half of 1957. The CEC 4½%, 25-year, $7,616,500 convertible subordinated debenture issue was 96.61% subscribed through exercise of stockholder rights.

contracts

MISCELLANEOUS

$8,500,000—Bendix Aviation's System Division, Ann Arbor, Mich., for development of communications subsystem for Project *Notus*.

$5,500,000—General Electric, Missile & Space Vehicle Dept., for development of the satellite vehicle system for Project *Notus*.

$3,100,000—Cornell Aeronautical Laboratory, Buffalo, N.Y., for construction and operation of a wind tunnel for long-duration testing of hypersonic missiles.

$1,535,000—Bell Aircraft Corp., Avionics Division, Buffalo, N.Y., for spare parts for a coder-decoder group used with radars to determine friend-or-foe.

$1,000,000—General Dynamics Corp., for continuation of feasibility study of space vehicle propulsion through controlled nuclear pulses at John Jay Hopkins Laboratory for Pure and Applied Science, San Diego.

$117,000—Northrop Corp., Radioplane Div., for development and production of four prototype recovery systems for the Mark 3C test vehicle. (Sub-contract from General Electric's Missile and Space Vehicle Dept.)

ARMY

$4,430,000—Radio Corp. of America, Moorestown, N.J., for UHF precision-tracking radar for *Nike-Zeus*.

$264,000—Parabam, Inc., Hawthorne, Calif., for design and fabrication of 21 astrodome-type shelters for the protection of optical missile-tracking instruments. (Three contracts.)

$262,805—General Electric Company, Schenectady, N.Y., for electron tubes. (Two contracts.)

$191,151—Steel Erectors, Inc., Savannah, Ga., for construction of radar tower, utilities and electrical distribution at Charleston AFB.

$64,932—Kuthe Laboratories, Inc., Newark, N.J., for electron tubes.

$56,475—Sylvania Electric Products, Inc., N.Y., for electron tubes.

$50,683—Raytheon Co., Newton, Mass., for electron tubes.

$31,616—International Telephone & Telegraph Corp., Clifton, N.J., for electron tubes.

$26,462—Tung-Sol, Inc., Newark, N.J., for electron tubes.

$25,500—Raytheon Co., Microwave & Power Tube Div., Waltham, Mass., for electron tubes.

AIR FORCE

General Electric Missile and Space Vehicle Dept., Philadelphia, has been awarded a contract for research and development of the re-entry vehicle or nose cone of the *XGAM-87A* missile. Amount not disclosed. (Subcontract from Douglas Aircraft Co.)

$9,000,000—Burroughs Corp., for SAGE air defense units.

$1,750,000—Summers Gyroscope Co., Santa Monica, Calif., for additional guidance subsystems and parts for the GAM-72 *Quail* missile. (Subcontract from McDonnell Aircraft Corp.)

$1,365,343—Canadian Commercial Corp., for 60 coordinate data monitors which decode telephone line signals from search radar.

$45,080—American Institute for Research, Pittsburgh, Pa., for investigation to determine optimal learning units and optimal presentations for use with automated instruction.

$26,101—Boston University, for research in statistical quantum mechanics.

$25,997—University of Miami, for continuation of research on Nuclear Emulsion Studies of Antiprotons, Strange Particles and K Meson Interactions.

$23,000—Bogue Electric Manufacturing Co., Paterson, N.J., for development and production of ultrasonic continuous liquid level measuring equipment to control both liquid oxygen and liquid nitrogen level in a double dewar vessel, storing super cooled liquid oxygen.

when and where

AFOSR/Directorate of Aeronautical Sciences, Office of Naval Research National Science Foundation, Sixth Midwestern Conference on Fluid and Solid Mechanics, University of Texas, Austin, Sept. 9-11.

New York University's College of Engineering, Titanium Metallurgy Conference. For information: Dr. Harold Margolin, New York University, University Heights, New York, Sept. 14-15.

Society of Automotive Engineering, Display of USAF Ground Support Equipment for Manned and Unmanned Aerospace Vehicles, Milwaukee Arena, Milwaukee, Sept. 14-15.

Institute of the Aeronautical Sciences, Western Regional Meeting on Frontiers on Science and Engineering, Los Angeles, Sept. 16-17.

Army Signal Corp., Conference on Effects of Nuclear Radiation Semiconductors, Western Union Auditorium, New York, Sept. 17-18.

—people—

CASTRUCCIO

Dr. Peter A. Castruccio, one of the country's foremost space scientists, has been elected technical director of the newly-formed Aerospace Division, Aeronca Manufacturing Corp. Dr. Castruccio has played a major role in the development of several military missiles and weapon systems. In 12 years with American industry, he has to his credit some 200 disclosures and about twenty patents pending or issued. He is on M/R's Editorial Advisory Board. **J. A. Wascavage,** formerly of Westinghouse Air Arm Division, has been named director of marketing of the new division.

James E. Veres has joined the staff of Summers Gyroscope Co.'s military relations department as senior applications engineer. Veres formerly was a sales engineer with Brush Instruments Division, Clevite Corp.

Filtron, Inc., has announced the appointment of five new engineers and scientists to staff positions in the Systems Division. The new associates are: **Kim R. Schuette,** former physicist with the National Bureau of Standards; **Denny Williams,** former chief engineer and consultant in radio interference suppression; **Clifford T. Culver,** formerly with Convair Astronautics Engineering; **George C. Stump, Jr.,** former senior engineer at Martin-Denver; and **Hollice Favors,** former project engineer on the AN/APQ53 project.

WHEELER

Harold A. Wheeler has been elected a vice president and director of Hazeltine Corp., producer of military electronics equipment. Wheeler worked with **Prof. Alan Hazeltine** on the original neutrodyne radio receiver, invented diode automatic volume control, and holds more than 150 patents.

Ronald Compton has been appointed senior engineer for computer design at Bendix Aviation Corp.'s Computer Division. Compton has been an associate engineer at the division and previously was affiliated with Librascope, Inc.

Rheem Semiconductor Corp., has named **David F. Brower** assistant manager of the engineering department. Brower for three years engaged in advanced research in the controlled thermonuclear research program of the General Atomic Division of General Dynamics Corp. and co-authored several research papers including "Atoms for Peace." He also holds several patents on fusion devices and allied components.

Dr. Alexander H. Flax, vice president and director of the Cornell Aeronautical Laboratory, has been appointed chief scientist of the Air Force. He will serve as scientific adviser to the Air Force Chief of Staff.

CRITTENDEN

General Electric has announced the appointment of **John R. Crittenden** as "severe environment specialist," a newly-created position in the company's receiving tube department. Crittenden will provide information on difficult environments in which electronic equipment must operate. Prior to joining the firm, he was associated with Chance Vought, where he worked on guidance system design for the *Regulus* missile. He also holds a patent application concerning a guidance system.

HALLOCK

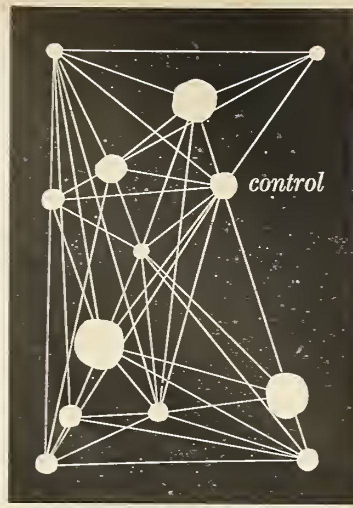
Robert D. Hallock has been named manager of the Leach Corp. Inet Division, producer of ground power support equipment for commercial and military aircraft, missiles and space vehicles. Prior to joining the company he was staff engineer at Convair where he coordinated engineering and manufacturing activities on major missile projects. Other previous affiliations include: National Electronics, Acme Electronics Co., Bardwell and McAllister, Inc., Solar Mfg. Co. and Standard Coil Products Co.

Zembry P. Giddens has been named to the newly created post of executive vice president of Dynamics Corporation of America. Giddens previously held the position of assistant to the president and executive vice president of Electronic Switch and Signal Co. Before entering the electronics field, he was president of the Palmer Stendel Oil Company.

Glenn N. Hackett has been appointed to the newly created position of Director, Purchases and Traffic for Thompson Ramo Wooldridge Inc. He served in a similar capacity on the corporate staff of Thompson Products, Inc., prior to the merger with The Ramo-Wooldridge Corp.

EMPLOYMENT

Advertisers' Index



The First Man on the Moon

The scientific community which deals in such matters, has, according to reports reaching us, divided into two camps and drawn sharp battle lines over a most unusual problem. Three years ago it would have sounded ridiculous, even today it sounds a little remote. But tomorrow it may be as pressing as the matter which Columbus took before Ferdinand and Isabella.

The problem? Whether space exploration should be done with men or with instruments.

One school of U.S. scientists maintains that most space exploration should be done with instruments, that men should be sent far aloft only after years of unmanned exploration. This group seems to be pretty much in command at the moment.

But there is another group pressing to be heard—a group which insists that we could learn much more about space environment, particularly our lunar satellite, and learn it sooner by using men.

Last week in London (M/R Aug. 31, Page 24) two champions of the bolder approach presented their views on manned lunar exploration at the annual Congress of the International Astronautical Federation. They were M. W. Rosen and F. C. Schwenk, who emphasized that their views did not necessarily represent those of their employer—the National Aeronautics and Space Administration.

They contended that because our knowledge of distant celestial bodies is so meagre the scientific community tends to magnify the importance of the simple data which can be obtained by instruments. Specifically:

"We overlook that, if an instrument can do one or several things, there are thousands, indeed millions, of things it cannot do. To put it bluntly, no instrument or array of instruments exist that can duplicate the sensing capabilities of a man. When to this is added man's capability to record, remember, interpret and discriminate, we see how paltry are the powers of the most sophisticated mechanical substitute."

They agree that there are a number of things man cannot do—see ultraviolet light, sense magnetic fields or detect cosmic rays, for instance—and that instruments have their purpose, with or without a man along. But they feel, and in this they undoubtedly will get plenty of popular support, that in the space race with Russia we haven't time for the waiting game; that while we are being cautious, bolder and braver men will be on the moon.

We agree with Messrs. Rosen and Schwenk, because in these days national prestige is of overriding importance. But we cannot escape the feeling that the entire matter is academic.

Man is born to explore, to dare the unknown. Just as he has always scaled the mysterious mountains and braved uncharted seas, so he will want to fly into space. Call it thirst for knowledge, quest for adventure, escape from the humdrum, search for glory, a contract with Life Magazine—man cannot face the unknown without wanting to know what in blazes is there.

So we suspect that mechanical progress and not policy will really solve the question of who is first on the moon. The nation which first produces a device capable of flying to the moon and back will also find men willing to ride in it—and a government willing to let them. And if the first man doesn't return—others will follow, for that's the way men are.

Need to Standardize

The recent word that studies are being made with a view to forming an industry-government group for coordination and standardization of missile telemetry (M/R, Aug. 24, Page 11) comes as welcome news and has already created considerable interest. The inadequacy of coordination between missile makers, instrument manufacturers and test ranges, and the lack of proper and authoritative standards, has been a basic fault of the U.S. missile program for a long time.

Maj. Gen. Donald N. Yates, commander of the Air Force Missile Test Center, only recently pointed out that there must be significant progress in range instrumentation—of which telemetering is a large part—if the ranges are to keep up with the advances which will come with second and third generation missiles.

This is a problem which affects the entire missile industry—one which should get the attention of both business and government. The early indications of strong interest in the formation of a coordinating group point up the fact that such a body is urgently needed—and has been for many years.

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NEW PRODUCT BRIEFS

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...VING JOINTS. New stainless steel ...ing joints now available from OPW-...rdan. Used as elbows in pipe lines ...erever flexibility and rigidity are ...th needed. Easily withstands tough, ...rrosive conditions and prevents prod...t contamination. The series 7400 ...inless steel swing joints are available ... 1-1/" 4" sizes; in 17 different styles. ...ist in 316 stainless steel and designed ... 1000 psi service; temperature de...mined by O-ring seal. O-rings avail...le in a veriety of materials: Viton, ...na-N, Neoprene, Butyl and Teflon. ...mplete engineering information, illus...tions, specifications, chemical recom...ndations and prices in 12-pege bul...in, F-8 and SRBC 52-59.
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...SC CAPACITATORS. Three new high ...pacitance ceramic disc capecitors have ...en added to the centralab line of ..."D" series hy-kaps, it was announced ...day by Gerry Mills, distributor sales ...nager. With capacitances of .03, .04, ...d .05 mfd, 600 VDCW these units ...asure only 7/8" in diameter and 15/64" thick. They wax to withstand extremes of temperatures end humidity. No. 22 tinned copper leads are 1 1/2" long. Primarily designed for by-pass, coupling and filter applications, these "DD" series units are available from stock through electronic parts distributors. A separate group, the "ID" series, rated et 500 V.D.C.W. are available from parts distributors in industrial quantities only.
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TIME TOTALIZER. New Cramer Type 632 time-totalizers offer a simple, accurate means of recording elapsed time in industrial or laboratory operations. Time ranges available are seconds or tenths of seconds, minutes, tenths or hundredths of minutes, and hours, tenths or hundredths of hours. High torque instent start-stop motor drives a drum-type counter from the instant power is applied. External connections are easily arranged to operate the meter during equipment running time, idle time, or any operational phase. In all time ranges, the meters are available with or without reset, and in hermetically sealed cases designed to meet applicable specifications of MIL-E-5272A.
Circle No. 279 on Subscriber Service Card.

TEMPERATURE INDICATORS. Accurate temperature measurements even at remote locations are said to be possible with Kahn and Company's Thermi-Tran Temperature Indicators. Thermi-Trans are designed for use with thermisters, which are inexpensive, thermelly sensitive resistors having high negative coefficients of resistance. The high resistences of thermistors permit the use of ordinary copper wire leads of eny practical length with negligible effect on eccuracy of meter readings. This accuracy is plus or minus 2% of full scale. Coupled with the proper thermistor probes, Thermi-Trans can be used to measure temperatures of static or dynamic liquids, gases soft solids as well as surface temperature changes. Thermistors respond quickly to temperature changes and readings are practically instantaneous. There are two series of Thermi-Trans available. Series KC-532 is a single channel, portable unit which can be supplied with single or dual temperature range scales. Series KC-871 is e panel-mounted, multi-input unit with provision for up to six temperature sensing channels and single or dual temperature ranges.
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MISSILE LITERATURE

SOLID STATE CONVERTER. The Remington Rand Div. of the Sperry Rand Corp. has published a 12 page booklet describing the new Univac solid-state computer. Compatible to any punched-card installation, and representing a major breakthrough in the field of data-automation, this new system provides high-speed processing at relatively low cost, compactness, and unsurpassed accuracy and reliability. Advanced solid-state design is the difference. Because of tiny magnetic core amplifiers and transistors, it can be operated in an area as small as 575 square feet. These new devices emit very little heat, and power requirements are extremely low.

Circle No. 200 on Subscriber Service Card.

SPRING CLUTCHES. The Marquette Division, Curtiss-Wright Corporation, Cleveland, Ohio, announced today publication of a new catalogue describing five standard lines of spring clutches in bore sizes from 1/8" to 1" and torque capacity up to 2500 pounds-inches. These spring clutches are specifically designed for use in machinery, equipment and instrument applications utilizing drive up to 5 hp. There are five basic series of clutches offered in the 30-plus page catalogue: Series A, Over-running and Back-stopping; Series B, Indexing; Series C, On-off; Series D, On-off Indexing; and Series E, Safety Lock Control.

Circle No. 201 on Subscriber Service Card.

FACILITIES. United States Testing Company announces availability of a new six-page Bulletin 5902, describing the company's Materials Evaluation Division's facilities and services for analysis, development, research and inspection of materials and products. Among the services offered are metallurgical studies, metals chemistry, plastics evaluation, and physical testing. This work is done with the help of a complete range of analytical equipment, such as an X-ray diffraction unit, emission spectrograph, spectrophotometer, a variety of tensile and compression test units, heat treating furnaces, and the like. The tests and studies handled in the laboratory include: defect analysis, legal investigations, photomicroscopy, chemical analysis, physical and mechanical properties at sub- and supra-normal temperatures, air pollution surveys, and many others.

Circle No. 202 on Subscriber Service Card.

WIRING HARNESSES. Methods, Inc., has published a 14-page booklet of key points in the design, manufacture, and use of wiring harnesses. It contains many practical hints for improving stripping, tinning, soldering, etc. of cable wires, and suggests design procedures for facilitating in-the-instrument connecting operations and ways for the harness user to plan, simplify and improve cable installations. Also delineated are ways for stepping up speed and accuracy of inspection. Line drawings are used throughout to illustrate techniques.

Circle No. 203 on Subscriber Service Card.

SOLDERING MANUAL. The American Welding Society has announced publication of the first manual on soldering ever published. Containing 176 pages, 81 illustrations and 34 tables, the book completely covers all phases of soldering, combining the theoretical with the practical. The twenty-one chapters deal with the following subjects: principl of soldering; solders; fluxes; joint d sign; precleaning and surface prepar tion; equipment, processes and proc dures; flux residue treatment; inspecti and testing; copper and copper alloy steel; coated steels; stainless stee nickel and high-nickel alloys; lead a lead alloys; aluminum and alumin alloys; magnesium and magnesium alloy tin; cast irons; precious metal coatin printed circuits; and safety.

Circle No. 204 on Subscriber Service Ca

MICROWAVE METERS. A new 12-pa catalog with complete technical da on a line of microwave meters a filters is available from Frequen Standards. The catalog includes pre sion frequency meters in the 500-180 mc tuning range and tunable band p filters with tuning ranges from 960 9600 mc. General design data coveri cavity types, and frequency response a insertion loss information on filters included, together with frequency—kr dissipation loss-db, and rejection— curves.

Circle No. 205 on Subscriber Service Ca

PLASTIC RESINS. A technical bulle describing the properties of reinforc plastic resin systems as ablation m terials for re-entry into the earth's atm phere has been published by Zer Plastics, Co. Designated as Technical letin #2.15, the report covers a resu of general results obtained in a se of tests using variations of "Scotchp" brand reinforced plastic.

Circle No. 206 on Subscriber Service C.

POWER SUPPLIES. Sixty-three high-v age dc power supply models are scribed along with tabular specificati in a new "HV DC" product data sh now available from Sorensen and C pany. Data is given on the new Soren P, MP, HP and VHP Series high-v age supplies as well as on the 1000 d 2000 Series high-voltage supplies. M mum output voltage ratings comple y cover the range from 1 to 350 kilov s. Nominal maximum output powers ra e up to 60 kilowatts. Recommended plications include: dc dielectric test, capacitor charging, injection and fo ing sources for nuclear particle accel tors, electrostatic precipitation and eration, vacuum tube testing, and m y similar applications.

Circle No. 207 on Subscriber Service C d.

TURBINE GRINDER. A new low c t, 12½ oz. light duty turbine grinder m le by Desoutter Brothers Ltd., Engl d, now being distributed throughout e U.S. by Newage Industries, is descri d in a booklet offered by the distrib r. The new grinder uses a "balanced e sign body for comfortable handling It comes complete in a fitted wooden c e, with 6 mounted grinding wheels, c k spanners, a hed spanner, 10' of 3/8" se with two connectors, jet plates an a dressing stone. It is guaranteed fo 12 months. The grinder runs cool, blo g chips away from work, and feat es automatic air shut-off when it is dis n nected. It is specially designed for ol and die makers requiring a grinder or intricate hand work. The Desoutter). 000 rpm turbine '03' grinder grinds, e burrs, cuts, polishes, and engraves

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