AUGUST 3, 1959

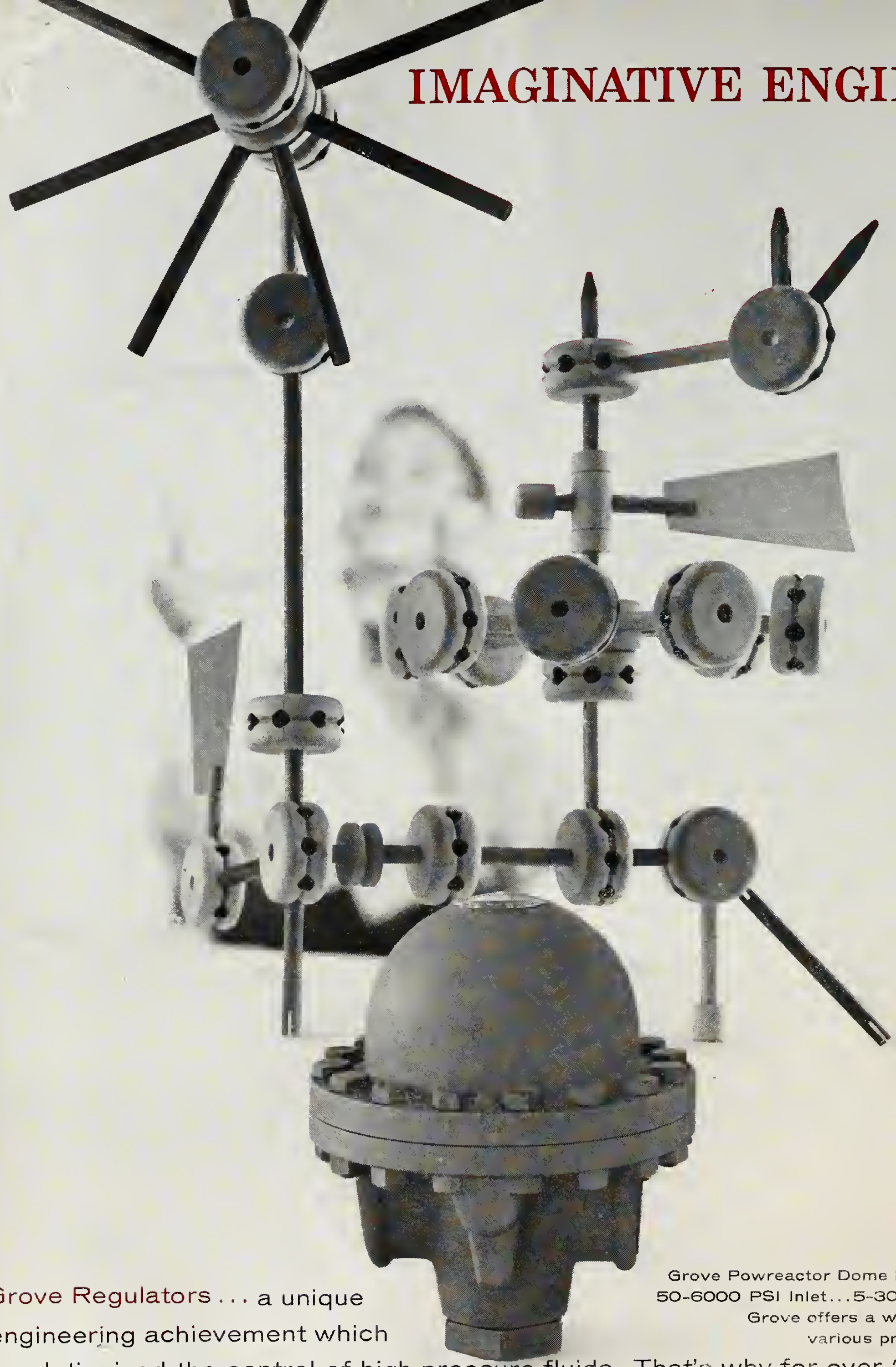
ATOMIC ARMY'S NEW REDEYE

missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS

AN AMERICAN AVIATION PUBLICATION

IMAGINATIVE ENGINEERIN



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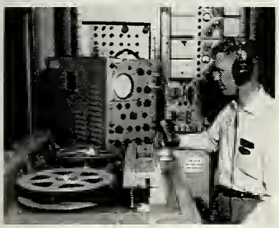
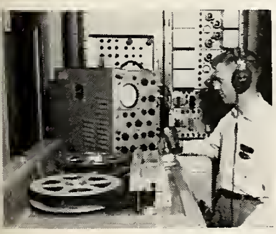
COVER: Details of Army's *Redeye*—fired like a bazooka, have been revealed. For this Convair development see p. 12.



BMD which is marking its fifth anniversary has had a radical approach to ICBM development such as the *Atlas*. See p. 11.

P&W's liquid hydrogen engine for tbe *Centaur* vehicle is undergoing full-scale test. For details see p. 20.



TAPE RECORDING industry is growing by leaps and bounds into multi-million dollar business. For details see p. 34.

missiles and rockets ®

MAGAZINE OF WORLD ASTRONAUTICS

AUGUST 3 HEADLINES

ASTRONAUTICS ENGINEERING U. S. Reg. Pdg.

MISSILE SUPPORT U. S. Reg. Pdg.

ASTRIONICS

THE MISSILE WEEK U. S. Reg. Pdg.

DEPARTMENTS

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Newest techniques. Many milestones in magnesium casting have been reached at this Dow foundry. In fact, Bay City has men permanently assigned to developmental work, keeping the foundry in the forefront of technological advances at all times.

Results of their work include special processes for cast-in inserts and tubeless passages, and improved melting techniques. Casting methods have been developed for many of the newer magnesium alloys, such as the elevated temperature group and the new high damping capacity alloy, K1A.

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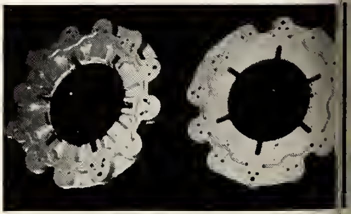
THIS SAND CAST WAVE GUIDE was held to ±.0 on passageway dimensions. Surface smoothness quirements are 63 RMS. The foundry has governm approval for any phases of its operations where approvals are applicable.



THIS BRAKE CARRIER is sectioned to show how hydraulic lines were integrated by use of tube passageway casting techniques.

WRITE TODAY for this illustrated brochure discussing Dow foundr services. THE DOW CHEMICAL COMPANY, Midland, Michigan, Magnesium Product Sales Dept. 1303CLB-3.

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Washington Countdown

IN THE PENTAGON

A new type of guidance system . . . called *Fingerprint* is under consideration by the Air Force. **Chance Vought** is the developer. The system is proposed for use in *Slam*—the proposed supersonic low altitude missile that would be powered with a nuclear ramjet engine.

• • •

Project *Slam* . . . is still in the study stage. **Chance Vought, Convair** and **North American** are in the competition for the R&D contract. *Slam* apparently is being designed with the idea of getting past any Soviet-developed anti-missile missile.

• • •

Big new family of "pocket" missiles . . . designed for limited nuclear warfare can be expected to result from development of **Martin's** *Davy Crockett*. The secret Army missile with its fractional-yield nuclear warhead is designed to be fired like a rifle grenade. Next to be added to the new family of nuclear weapons probably will be **Martin's** *Bullpup*. (See page 12)

ON CAPITOL HILL

Deep slashes in the foreign aid bill . . . are worrying a number of defense-minded Democratic congressmen for political reasons. They fear the reductions in money slated to buy missiles for NATO undercut their fight for bigger defense expenditures at home.

• • •

Foes of a double congressional check-rein . . . on missile and aircraft procurement can be expected to try to kill it again next year. Meantime, it is certain to go on the law books with a 1962 effective date. The new provision will force the Pentagon to get congressional authorization of missile and aircraft procurement programs prior to getting Congress to vote the cash.

AT NASA

The proposed imperfect orbit . . . of the "paddle wheel satellite" *Thor Able III*, scheduled for launching Aug. 7 has been modified from an apogee of 30,000 miles and a perigee of 150 miles to an apogee of 20,000 miles with the same perigee. Reason: Though NASA scientists would like to test the multi-solar celled payload at the longer distance, the shorter apogee is designed to give the *Thor-Able* vehicle a better chance of performing the mission.

• • •

A competitor for *Thor-Delta* . . . the small satellite booster under development, is reported being proposed by ABMA and JPL. NASA recently cut *Juno II* and *Thor-Able* from its programs in favor of *Thor-Delta* on grounds they are uneconomical. ABMA now is proposing as a substitute a *Jupiter*-JPL 6K combination. The 6K is a second stage with an encapsulated, storable 6000 pound thrust engine.

• • •

Launching date censorship . . . of NASA space projects has put the space agency in the embarrassing position of having to deny what they know to be true. For example, English newsmen learned from NASA technicians at Jodrell Bank that *Thor-Able III* was to be launched June 7 and transferred this information to their American colleagues. NASA is under pressure from the White House and Cape Canaveral's Maj. Gen. Donald Yates not to release satellite launching dates before the fact.

AROUND TOWN

More large Soviet missile bases . . . are reported to be under construction in the Eastern European satellites. Iron Curtain sources report the Russians are closing off large tracts of land for the bases. The amount of heavy construction indicates that hardened sites are being built.

• • •

The Kremlin apparently decided . . . in advance of Vice President Nixon's Soviet tour that it might be a good idea to let him see a missile launching. A top Soviet source says Nixon's chances of seeing one looked good . . . all he had to do was ask.

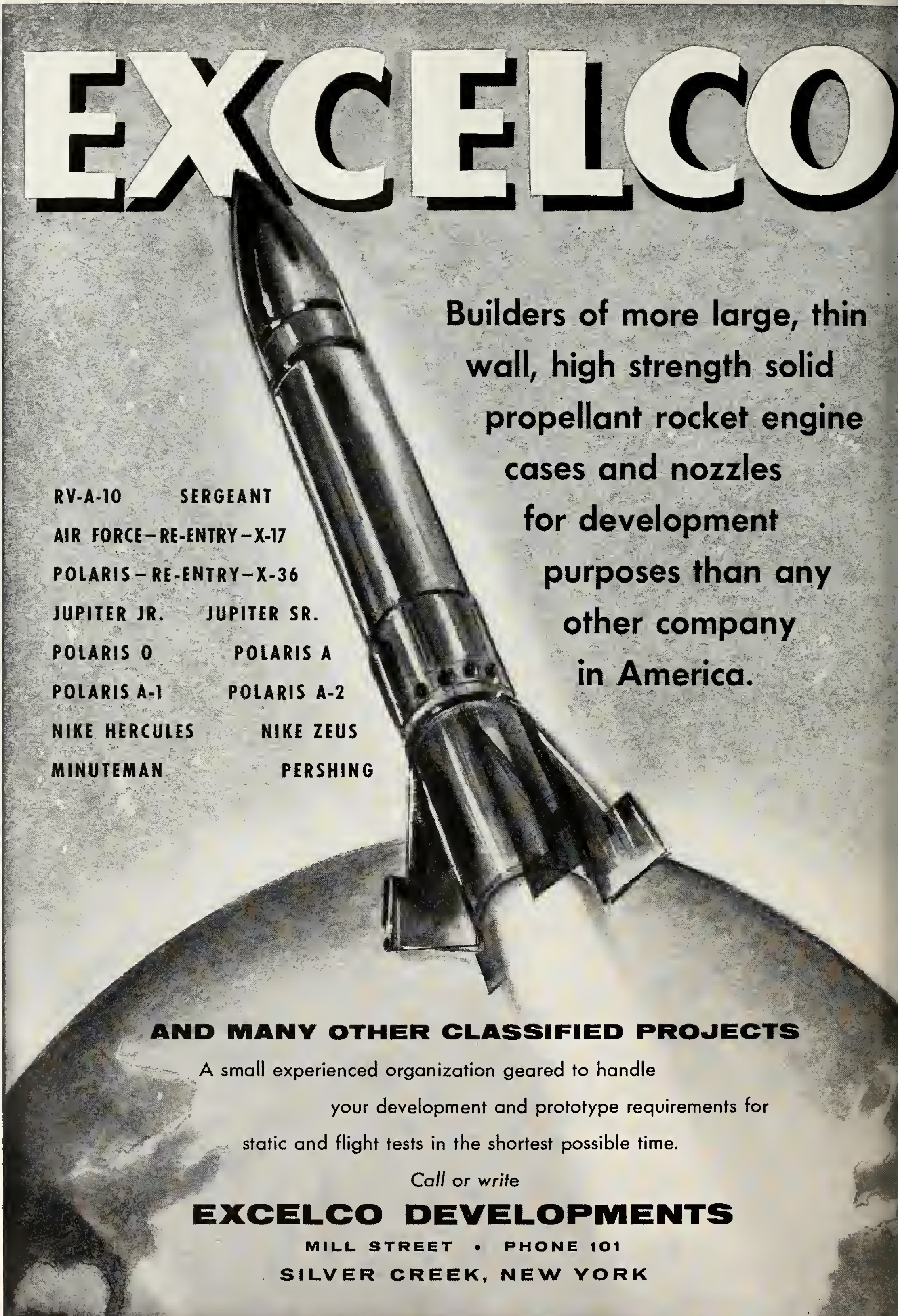
Some of the reports . . .

that are being passed as the "latest" in the nation's capital:

. . . The Administration is determined to hold the budget line next year for the presidential campaign. It looks now as if only a major international flareup can change the decision.

. . . The U.S. radar net in Turkey has detected more than 30 Soviet failures to launch either ICBM's or space vehicles.

. . . Red China is putting new pressure on the Soviet Union for red missiles.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Industry Countdown

STRUCTURES

Combat *Atlas* ICBMs . . .

are now in the hands of 704th Strategic Missile Wing missile troops at Vandenberg AFB. While Air Force is still ironing out bugs which showed up during recent test failures, these **Convair**-made missiles are considered "ready to shoot" in event of war. All changes resulting from tests are being programmed immediately into these missiles. Unit will not be declared operational until after the 6300-mile *Atlas* passes four or five more flight tests.

• • •

Proposals are descending . . .

on NASA at rate of 60 per month. About 250 have been submitted since January—two-thirds of them from universities and remainder from industry. Average proposal would cost $102,000. They range from such basic research projects as the physics of certain structures under stress to the R&D of instruments to be used for a space vehicle landing on another planet. NASA officials report that they are funding about 34% of the proposals at an average of $62,000 each. Their big problem: money. "We have more good proposals than we know what to do with," says one expert. "We can't afford to sponsor them all." Funding of proposals from universities comes from special $3 million account, while industry proposals are paid for out of R&D money.

• • •

The French will activate . . .

first *Nike* and *Honest John* missile battalions this autumn . . . Britain's **Bristol Aeroplane Co.** is running a feasibility study of Mach 7 commercial transport that would take off pick-a-back style with a separable booster weighing 250,000 pounds. Plane would be powered by both turbo-jets and rockets.

• • •

Answer to maiden's prayer . . .

or *Jupiter* nose cone production problem: **C. T. L. Inc.,** original developer of this country's first ablation nose cones for ballistic missiles, uses hand held hair driers to soften the glass phenolic laminate layers during stretching over *Jupiter* cone forms.

PROPULSION

Magnetic ramjets may be . . .

involved in new contract to **Fluid Dynamics Division of Ryan Aeronautical Co.** for development of Ryan "MiniWate" hollow core material as high-altitude propulsion device. AF Office of Scientific Research, ABMA and NASA's Ames Laboratory (which placed the contract) long have been interested in possibility of utilizing ionized upper air as a boost to efficiency of systems based essentially on ion acceleration. NASA-ONR-AFOSR sponsored symposium on dynamics of ionized gases Aug. 24 and 25 at Northwestern University may produce some interesting leads.

• • •

Process for electroplating . . .

metals on almost any material—including paper—has been developed by **Ethyl Corp.,** maker of gasoline additive. **United Car Snap Corp.** developed a method some time ago for electroplating metals on plastics. Such processes hold hope of weight reduction in solid rocket nozzles, which seem to be getting heavier and heavier as motor case weight goes down.

• • •

Way to overcome melting . . .

of aluminum powder in new solids, which reduces combustion efficiency, may be through alloying aluminum with zirconium, magnesium or lithium. Government researchers say this also may yield greater I_{sp}. But there is a problem—how to produce ultra-fine powders (say, 10 microns) of these alloys, particularly when Al-Li has the same nasty characteristics as Li alone.

ELECTRONICS

Look for Soviet approach . . .

perhaps at London IAF Congress next month for pooling of U.S. and Russian satellite tracking facilities. Reds admit they feel lack of tracking stations in Non-Communist world; figure U.S. would appreciate tracking data on Russian space vehicles. Pool would require prior notice of shots on both sides. The Russians make no mention of extending cooperation to military satellites.

• • •

EIA is supporting . . .

the Saltonstall bill designed to revamp procurement. EIA believes S.500 will provide flexibility in procurement by specifically authorizing competitive negotiation on an equal basis with formal advertising; and will speed up weapon system deliveries by eliminating advance determinations in making cost-reimbursement type contracts for R&D.

(Continued on page 43)

Hebert Has Hand Grenades Ready To Toss

by James Baar

WASHINGTON—So far the House Armed Services Subcommittee investigation of the so-called "munitions lobby" has taken on the aura of a relatively pleasant tennis match.

However, Subcommittee Chairman F. Edward Hébert (D-La.) can be expected shortly to try serving up a few hand grenades.

The subcommittee has spent most of the month since it opened its investigation listening to testimony from other congressmen, top military officials and retired high-ranking military officers now holding key jobs in the defense industry.

Both the unsensational conduct of the hearings and some superficial reports have given the impression in a number of quarters that the whole investigation is preparing to wander off somewhere and die.

This impression is very misleading. Actually the subcommittee has proceeded according to pre-established plans.

The subcommittee has sought to hear first from the number of prominent figures whose names were tossed about in the noisy developments that brought on the hearings. The second phase is scheduled to involve detailed examination of specific cases.

• **Testimony may be damaging**—Moreover, the testimony taken to date could well be far more damaging than it may at first appear.

One by one the witnesses beginning with Deputy Defense Secretary Thomas Gates have sat in the crowded subcommittee room and stated that they know of no attempts by retired military officers to influence defense contract awards by the Pentagon.

As Gates told the subcommittee: "All these contracts are made in the interest of the department and are not awarded on any other basis—friendship, influence or anything else."

Gen. C. S. Irvine, former Air Force Deputy Chief of Staff for Material and now an **Avco** vice president, testified bluntly: "If I wanted to make sure my company didn't get a contract, I would go talk to my successor and ask him to do me a special favor."

But under questioning most witnesses also said other things.

For example, Irvine agreed that he might be more readily listened to by a former junior officer who over the years had come to respect his judgment.

Others agreed that it certainly might be easier for a retired military officer to gain the ear of a former associate still in the Pentagon.

And Gates, himself, said that the president of a company was its "No. 1 salesman" and agreed that the company's board chairman was its "No. 2."

The new Deputy Secretary attempted at this point to draw a distinction as to what is meant by the term "salesman."

"What is selling?" he asked rhetorically.

"That is what we are trying to find out," Hébert snapped.

Since then subcommittee members have repeatedly quoted Gates as in identifying defense contractors' "No. 1" and "No. 2" salesmen.

• **Not enough testimony**—In all, the subcommittee already has enough of such testimony to state in its report if it chooses that a number of the nation's top present and former military leaders concede that the subtle pressuring of military officers by their former military associates is possible.

What is still lacking, of course, any proof that this is what has be happening.

That is what the subcommitt staff is already digging for as it si more than 5,000 questionnaires ma out by ex-military officers and e Federal officials now employed by d fense contractors. That—or the lack it—is what will make up the seco phase of the hearings.

The subcommittee can be expect to attempt to show that the award Contract X was influenced by alleg influence brought to bear by retir Gen. or Adm. or Col. or Cmdr. Y.

Nor for the purposes of bringi about new legislation need such e dence be capable of standing up in court of law. It needs only to be stro enough to convince Congress and t public.

The writing of any legislation th might result from the hearings wou be an extremely complex problem. many astute lawmakers have found the past, it is most difficult to legisla honesty.

However, several proposals have a ready come up a number of times the hearings.

One would put some kind of b —say two years—on the hiring of r tired military officers for anything b technical jobs. Of course, such a li is most difficult to draw.

A second proposal is that Pent gon officers involved in the contra ing process be required to submit lis of all who talk to them about contrac to all interested parties.

Other proposals are far mo drastic.

Whether any of them will ever enacted into law will depend on ho explosive Chairman Hébert's han grenades may prove to be.

QUOTABLE QUOTES ON RETIRED OFFICERS

General of the Army Omar Bradley, now chairman of the board of the **Bulova Watch Co.**—*"The greatest contribution we can make is because of our experience in administration and organization."*

Rep. Paul J. Kilday (D-Texas), high-ranking member of the House Armed Services Committee—*"I take the position that no officer should retire and soon thereafter enter the employment of a contractor in a position which would give him an opportunity to have that contractor favored or even give the appearance of so doing."*

Vice Adm. Hyman Rickover—*"I believe it is where you get up to captain and admiral and it is in positions such as Washington representative or where due to their personal contacts (they) can influence policy."*

Rep. Samuel Stratton (D-N.Y.)—*"It would be a grave mistake if this committee were to proceed in the assumption that there is something inherently wrong with a retired o ficer going to work for a defense contractor . . ."*

Rep. Alfred E. Santangelo (D-N.Y.)—*". . . I sense odorous aura created by the extensive hiring of retir military personnel. This practice . . . smells to the hi heavens and races with missiles and aircraft to outer space*

Gen. C. S. Irvine, (ret.), now vice president of Av Manufacturing Corp.—*"You just can't go back and say a guy who used to work for you: 'You know, give me a ha sandwich.' You got to have a little pride."*

Rep. Porter Hardy Jr. (D-Va.), Hébert Subcommitt member—*"No military man or nobody else . . . would into the office of a procurement officer and say: 'Do me favor and buy what I have here.' I don't think it would done that way. But there are a lot of other ways to sk a cat."*

TWO YEARS of development time shaved off *Titan.*

BMD's 'Radical Approach' To ICBM Pays Off

Concepts of concurrency & central-direction responsibility produce ahead-of-time weapon systems

by Erica Karr

WASHINGTON—Five years ago this ıth Brig. Gen. Bernard A. Schriever ‹ over command of ARDC's new ;tern Development Division, set up accelerate the Air Force's ICBM gram. In a short half-decade the ınization, which became the Air ce Ballistic Missile Division, ıched and proved out a revolution- approach to development of a pon system. Using the concept of currency (simultaneous developıt of components), and turning over responsibility for engineering and ınical direction to the **Ramo-Wool-lge Corp.,** the AF ICBM program ved ahead of schedule, with an nated two-year shaved off developıt of the *Atlas, Titan* and *Thor.*

Growing at first slowly from a ıp of less than 50, Gen. Schriever's entific community" expanded to to-'s 1600, backed up by the 3000 em-/ed of **Space Technology Labora-es** (offshoot of Ramo-Wooldridge).

In the long record of achievements, e highlights stand out:

• Re-entry—Bucking general scien- opinion, BMD proved through its ɛs of tests with the *X-17* ballistic vehicle that successful re-entry was ible at more than 12 times the ɛd of sound (July, 1956).

• *Thor*—First fully successful flight of the *Thor* 105 (September, 1957).

• *Atlas—Atlas* takes off without a hitch for the first time. (December, 1957).

• Capsule Recovery—Data from space was recovered with the capsule sent up at 10,000 mph in a *Thor* re-entry vehicle (June, 1958).

• ICBM flight—The first successful ballistic flight, impacting successfully after re-entry at ICBM range was achieved after second launch of a *Thor Able* (July, 1958).

• *Pioneer*—Deepest probe into space by a man-made object was *Pioneer I's* 71,300 mile journey during which it picked up data confirming existence of the Van Allen radiation belts and confirming they would not be insurmountable obstacles for man in space (October, 1958).

• Full-range *Atlas—Atlas* capability was confirmed when it flew 6300 miles (November, 1958).

• Operational *Thor*—First SAC launch of operational-type *Thor* took place three years after it was given ok for development (December, 1958).

• Multi-stage ICBM — Completely successful first test flight of the *Titan* launched the free world's second type ICBM—a multi-stage heavier and "more sophisticated" vehicle.

"FOUNDING" father of BMD was Brig. Gen. Bernard A. Shriever, now heading ARDC.

• Polar-launched satellite—*Discoverer I,* man's first polar-orbiting satellite circled the earth over 10 days. Weight with orbiting 2nd stage—1300 pounds (February, 1959).

• Re-entry vehicle recovery—*Thor Able* carried aloft a test vehicle which radioed back evidence of its successful re-entry and then was retrieved from the Atlantic Ocean where it impacted (April, 1959).

• Space Pix—First pictures of on-the-scene rocket separation were made by motion picture camera carried by *Thor IRBM* re-entry vehicle to 300 miles altitude (May, 1959).

Looking to the future, BMD has set for itself an ambitious long-range goal: development of integrated space forces, since "space is our newest military medium." Meanwhile, BMD's sights in the near future are set on perfection of the missiles now in being; bringing to maturity such second generation missiles as the *Minuteman,* concentrating on greater mobility and protection at launch and greater accuracy; development of a reconnaisance satellite, a satellite-launched missile, and an anti-missile defense system satellite (MIDAS).

I JOB OF BMD now is preparing for operational status of Atlas ICBM. Here is ʳt concept of proposed facility at Warren AFB, Wyoming.

Convair *Redeye* is fired from tube.

REDEYE AND BULLPUP

Bazooka-type missile details released
Martin ASM becomes operational in Atlan

by James Baar

WASHINGTON—The Army and Navy have publicly unveiled two of their latest missiles—the **Convair** *Redeye* and the **Martin** *Bullpup*.

One carries death over the battlefield to straffing jets. The other carries death to ground installations and ships at sea.

Development of both arises directly from needs learned in battle.

Army foot soldiers have needed a light, mobile weapon to strike back at ever faster tactical aircraft. So have the Marines. They will get *Redeye*.

Navy pilots have needed a substitute for costly divebombing. So has the Air Force. They will get *Bullpup*.

Both missiles pack conventional warheads. However, the Navy is understood to be planning development of a *Bullpup* with a nuclear warhead.

The Navy also is planning development of a super Bullpup with a conventional warhead. This would pack the punch of a 1000-pound bomb. The present model contains a 250-pound bomb.

The Army unveiled its formerly-secret *Redeye* for the 1959 annual meeting of the Association of the U.S. Army.

• **Redeye specs**—The four-foot long, solid missile is designed to be fired by one or two men from a tube similar to the bazooka. Its diameter is about three inches. It has infra-red guidance and undoubtedly has a proximity fuse. The entire weapon weighs about 20 pounds —some 15 pounds lighter than a bazooka of approximately the same size.

The *Redeye* program—now in an advanced R & D stage—was started before the Korean War. More than 5 million has been spent on it.

The missile is one of the first o series of new secret missiles being veloped for arming an Atomic Army. Among the others are *Claym* and the Martin *Davy Crockett.*

Davy Crockett, a nuclear-tip missile designed to be fired like a grenade, is of particular interest in development of a nuclear *Bullpup*. generally similar fractional yield head would be used for both missi

The Navy demonstrated the ca bilities of the newly-operational *B pup* as part of a fire power show on the end of July from the Car Saratoga.

The carrier, which lay about miles off the Florida coast, launc three Douglas A4D Skyhawks ar with one *Bullpup* each. The t

FOUR FOOT long *Redeye* has a diameter of about three inches and carries infra-red guidance.

ENTIRE WEAPON weighs about 20 pounds, some 15 po lighter than a bazooka and probably carries a proximity f

IESE A4D's can carry three *Bullpups* if extra fuel is not required. Aircraft belong to VA-34 of CAG-3, NAS Cecil Field, Fla.

hter-bombers fired their missiles at oke pot targets floating on a rela- ely calm sea. One missile overshot target. Two scored direct hits.

The Mach 1.8 *Bullpup* is 11 feet ıg. It has a one foot diameter. It ighs about 600 pounds including a 0-pound conventional warhead.

The simply-designed missile is di- led into three sections: The rear sec- n contains a solid motor and tracking res; the center, the warhead; the se, the command guidance and con- l equipment.

The *Bullpup* can be launched at a get from 12,000 to 15,000 feet away. e launching plane then follows the ssile part of the way in while the ot guides it with a thumb switch. e launching plane is able to pull out its dive while it is still one to two es from the target.

The missile is designed to meet two cific problems:

• Cut the high loss of aircraft ced to fly through heavy ground fire.

• Improve the reduced accuracy of nbs dropped by supersonic aircraft.

• **Deployed in Pacific**—Operational *llpups* were deployed for the first e aboard the Carrier Lexington in Pacific.

An A4D can carry three *Bullpups* t does not carry extra fuel tanks. **North American** FJ Fury can carry .

So far Navy pilots generally have nd *Bullpup* a highly reliable and urate missile. However, the principal blem confronting them at this time btaining enough for training. Most *lpups* now being manufactured are ced in the national war stockpiles.

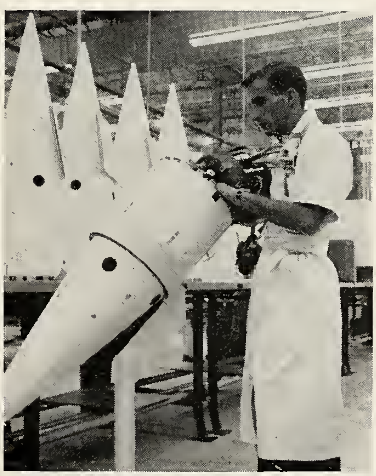
The Air Force originally sought de- opment of a much more advanced sion of *Bullpup* known as *White Lance*. This plan now appears to be dead. Instead, the Air Force will buy a *Bullpup* with a few special modifications.

At present, the *Bullpup*, because of its relatively small warhead, is designed for use against such targets as bridges, tanks, pillboxes and similar ground installations.

However, the nuclear-loaded *Bullpup* would be capable of sinking any ship afloat. The Air Force also would presumably be interested in such a weapon for tactical use.

A *Bullpup* with a nuclear warhead would not need the great accuracy of the conventional models. It could be fired from greater distances and the launching plane would not have to follow it as far toward a target.

The peak destructive overpressure from a shallow underwater nuclear explosion carries much farther than it does in an air burst.



CONTROL section for *Bullpup* is installed at Martin's Orlando, Fla. facility.

For example, only an 8 kiloton warhead detonated nearly a half-mile from an enemy ship would smash its hull with an overpressure of about 3000 pounds psi.

An overpressure of 3000 to 4000 pounds psi is considered sufficient to sink any ship of substantial construction. But even much lower overpressures can sink a ship or completely disable it. And overpressures of less than 1000 are considered sufficient to badly damage internal equipment.

Finally, such underwater blasts even a considerable distance from a ship also result in damage to superstructures from both shock waves in the air and high waves.

• **Development of weapons**—Like *Bullpup*, *Redeye* and *Davy Crockett* are part of an overall attempt by both the Army and Navy to build up the nations limited war potential.

Such weapons are designed to enable a small force to mount sizeable firepower against an attack by much larger conventional forces.

Some observers have noted a trend in congressional thinking toward a greater buildup of such forces in the next few years. However, without a budget increase the billions that would be needed for such a buildup would have to come from funds that have been spent in the past for a buildup of U.S. strategic forces.

Moreover, there has been no indication that the cost of maintaining U.S. strategic power is about to decrease. Instead, with the coming of hardened missile sites and large-scale ICBM production, it is expected to increase.

ARPA Obligating $18 Million for Solids Research

by **Betty Oswald**

WASHINGTON—The Advanced Research Projects Agency is spending a total of about $33 million for exploration in new high-energy solid propellants and supporting programs. Of this figure $18 million will be obligated in fiscal 1960.

The objective is to develop improved solid propellants with useful energy 10 to 20% above the solid propellants now being used. The net effect would be to double the warhead-carrying capacity potential of future intercontinental ballistic missiles.

Funding in 1959 amounted to $15 million spread over 54 contracts in seven broad research areas. As listed in a Pentagon Fact Sheet, they are:

• **Integrated programs:** $6,000,000—4 contracts. **Minnesota Mining and Manufacturing; American Cyanamid; Dow Chemical; Esso Research & Engineering.**

The integrated program concept involves thermochemistry, thermodynamics and performance estimates; chemical studies aimed at the synthesis of new ingredients; propellant formulation and compounding; and the study of the properties of the final propellant including ballistic and mechanical properties all in a single contract. The primary criterion for the selection of these contractors was the caliber and suitability of the scientific personnel available. The concept involves the definition of the research program in terms of the objective rather than in terms of ways and means of attaining the objective.

• **Propellant performance:** $1,720,000—11 contracts. National Bureau of Standards; University of California; Ohio State; **Arthur D. Little;** Bureau of Mines (Bartlesville); **Allegany Ballistics Laboratory; Aeronutronic Systems, Inc.; Rohm & Haas; Atlantic Research Corporation;** University of Chicago; University of Wisconsin.

A substantial program has been set up involving the selection and assembly of best thermodynamic values, performance calculations based upon these values, and kinetic studies aimed at the elucidation of processes which occur during expansion. These studies are providing a firm basis for the selection of those areas of chemistry which are most likely to contribute substantially to the desired goals.

• **Specialized synthesis:** $3,840,000—18 contracts. **Magna Products;** Penn State; Duke University; New York University; University of Florida; WADC, Materials Laboratory; Rohm & Haas; NOTS, NOL (Corona); **Olin-Mathieson; Allied Chemical; Callery Chemical; Monsanto Chemical; Pennsalt; Borden; Peninsular Chemresearch; Ethyl Corporation;** Atlantic Research Corporation; **National Research Corporation.**

The work under the integrated programs involves a large percentage of synthetic work. However, the necessity for new ingredients, if the objectives are to be achieved, recommends the placement of contracts concerned solely with synthetic work. This type of program will enable the DOD to obtain the services of laboratories especially highly qualified in certain branches of synthetic chemistry of special pertinence. The principal areas covered in the specialized contracts for synthesis already placed or planned include: new oxidizers, new light metal fuels, and research directed towards new chemical techniques.

• **Propellant research:** $750,000—3 contracts.

The new ingredients which are expected to become available as a result of the synthesis programs are likely to have properties quite different from those now used. This would recommend that new compounds be made available as quickly as possible to all major propellant research centers. However, it is also essential to preserve the Government's interest by seeing that compositions involving new ingredients do not become proprietary if the research is Government-sponsored. It has been decided that initial work on the use of new ingredients would be confined to certain laboratories which are free of proprietary restrictions. The designated laboratories are:

Ordnance Missile Laboratory; Naval Ordnance Test Station; Picatinny Arsenal; Naval Propellant Plant; Jet Propulsion Laboratory; Rohm and Haas, Redstone Division.

All propellant research on new ingredients coming out of ARPA synthesis contracts will be coordinated through the three Services.

• **High temperature research:** $-900,000—8 contracts. Applied Phys Laboratory; Allegany Ballistics Labo-tory; **Union Carbide Corporation; C-nell Aeronautical Laboratory; Aton International; AVCO Manufacturi; General Electric;** National Bureau of Standards.

Present day high performance so propellants have flame temperatures in the vicinity of 5000°F. Propella now under development may be s-stantially hotter and accordingly, s-ject the inert parts to extreme cor-tions. It is necessary to have a resea program designed to solve this proble. The research program planned invol the mechanism of ablation, propert of refractories, insulation studies, a a study of the pyrolysis of orga polymers. These programs are meant supply fundamental knowledge as the resistance of inert components high temperature.

• **Non-destructive testing:** This p-gram is now being reviewed and de-sions will be announced shortly. Due the fact that solid-fuel engines are coming successively larger every ye, this has placed an ever increasing mand on the mechanical properties the propellant. Failures such as cra-ing, separation from the liner and ar of porosity are likely to occur. Th faults can increase the burning surf over that expected, leading to u predictable and occasionally disaster pressure increases. Additionally, c tain faults may expose the wall surfa of the engine to high temperatures p maturely, leading to failures at oper ing pressures. Accordingly, an advanc solid propellant program should clude a substantial effort on techniq for non-destructive testing and insp tion. Failure criteria need to be veloped and instrumental methods the detection of faults require a gr deal of refinement. This program being reviewed for future funding.

• **Basic research:** $873,000—contracts. Bureau of Mines (Pittsburg Brooklyn Polytech; University of Ca fornia; Princeton University; **Aeroj General Corporation; Aerochemi Research Laboratory;** University Texas; **Stanford Research Institu Materials Research Corporation;** Va derbilt University.

A variety of basic research progra involving many areas pertinent to t overall objective were set up throu the basic scientific offices of the th Services. These programs include study of detonation, the study of bu ing rate of solid propellants, meta able systems, ductile ceramics, ceran fiber-alloys, and various spectrosco studies of combustion products.

TV Watches Engine Case Tests

Newbrook Engine Corp. engineers learn how failure occurs by observing hydrostatic skin tests from safe vantage point

by Jay Holmes

SILVER CREEK, N.Y.—Closed-cir-
iit television has been put to work
sting rocket engine cases safely at a
issile hardware plant here.

Engineers at the **Newbrook Ma-
ine Corp.** have installed a TV camera
side their hydrostatic test cell so
ey can see just when, where, and
what pressure a case begins to fail.

Newbrook, which manufactures
ses for such large missiles as *Polaris,
inuteman, Sergeant* and *Jupiter*, can
st all of them in its cell. In most
ses, observation by television makes
possible to turn off the pressure be-
re complete failure occurs. The
tential failure is located precisely
a small stream of water issuing
om the spot. And the Newbrook en-
neers know exactly how much pres-
re causes the rupture.

Most hydrostatic testing of rockets is done in a closed chamber for safety. But without a TV viewer, cases are often tested to failure. And when they do fail, there sometimes is no way of knowing just where and when it happened.

Normally, the cases are tested for one minute at pressures up to 1235 pounds per square inch. However, additional pumps are available for pushing the pressure up to 10,000 psi.

The hydrostatic test is only one of several tests given rocket engine cases before they leave the Newbrook plant in this Lake Erie community. Hardness of the surface is checked with use of an instrument that measures magnetic and electric properties. This avoids damaging of the case in a diamond-point test. Other tests include tensile pulls, X-ray examination, biaxial disc tests and hydrostatic tests of triaxial forces.

ELEVISION HELPS watch remote-control rocket-case test at Newbrook Machine.

A. J. Newman, Newbrook president, is confident that any metal can be welded to meet the exacting standards of the missile industry. As evidence, he showed a recent visitor dozens of cases tested to failure. In every case, the failure occurred away from the seam. "You have to do your welding properly," he said. "Close control is necessary. And you have to have welders who know their business."

Newbrook Machine is the second corporation started by Newman and Leroy Brooks, two engineers who set out on their own after World War II from the **Cornell Aeronautical Laboratory** in nearby Buffalo. They established **Excelco Developments Inc.** in 1946 and Newbrook in 1951.

They started small but have grown steadily. Employment now ranges from 200 to 250. Newbrook and Excelco say they have delivered more rocket engine cases for research and development than any other single vendor in the country to date.

Newbrook uses closed-circuit television for other uses besides watching what goes on in the test cell. A camera has been installed next to one bench where fine-tolerance machining is done. The worker can examine his piece of metal on an enlarged image in a television receiver above his head.

Another application is in maintaining plant security while showing customers the progress of their work. Often, work is being done on classified projects next to a civilian or unclassified job. In such a case, the customer may not be cleared to view the classified work. The solution is to point the camera at the unclassified job. Then the customer can view it on the office receiver.

Newbrook's facilities are sufficient for manufacturing the largest rocket cases that could be transported on a highway under a bridge. If he gets orders to build anything larger, Newman said, he will clear an area a half-mile away on the Lake Erie shore and fabricate at dockside.

No Action Soon on Industrial Security

Three bills introduced in Congress but vote not expected before next session even in light of Supreme Court decision

WASHINGTON—It's becoming increasingly apparent that industry will have to play the "industrial security program" by ear until the next session of Congress. This means that defense contractors will have to continue to follow the elaborate set of rules established by the Defense Department which are applicable both to military and National Aeronautics and Space Administration contractors.

Trouble will come only in those cases where a charge is made that an employee constitutes a security risk. A discharge of such an employee, even if ordered by the Pentagon, could cause trouble in view of the decision of the U.S. Supreme Court in the Greene case. There the high court held that the industrial security program was invalid since it was based neither on legislation nor an executive order of the Congress.

Seemingly this meant that the program could be revalidated by the simple act of issuing an executive order. However, there is language in the opinion of Chief Justice Warren which points to a new concern that those charged with being security risks must be given the right to confront their accusers. This language runs squarely counter to the basic security tenet that it is essential that informers and information gathered in so-called "raw" files be protected. Efforts to solve this problem have not been successful, and both the White House and the Justice Department continue "to study" the possible solutions.

• **Bills offered**—In the meantime, three bills have been introduced. Two (S2392, S2146) have been referred to the Senate Judiciary Committee but have not yet been assigned to a subcommittee for hearings. On the House side, one bill has been introduced. It's HR8121, introduced by Rep. Francis E. Walter (D-Pa), head of the House Un-American Activities Committee.

That Committee has asked for reports from the affected executive departments but has not yet received replies. Until those replies are received, hearings are not considered likely.

On the Senate side, one bill, S2392, has been labelled as "emergency" legislation by its sponsors, Senators Olin D. Johnston (D-S.C.) and James O. Eastland (D-Miss.). It would establish legal authority for the industrial security program as required by the Supreme Court decision. It would not, however, touch the tricky constitutional question of the right of the accused to confront his accusers. In introducing the bill, Sen. Johnston commented that industrial security could thus be kept alive while Congress sought to determine what, if anything, should be done to solve constitutional questions.

The other Senate Bill, S2146, seeks to meet the right of confrontation head-on. Introduced by Senators Thomas J. Dodd (D-Conn.) and Kenneth Keating (R-N.Y.), the bill, in the words of its sponsors, is designed "to eliminate unsupported charges by faceless informers in such cases by subjecting them to confrontation and cross-examination, and at the same time to protect regularly established confidential informants engaged in intelligence work for the government whose identity may not be disclosed without compromising the national security."

Under the terms of the Dodd-Keating bill, any person denied clearance for access to classified information or material or whose clearance has been suspended shall be given: (1) a written statement within 30 days showing the reasons, "stated as specifically and in detail as security considerations permit"; (2) an opportunity within 30 days to reply and submit affidavits in support of such reply; (3) a hearing, at his request, before a hearing officer designated for such purpose, who is required to prepare a recommended decision; (4) a review of the recommended decision by the head of the agency involved; and (5) a written statement of the decision of the agency head.

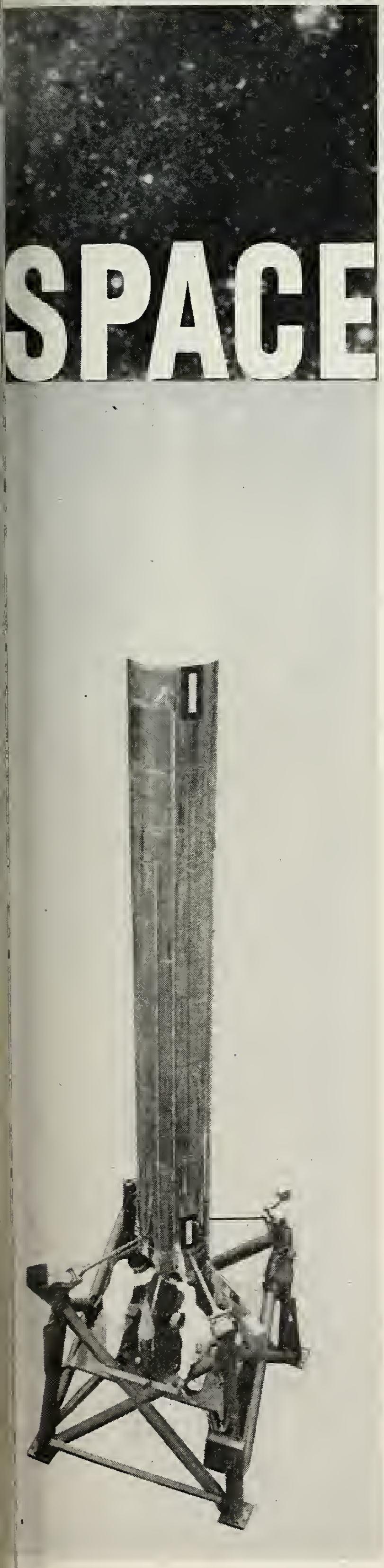
The bill spells out in detail how hearings shall be conducted to prov[e] maximum opportunity for the accu[d] to protect himself. It provides am[g] other things that hearings shall be c[-] ducted so as to assure "a full disclos[e] of any evidence against the accu[d] and confrontation of all adverse [t-] nesses."

• **Exception**—There is one imp[t-] ant exception spelled out. This wo[d] bar the right of the accused if a fin[g] is made by the hearing officer [r] agency head that the national secu[/,] public safety or public interest wo[d] be adversely affected. However, [e] bill would bar reliance on "deroga[y] information" as a basis for den[g] clearance "unless the applicant has b[n] furnished a statement by the hea[g] officer summarizing such informa[n] in as much detail as is possible wit[t] adversely affecting the national secu[/,] safety or public interest."

The bill also assures the right [a] person who loses security clearance [d] his job, as a result, to recover the [f-] ference between the pay he would h[e] earned if allowed to remain on the [b] and his aggregate earnings during [e] period in which his employment [is] suspended or terminated. Obvio[/,] this right goes only to the man [o] wins his case on review.

• **No action soon**—Despite [e] fact that this bill comes close to m[t-] ing the goals set by the Supreme Co[t,] it is a virtual certainty that Cong[-] sional action will be delayed until [e] next session at the earliest. Infor[d] sources say that lack of time a[e] would dictate the delay. They add [t] there is no particular urgency at [is] time since defense contractors are [-] erally playing along, and can alw[s] pass on the bill to the Pentagon [a] discharged employee successfully [s] a fight for reinstatement.

Other tough problems include [e] need for a definition of such term[s] "derogatory" information, as well [a] clear definition of the procedures u[r] which adverse security decisions w[d] be reviewed.



RESEARCH

BRISTOL SIDDELEY GAMMA ROCKET ENGINE POWER BLACK KNIGHT- BRITAINS HIGHLY SUCCESSFUL SPACE RESEARCH VEHICLE

On the 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.

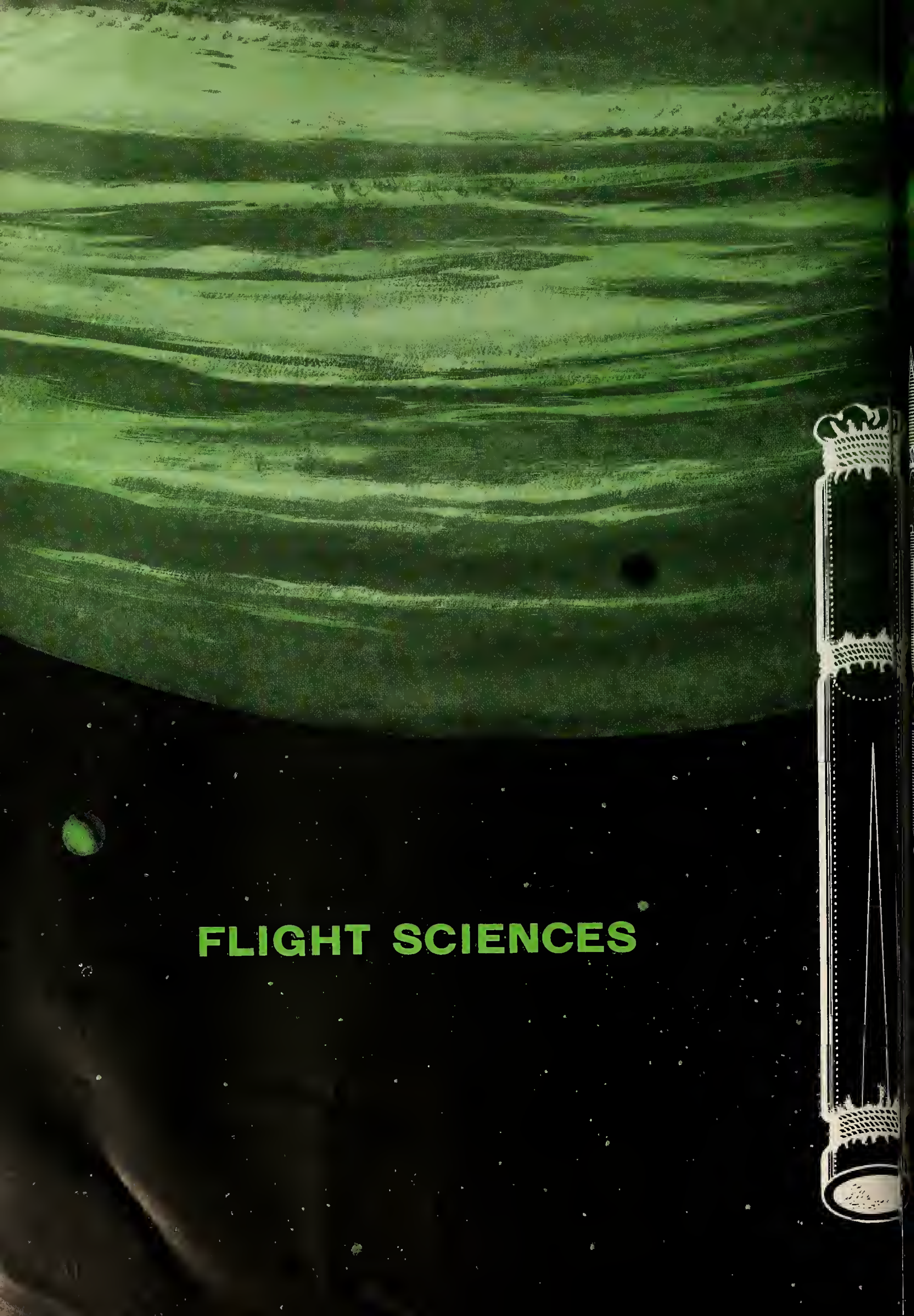
The Bristol Siddeley Gamma 201 is a liquid propellant rocket engine. Four trunnion-mounted chambers burn kerosene with HTP and each chamber is fed by its own turbopump unit. The complete weight of the engine compartment is less than 700 lb. (dry) and Gamma delivers 19,000 lb. at altitude—16,400 lb. at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

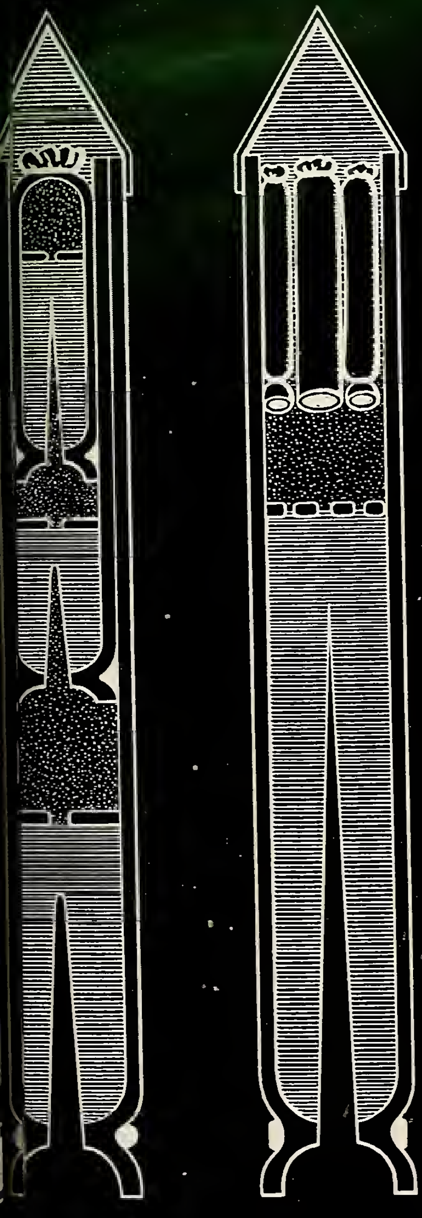
Bristol Siddeley

ENGINES LIMITED



FLIGHT SCIENCES

FLIGHT SCIENCES: Principle of the step or multi-stage rocket, considered fundamental to the art of modern missiles and space flight, was set forth as long ago as 1650 by Kazimierz Siemienowicz, lieutenant-general of ordnance to the king of Poland. His design featured a 3-stage rocket with each step having its own gunpowder fuel, fuse, and nozzle.



EXPANDING THE FRONTIERS OF SPACE TECHNOLOGY

Pioneering work at Lockheed is being conducted in free molecular flow in orbital flight; high altitude atmospheric properties; trajectory studies and missile flight dynamics; celestial mechanics with emphasis on orbital tracking predictions and de-orbiting.

Lockheed's capabilities in gas dynamics and thermodynamics are unsurpassed in private industry. Basic work is being performed in boundary layer flow and heat transfer; cooling and insulation; thermodynamic flight test; instrumentation; rocket motor controls and nozzle structures; reentry and materials; thin film thermometry; and measurements of dissociation and re-combination reactions.

Fundamental studies include hypersonic aerodynamics; environmental effects on satellite surfaces; magnetohydrodynamics; ultra-violet and infrared radiation from high temperature air flows; structure of hypersonic shock waves; new measurement methods; analysis of boundary layers near melting surfaces and study of lag or non-equilibrium in high speed flow through shock waves.

Equipment includes an electrically-driven wind tunnel—fastest in industry—which produces airflows to Mach 20-plus and stagnant temperatures approaching 16,000°F, with an instantaneous power output of 20 million kilowatts. A spark-heated, magnetically driven research shock tube produces velocities of over Mach 250 and temperatures of 500,000°F, and a specially designed, electric gun has accelerated projectiles to speeds approaching 20,000 ft/sec.

Major emphasis in structures concerns the design of reentry bodies, thrust termination and underwater launching devices. The Navy Polaris FBM required the solution of complex structural problems necessitated by the unique launching environment—water.

Other significant work has been accomplished in diversified aspects of aerodynamic and hydrodynamic load distribution, aeroelastic effects, studies of special dynamic problems arising from aerodynamic disturbances, cavitation, launching conditions and thermal problems relating to analysis of a complex structure taken through a complete time-temperature environment.

Lockheed Missiles and Space Division programs reach far into the future and deal with unknown environments. It is a rewarding future which scientists and engineers of outstanding talent and inquiring mind are invited to share. Write: Research and Development Staff, Dept. H-29, 962 W. El Camino Real, Sunnyvale, California. U.S. citizenship required.

Lockheed

MISSILES AND SPACE DIVISION

Weapons Systems Manager for the Navy POLARIS FBM; DISCOVERER SATELLITE; Army KINGFISHER; and Air Force Q-5 and X-7

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Centaur Engine Tests Begin

Scheduling calls for Pratt & Whitney to deliver first operational liquid hydrogen engine to Convair in 1960 for use in NASA's space vehicle Centaur, to be finished in 1961.

by **Paul Means**

WASHINGTON—The nation's first second generation space engine—**Pratt & Whitney**'s liquid hydrogen-liquid oxygen XLR 115 P-1—is scheduled for delivery to **Convair Astronautics** for integration into NASA's *Centaur* space vehicle in 1960.

Two years later, the high energy engine will be placed on top of ABMA-ARPA's million and a half pound thrust clustered *Saturn* booster for initial flight tests.

XLR 115 P-1, which will give the upper stage push to perform such missions as orbiting 24-hour communication satellites and sending man to the moon and back, is currently undergoing full scale developmental static run-up tests at Pratt & Whitney's Florida Research and Developmental Center at Palm Beach, Fla.

THRUST CHAMBER of XLR 115 is lifted onto test stand for static firing.

Its first use will be as the second stage of *Centaur,* which will have the Convair *Atlas* for its first stage, and optional use of JPL's 6 K, a 6,000 pound thrust storable propellant engine, for its third stage.

Upon receipt of the Pratt & Whitney engine, Convair has about one year, under present scheduling, to design and fabricate the second stage, and to integrate and test the complete *Centaur* vehicle before delivery to NASA.

• **Six vehicles slated**—The six *Centaur* vehicles NASA has contracted for are staged to come through in intervals of about two months during 1961 and 1962.

Project *Centaur* was funded for $22 million by ARPA in FY 1959 and for $42 million by NASA in FY 1960. Estimated individual cost of the first six *Centaur* vehicles is $7,500,000.

Early development of liquid hydrogen as a rocket fuel has been carried on for some years by NASA's Lewis Laboratories at Cleveland, and by the Air Force.

The low molecular weight fuel has a heating value of some 2.8 times that of kerosene. Its specific impulse when used with liquid oxygen is 391 compared to 300 for a LOX-kerosene combination, an improvement of about 40%. In spite of its low density and attendant large tank volumes, liquid hydrogen's better fuel economy allows for great increases in payload weights.

Before liquid hydrogen could considered seriously as a space vehi fuel, methods had to be devised whe by it could be produced with exacti standards of purity in great quanti and could be handled and transport safely.

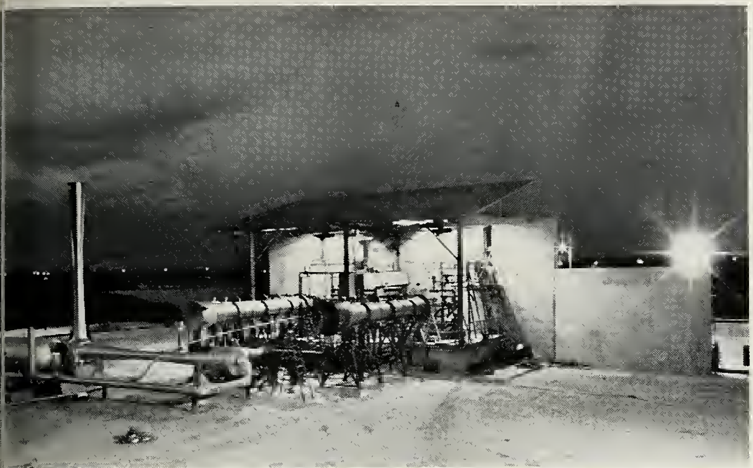
The U.S. Air Force, project sup visor of *Centaur* under ARPA, a retained in this role by NASA, beg large tonnage production of high pur hydrogen under contract to **Air Pro ucts Inc.,** at the U.S. Air Force Pla No. 74 in the Florida Everglades, r far from Pratt & Whitney's West Pa Beach facility. Other hydrogen plan initiated by the Air Force are an A Products, Inc. plant at Painesville, (and a **Stearns-Roger Manufacturing C** plant at Bakersfield, Calif.

AF Plant No. 74 combines cru oil, air and water to generate the g and then uses expansion turbines remove energy and liquefy it.

The liquefied gas is then shipp in Dewar tanks enveloped in nitrog to users. At the Pratt & Whitney W Palm Beach installation, the Air For currently is piping the fuel over distance of nearly half a mile in vacuum-jacketed pipe system.

The problems Pratt & Whitney fa in developing the first practical liqu hydrogen engine center around t fact that the cyrogenic material has boiling point of −422F°.

• **Quick disconnect necessary**—Since the Pratt & Whitney engine w be fired after the *Atlas* booster h carried it far into space, the fuel w have to be kept cold during the bas booster phase or the pressure in t tanks will rise to bursting point. Oth problems besides insulation inclu the necessity of keeping lines a



WILIGHT VIEW of Pratt & Whitney's double test stand for liquid hydrogen ›cket engines showing the big tubes through which the engines fire.

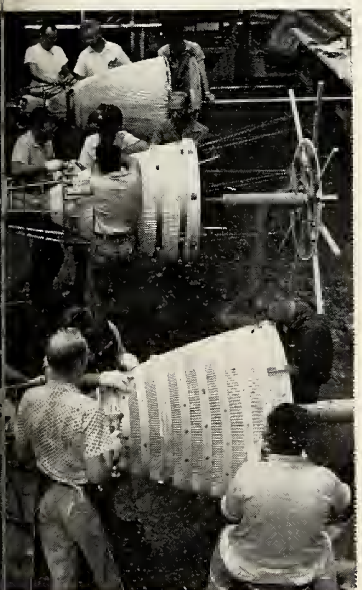
PRATT & WHITNEY technicians prepare for an XLR 115 engine test.

ımps from freezing, and the necessity f making quick disconnects.

To counteract these problems, the ratt & Whitney test facilities simulate ıe space conditions under which the ıgine will be fired by the use of ɪyogenic plumbing, high-pressure gas ırge systems, and a whole new techɔlogy of test instrumentation.

Rather than develop one 30,000 ɔund thrust engine for *Centaur,* P&W ıgineers found it advantageous to uster two gimballed 15,000 lb. thrust ıgines.

The XLR 115 P-1's components, ıd full scale developmental models are currently being tested on four large horizontal test stands constructed without government subsidy by Pratt & Whitney. The stands are designed to test engines up to 300,000 pounds of thrust.



HRUST CHAMBERS for *Centaur* ıgine take shape in Pratt & Whitney's ssembly area.

A fifth and larger vertical test stand, jointly financed by the government and Pratt & Whitney, will have a capability of static testing a complete space vehicle, including engines and propellant tanks. This stand will be ready this fall—in time to begin the vertical testing of XLR 115-P-1.

The P&W engine will have a start-restart capability in flight, with sets of hydrogen peroxide rockets providing upper-stage altitude control during the coast period. The coast period, plus the high energy propellant, give the P&W engine a gain in payload weight of approximately 50% over *Vega* for similar missions.

Straightforward engineering progress should increase the thrust of XLR 115 in the near future from 15,000 lbs. of thrust to 20,000 lbs. of thrust.

• **Three more families**—Beyond the *Centaur* engine, P&W engineers are planning three families of upper stage liquid hydrogen eingines, one ranging from 10,000 to 30,000 lbs. of thrust, one from 30,000 to 100,000 lbs. of thrust, and one from 100,000 to 300,000 lbs. of thrust.

NASA has already indicated that engines from both the second and third families may be used on top of the 6 million pound clustered booster *Nova.*

And P&W engineers feel that progress in hydrogen engines will come with such rapidity that *Nova's* second and third stage hydrogen engines may be completed before the mammoth clustered booster is ready for them.

Though a liquid hydrogen-liquid fluorine rocket engine would be the ultimate chemical rocket engine, P&W engineers do not believe that the highly toxic oxidizer will ever replace liquid oxygen in liquid hydrogen engines.

They point out that liquid hydrogen's impulse is only slightly higher with fluorine than with oxygen, and there would be few missions which would require exploiting this advantage. On the other hand, hazards introduced by fluorine toxic and corrosive qualities should prevent its use as a propellant for manned missions.

DuPont Constructing Metals Research Plant

WILMINGTON, DEL.—**DuPont** will build a center for development research in niobium, niobium alloys and titanium at its Baltimore plant.

The installation, to be completed by the fall of 1960, will contain equipment to forge, extrude, roll, draw and heat treat all the refractory metals—such as tantalum, zirconium, tungsten and chromium. But it will concentrate on niobium and titanium at first.

F. H. Weismuller, general manager of DuPont's Pigment's Department, said basic research on other refractories will continue "while we engage in large-scale testing . . . of metals that are closer to commercialization."

The unit will be at a plant where DuPont has manufactured titanium dioxide white pigment for 28 years. The company has been interested in niobium, also known as columbium, since 1957, when it entered a joint development program with **Thompson Ramo Wooldridge Inc.** of Cleveland.

astronautics engineering

Inert-Gas Brazing Room Proposed

Aerospace Industries suggests manufacturers study joint establishment of 'space room' for high-temperature work on metals

Los Angeles—An industry group suggests it may be feasible to set up a jointly sponsored "space room" capable of providing a total inert-gas environment for welding and brazing metals.

The **Aerospace Industries Assn. of America** advanced the idea last week in its 1959 annual forecast of trends and requirements. The association proposed a study of the project's feasibility.

The report made no estimate of the cost. However, one engineer familiar with the association's thinking said such a facility could easily cost 10 or 15 million dollars. The engineer, who preferred to remain anonymous, said the idea is for a room on the order 40' x 50' x 6' in size, where metals could be worked at temperatures up to 3500°F. The room would be used for both manufacturing and research.

Another idea being kicked around, the engineer added, is that equipment in the room should be entirely remotely controlled. This would have the obvious advantage that it would not be necessary to keep atmospheric temperatures down to those tolerable to human workers. Otherwise, they would have to be equipped with asbestos clothing and air helmets. The air in the room would be argon or some other inert gas.

No consideration has been given to how the cost might be apportioned. It may not be possible to finance it without government sponsorship, the engineer said. As yet, however, no approach has been made to any government agency.

The industry group's report also forecast requirements within five years for missile materials that will withstand brief exposures to temperatures of 3000°F and within 10 years to 5000°F.

In addition to these stern demands, Aerospace Industries called for development of new materials and methods in ever-shorter time spans. The report outlined the needs of the coming decade in assembly and joining, metal shaping, materials removal, plating and cladding, and heat treatment.

• **Combined processes**—Trends in assembly and joining are toward brazed and welded structures and indicate particular need for equipment development in this area, the report said. Combined processes will be necessary—for instance, welding and machining in a welding positioner.

The two chief problems will be achieving the very close tolerances required and brazing, welding and heat treating in a controlled atmosphere. To produce a stress-free, dimensionally accurate unit and locate details throu high-temperature processes, precisi sub-assembly tooling will be needed. A sembly tooling and manufacturing w be required for joining large sub-asse blies already in the hardened cond tion. For welding and localized he treating during final assembly, portab equipment and techniques must be d veloped.

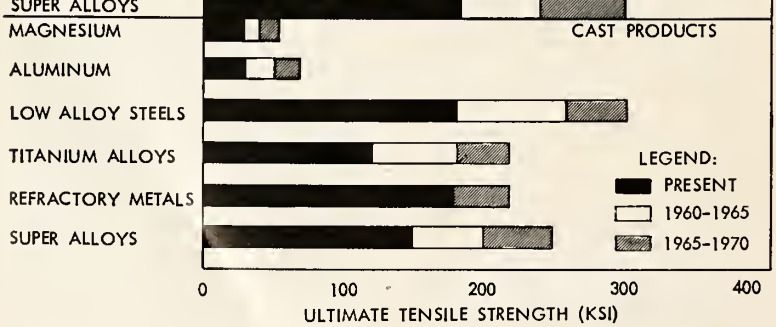
Aerospace Industries forecast ne for a method of joining metals witho heat. The group suggested an approa by use of metallic compounds plac in the joints, with fastening accor plished by a chemical reaction trigger by gas.

In metal shaping, the associati predicted a demand for fabricati techniques and equipment that w place the metal as close as possible its final configuration. This will con as more emphasis is placed on develo ing high-strength steels with yields 300,000 psi and titanium alloys wi yields of 200,000 psi.

• **Temperature barrier**—In materia removal, Aerospace Industries predicte that operations such as shearing, blan ing and machining, now performed room temperature, will have to be do with materials or tools heated or at su zero temperatures. Since some meta and almost all ceramics and cerme cannot be machined with ordinar tools, these jobs will require cerami tools, ultrasonic machining or electric discharge machining.

Trends in plating and cladding in dicate the demand for automatic sy tems to control the processes, the ass ciation declared. The report called fo development of nondetrimental platin and cladding processes to withstan temperatures of 1200°F.

The industry association forecas demands in heat treatment for mini mum-mass materials for tempering an fixtures to control parts at treatin temperatures. Equipment for annealin or heat treating large component above 2000°F also will be required Sources using radiant heating or induc tion coils may be needed for treatin "localized" areas of assemblies to large for furnace treatment. The re port suggested resistance heating migh solve this problem.



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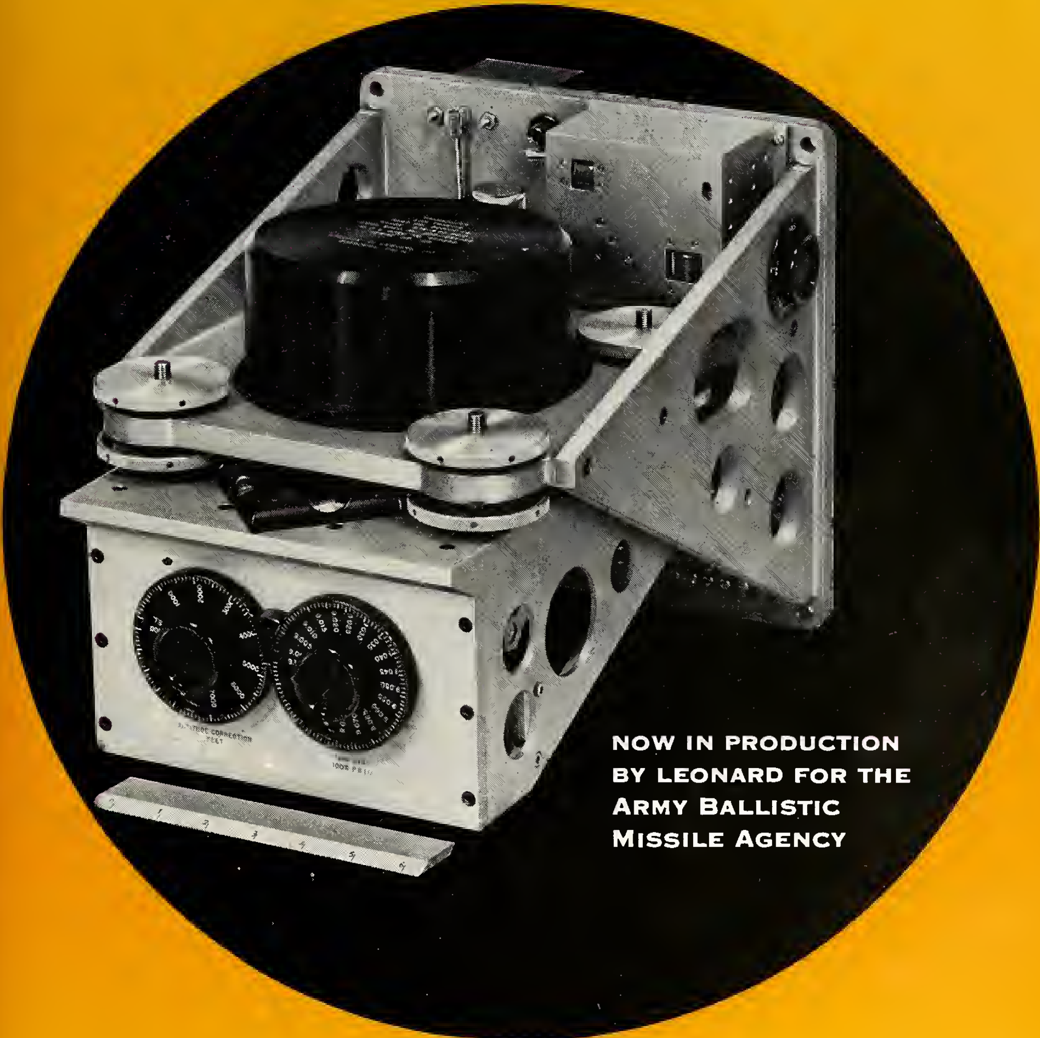

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What Can Withstand Re-entry Heat?

Bell Aircraft engineers find coated molybdenum, dense silicon carbide and coated graphite best for leading edge of boost-glide plane such as Dyna-Soar

Los ANGELES—Coated molybdenum alloy, dense silicon carbide, and coated graphite are the most promising materials for the leading edge of the wings of a hypersonic global boost-glide plane such as *Dyna-Soar*.

Two **Bell Aircraft Corp.** engineers made this report at the recent national summer meeting of the Institute of the Aeronautical Sciences. The engineers, Frank M. Anthony and Harry A. Pearl, did not mention *Dyna-Soar* by name in their paper, "Selection of Materials for Hypersonic Leading Edge Applications." But their reference to a manned plane with range of 22,000 miles made it clear they were discussing that project.

In a "typical trajectory," they declared, such a craft would reach a peak altitude of 300,000 feet six minutes after launch, at which time the vehicle velocity is 25,400 fps and a range of 700 nautical miles has been traveled. During the ensuing descent, when vehicle weight is balanced by lift plus centrifugal force, a range of 21,900 miles is traveled in 105 minutes.

The end of the glide is assumed to come when altitude falls to 85,000 feet and velocity drops to 1200 fps. From this stage on, the flight is considered to be in the landing phase.

Dynamic pressures and temperatures each peak twice during such a flight, once during boost and once during descent.

• **Critical conditions**—These data show that three potentially critical flight conditions exist—high dynamic pressure combined with moderate temperature during boost, high temperature combined with low dynamic pressure during glide, and high dynamic pressure combined with low temperature during landing. However, Anthony and Pearl report, studies have shown that air load stresses are not a major consideration in selecting hypersonic leading edge materials. The real problem is high temperature.

In the typical *Dyna-Soar* flight, the Bell engineers estimate that maximum temperatures will range from 2600° to 2900°F, when the benefits of geometry and material characteristics are considered.

They screened materials for oxidation resistance, thermal conductivi[ty,] thermal expansion, thermal emissivi[ty,] tensile strength (metals) and modul[us] of rupture (non-metals).

Molybdenum and its alloys we[re] given a favorable report because [of] high thermal conductivity, low coe[ffi]cient of thermal expansion, high mod[u]lus of elasticity and high mechani[cal] strength at elevated temperatures. T[he] metal oxidizes rapidly, however, [at] temperatures above about 1200°F [to] form a corrosive oxide that is volat[ile] at about 1500°F. Some alloys poss[ess] higher mechanical strength and hig[h re]crystallization temperatures but [no] truly oxidation-resistant alloy has be[en] developed.

Anthony and Pearl reported t[hat] an 0.5% titanium, 0.07% zirconiu[m] alloy developed this year is apprecia[bly] stronger than other alloys and has [a] recrystallization temperature of abo[ut] 2900°F—the upper limit of the te[m]perature range for a *Dyna-Soar* lea[d]ing edge. The short-time ultimate te[n]sile strength of this alloy is 54,000 [psi] at 2400°F and 14,000 psi at 3000°F[.]

• **Silicon coating**—A good coati[ng]

Fig. 1—Thermal Expansion vs. Temperature

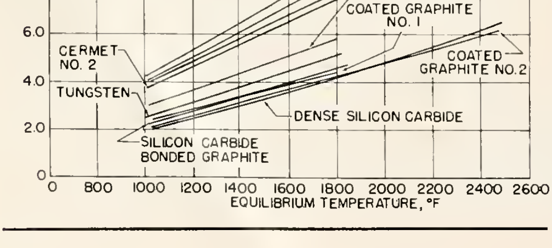


Fig. 2—Emissivity vs. Temperature

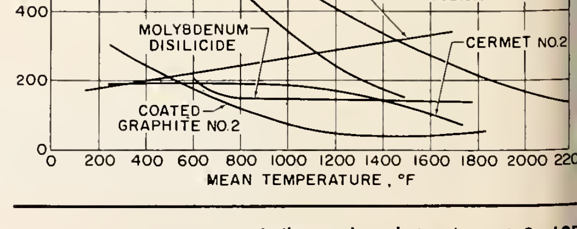


TABLE I COMPARISON OF TEMPERATURES AND THERMAL STRESSES FOR VARIOUS MATERIALS

I INCH DIAMETER, 10° WEDGE ANGLE, 60° SWEEP.
W/SC_L = 100 = 0.9 22,000 fps 241,000 Feet

Material	Temperature, °F Maximum	Minimum	Tension	Thermal Stresses, psi Max. Tension	Max. Compression	Tension (Bending) Ultimate Average	99%	Compression Ultimate
% Ti Alloy of Molybdenum	2,620	2,070	2,260	7,500	26,100	26,000	.....	17,000
bium Alloy	2,810	1,980	2,200	2,960	4,700	25,000	.....	..0
nse Silicon Carbide	3,060	1,840	2,100	10,350	25,000	18,000	6,920	52,000
ated Graphite, Type I	2,660	2,100	2,240	420	1,610	6,000	1,130	12,000
ated Graphite, Type II	3,290	1,770	2,100	1,620	15,900	4,350	800	.....
rmet, Type I	2,960	1,880	2,140	4,420	690+	46,500	34,400	0
rmet, Type II	2,960	1,880	2,140	5,200	9,650+	65,000	46,400	3,000
lybdenum Disilicide	3,040	1,850	2,120	4,930	2,780+	28,700	14,700	4,500

* For non-metallics measured bending strength on ¼" x ¼" x 5" specimens has been used for tension and compression stresses were taken equal to 3 times the bending values. For metals tension and compression allowables were assumed equal. Since scatter is small only average values for metals are used.

+ Values are low because modulus of elasticity becomes extremely low. In general this would indicate large plastic deformations. Therefore, stresses do not indicate a true picture.

r molybdenum, they said, is vapor-posited silicon, which reacts with the etal to form molybdenum disilicide. he final coating is a graded mixture "alloy" composed of relatively pure olybdenum disilicide on the outer rface with greater concentrations of ise material distributed through it as e proceeds below the surface, they plained. The bonding is chemical.

Silicon carbide is an exception nong carbides in that it is quite re-stant to oxidation. Like all carbides, icides and graphite, it has a high elting point. Anthony and Pearl re-orted that silicon carbide modified aterials, made experimentally by hot essing techniques, have modulus of pture of about 70,000 psi at 2500°F.

The **Carborundum Corp.** says it oduces a self-bonded form of this bstance (KT silicon carbide), which ins only 0.51 mg/sq cm in 5 hours oxidation when exposed to air at 92°F. Carborundum says the ther-al conductivity is 293 BTU/sq ft/-/hr at 1832°F, much higher than ost other ceramics and non-metals.

Graphite has high thermal conduc-vity and high thermal emissivity. hus, Anthony and Pearl reported, an ception is made to the general rule at it is undesirable to coat a ceramic aterial with another ceramic to pro-ct it against oxidation. Graphite also s desirably low modulus of elasticity d coefficient of thermal expansion. lthough its mechanical strength is ry low, it increases with tempera-re up to about 5000°F. Present rms of graphite do not approach eoretical density; thus it is expected at the mechanical strength will be creased in the future.

They said coated graphite is su-rior because of low weight, easy bricability and low modulus of elas-city. However, its strength is variable d the coatings are unreliable.

The investigators sought to obtain ta on material with the same process story. Although it might seem that some information is available from technical literature and need not be obtained again, they pointed out that different processing can result in different properties. For example, they asserted that the effect on mechanical and chemical properties of applying a coating to a material may vary considerably from those of the bare metal.

• **Other materials tested**—In addition to the materials mentioned, the Bell engineers also tested a ternary niobium alloy, pure tungsten, silicon carbide bonded graphite, cermet type I (chromium, molybdenum, aluminum oxide), cermet type II (chromium, tungsten, aluminum oxide) and molybdenum disilicide. Tables I and II give the resulting thermal expansion data and comparison of temperatures and thermal stresses for the materials. Figs. 2 and 3 show thermal conductivity and thermal expansion plotted against temperature for each of the materials tested.

Below about 2400°F, Anthony and Pearl noted, niobium alloy appears to be advantageous because of lower density compared with molybdenum. For high emissivity, a coating would be necessary but the protective oxide formed would make it unnecessary to have oxidation protection of expendable components. However, protection of reusable components would be necessary to avoid embrittlement caused by subsurface contamination.

The two cermets have similar properties except that their thermal conductivity is lower than niobium. Thus, operating conditions would have to be less severe.

Molybdenum disilicide is also promising for temperatures up to 2400°F, they declared. This substance does not need a coating because it has a relatively high thermal emissivity, about .8, and its oxidation resistance also is excellent.

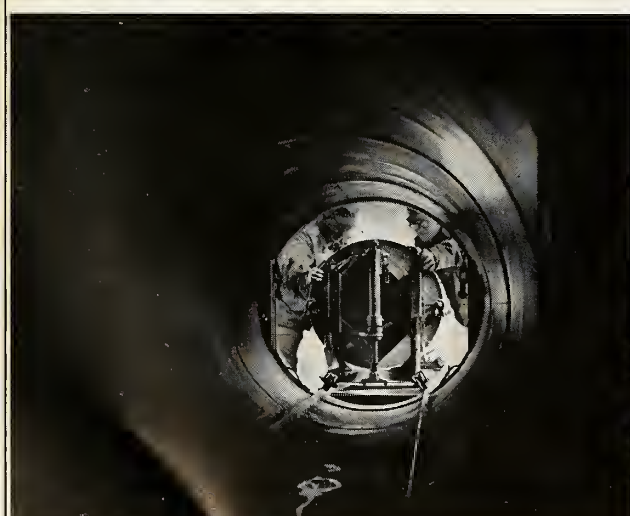
The Bell engineers said tungsten and coated graphite appear to be the most promising materials for use above 3100°F. But they added that much work is needed to advance the state of the art to the point where the materials can be used with confidence under such conditions. They noted, however, that for the leading edge of a boost-glide airplane of global range, temperatures ranged from 2600° to 3100°F for the materials considered.

Anthony and Pearl called for continued development in materials. Specifically, they urged more thorough definition of properties, improvement of processing techniques to reduce variability—particularly non-metal strengths, oxidation protection of coatings and extension of fabrication capabilities.

TABLE II THERMAL EXPANSION DATA

Material	Temperature Range (F)	Unit Expansion (in/in x 10^{-3})	Coefficient of Thermal Expansion (in/in°F x 10^{-6})
Dense Silicon Carbide	80-1040	2.1	2.2
	80-1800	4.2	2.5
	80-2485	6.6	2.7
Silicon Carbide Bonded Graphite	80-1000	2.2	2.4
	80-1840	4.7	2.7
Coated Graphite #1	80-1030	2.4	2.5
	80-1800	4.4	2.6
Coated Graphite #2	80-1020	2.1	2.2
	80-1820	4.3	2.5
	80-2482	6.2	2.6
Cermet #1	80-1000	4.2	4.6
	80-1830	9.1	5.2
	80-2496	14.1	5.9
Cermet #2	80-1000	3.7	4.1
	80-1850	7.7	4.4
Molybdenum Disilicide	80-1020	4.1	4.4
	80-1830	7.9	4.5
Columbium Alloy	80-1010	4.0	4.3
	80-1810	8.3	4.8
Molybdenum (0.5 Ti)	80-1010	3.8	3.2
	80-1810	5.8	3.3
Tungsten	80-1000	2.5	2.8
	80-1820	5.2	3.0

About the earthly side of the Corporal missile. The Army's Corporal mis sile is a surface-to-surface mobile artillery weapon. It's operational and it' in production. Tremendous quantities of materials fabricated into numerou pieces of ground support equipment operated by Army personnel are require to launch the Corporal with split-second timing and accuracy. And virtuall all of the steel material required can be purchased from one source—Unite States Steel. Whether we're talking about carbon steel, high-strengt low-alloy steel, alloy steel or Stainless Steel, steel fence, electrical cable

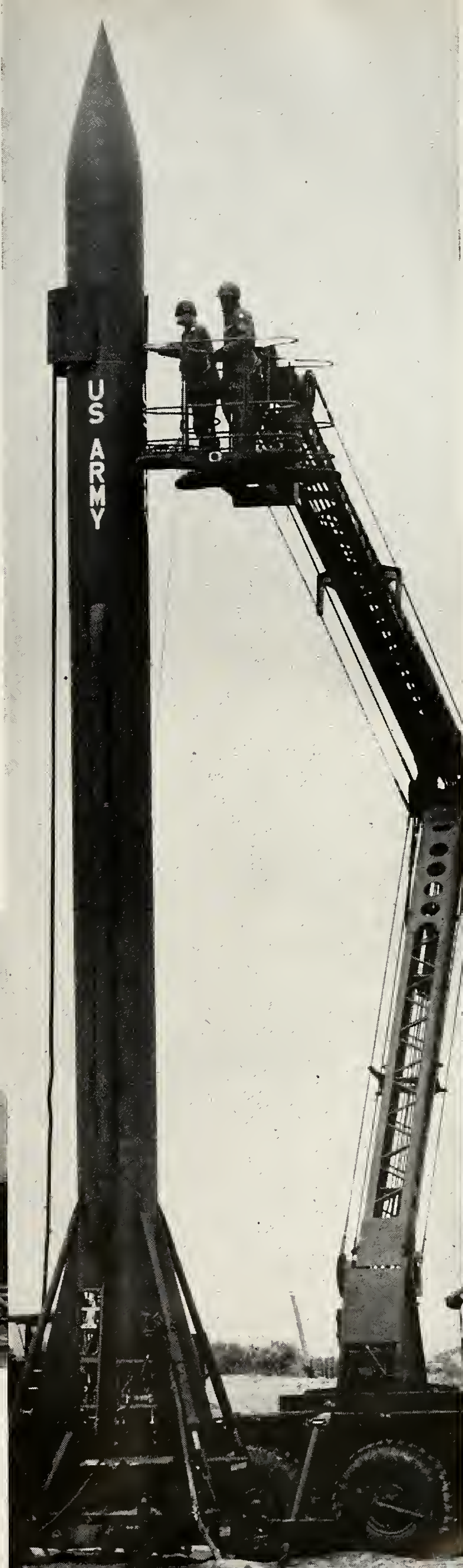


How thin and light can you make the shipping container for a rocket, and still have a strong, impact-resistant shell? The transportation industry specialists in strong, lightweight construction have overcome this same problem with the help of United States Steel.

This Corporal transporter is made of steel. Why? Because this has to be a rugged piece of equipment to withstand the abuse of moving the missile over all types of rough terrain.

cement or wire rope, United States Steel maintains the technical services to provide the proper assistance to cope with any problem on these materials for ground support. When a ground support program is ready for the drawing board, consult USS United States Steel

USS is a registered trademark



Technicians are carried to the "brain" of the Corporal missile on a "cherry-picker." Its boom is similar to that of an industrial crane. United States Steel representatives are constantly working with the manufacturers of cranes and power shovels to develop more efficient strength-weight ratios and better rigging.

Where Are We Going in Fuel Handling?

The cryogenic engineer still must be a jack-of-all-trades with industry having to gear up for multi-million-pound thrust boosters

by S. David Pursglove

WASHINGTON—The past year has seen many developments in propellant handling. New equipment and new materials such as corrosion-proof alloys and plastics already have been discussed in "new product" sections of magazines, and they have been widely advertised.

The developments we want to discuss here, however, are not machines and materials as much as ideas and techniques. Much of the equipment announced recently probably will be replaced by newer products before too long. However, the recent thoughts of missilemen—some pointing to new trends in thinking—will stay with us and should be examined.

The missile industry has encountered new problems, too, during the past year. However, even these problems represent progress: they signify that engineers are discovering and describing their problems—a first step toward solving them.

Solutions still call for brute force engineering at many stages; there's no easy way out yet. The cryogenic engineer, for example, must be an intellectual jack-of-all-trades. He must understand heat transfer and liquid flow. He has to know all about pumps, instrumentation, and the properties of his materials. Engineers still are faced with the problem of accurately topping a tank of cryogenic oxidizer, although a fairly new device now makes the job a little easier.

The industry is still faced with the nightmarish task of gearing up for multi-million-pound-thrust boosters and their formidable handling problems. This has introduced a new type of handling problem. It's no longer a matter of getting a missile to a launch site and then worrying about fueling it. Soon, the problem of moving the missile to the site will be just as big as—possibly bigger than—the fueling problem. This applies to solid-propellant missiles as well.

Cryogenic engineers must be at home in these areas:

- **materials properties**
- **insulation techniques**
- **liquid flow**
- **pumps**
- **heat transfer**
- **instrumentation**

For that matter, we don't have to wait for the advent of super-size solids to see that the old argument that "solids don't have any problems like liquids do" is out of date and not true. In the past year there has been such a clamor for greater sophistication in solid-propellant missiles that a whole new area of handling-engineering is opening up.

High-energy fuels based on boron still offer problems, but these soon may be solved by the simple withdrawal of boron from the fuels picture. The same is true of free radicals. In the past year it has become obvious that free radical propulsion is on the way out.

• **Real breakthroughs**—On the positive side of the picture for the year past, things are very bright. Thinking has been penetrating and dynamic. Many of the developments to which newspaper writers have applied the term "breakthrough" really have been genuine breakthroughs.

One of the most important events recently is something that built up over a period of time, and without fanfare. It is the unspoken, but nevertheless definite, acknowledgement in missile circles that LOX will continue for a long time as our primary oxidizer. This allows the kind of advance planning that has not been possible while there has been so much talk about replacing liquid oxygen with various "exotic" oxidizers. Eventually, fluorine may take over in some missiles, bu this still is in the future—and probabl on a limited scale.

The National Bureau of Standard has made it possible for liquid hydro gen to be handled much like an other cryogenic. This gives new hop to scientists and engineers who war to use H_2 as the "ultimate fuel." Ne high insulation powders and vacuur insulating techniques further the caus of liquid hydrogen, as well as help th entire cryogenic propellant field.

As an example of some seriou thinking that has been devoted to pro pellant handling problems, engineer point to **Arthur D. Little's** announce ment of a large-scale cryogenics se vicing system. And, almost withou fanfare, the National Bureau of Stan ards got its cryogenic data cente under way.

The cryogenic engineer still mu be at home in many fields, but abov all, he must be an engineer. He mu know approximately the same thing that are known by an engineer wh designs home refrigerators, but th emphasis has to be different.

Robert B. Jacobs, chief of the cr ogenic equipment section, Nationa Bureau of Standards, has this to sa in the April ARS Journal:

• **Principles the same**—"Cryogeni problems can be solved through appl cation of the same basic principle which have been successfully employe for many years in mechanical, chemica and electrical engineering. Situations i which new principles (e.g. supercon ductivity) arise are very rare. No mally, the significant deviations o cryogenic problems from the mo familiar ones are caused by chang in emphasis or differences in order o magnitude; design difficulties are us ally the result of insufficient knowledg of properties of materials."

As an example, Jacobs suggests th the engineer who understands the bas phenomena occurring in a centrifug ump can predict performance and ıvitation characteristics for a liquid ydrogen pump just as reliably as he ın for a cold water pump.

Although the differences between ɔld water engineering and cryogenic ngineering may be only differences in nphasis, they are very important. ıcobs points out that the engineer ho designs valves for operation at nbient temperatures is interested in ydraulic efficiency and leak tightness cross the seat and through the stem acking. When he takes on the design f a valve for handling a cryogenic ropellant, he has the same interests, ut some become more important: differential contraction, freezing of packıg materials, impact strength, insulaon.

Jacobs points out six areas in hich the cryogenic engineer must be articularly well versed:

• Materials properties, not too ritical at room temperature, become ll-important at extremely low temeratures. In missile work, low temerature strength is needed and, withı the missile, material density beɔmes important.

• Insulation techniques have to be familiar to the cryogenic engineer his own name. He must be on intiıate terms with conventional, powder, nd vacuum techniques. In ground andling of propellants, he has to dede between insulation and no insulaon—sometimes no insulation is prerred for the sake of economy and beed. It is up to the cryogenic engieer to make the decision.

• Flow of liquids is a function of ıany considerations, all of them aplying equally to ambient temperature nd cryogenic engineering. Cold flow resents additional problems involving ansient phenomona that take place uring cryogenic equipment cool down.

• Pumps, and what happens to ıem at low temperatures, must be nderstood thoroughly. The problems ıvolved in pumping LOX are about ıe same as those involved in pumpıg cold water, at least on paper. But ıcobs feels we need additional studies ıto cavitation characteristics.

• Heat transfer considerations are ll-important in cryogenic engineering, ut do not involve any new principles. owever, Jacobs warns of contradicons between much published heat ansfer data.

Instrumentation is an important rea for the cryogenic engineer conerned with fueling a missile. His udies of instrumentation must be anted toward pressure, temperature, ɔw, liquid level, and static mass easurement. Cryogenic instruments, nd the materials of which they are made, have to take into account the effects of low temperature and high vacuum.

Jacobs makes it relatively easy for the cryogenic engineer to bring himself up-to-date in his field through a 56-entry bibliography of references in his survey of "Recent Advances in Cryogenic Engineering. Particularly valuable are these references: a new book published this year by D. Van Nostrand, "Cryogenic Engineering," by R. B. Scott; a series of articles by R. J. Corruccini, "Properties of Materials at Low Temperatures," in *Chemical Engineering Progress*, June, July, and August, 1957.

The Cryogenic Data Center is now in operation at the Cryogenic Engineering Laboratory, National Bureau of Standards, Boulder, Colo. Its purpose is to make information available to all persons concerned with cryogenics. Jacobs says it probably will not be completely up-to-date for about two more years, but it is currently rendering whatever services it can.

• **Fill 'er up?**—It may sound strange, but one of the biggest problems still faced by missilemen is that of filling a missile tank to the top with a liquefied gas. Assume all handling problems have been solved, then it's fairly easy to fill a tank part of the way. It's another thing to fill it all the way, or to top it.

Daniel A. Heald, senior design engineer at **Convair Astronautics,** described the problem recently to a meeting of the Society of Automotive Engineers. For example, he says, a missile's mission may call for rapid loading and firing. It seems like a small enough problem to get 0.5% accuracy on propellant weight at launch, or to fill the LOX tank to 98% of capacity to assure maximum range.

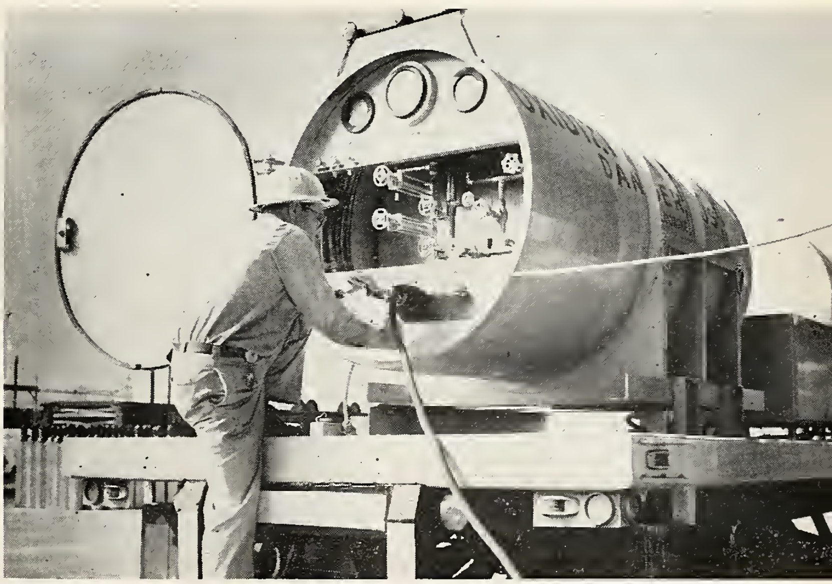
Just try to do it. Here is what Heald says we run into with a missile system with a large vertical airborne tank:

"The ground loading system, which must be considered an integral part of the whole, is a remote, high-capacity system with extensive automatic controls. Why not just weigh the filled missile on load cells, which have an advertised accuracy of 0.1%? This approach may have to be abandoned when one considers that the gross weight of the launcher system may nearly equal that of the missile, that misalignment of the missile and forces from cross winds introduce appreciable side loads which necessitate lateral load cells and complicate resolution of weighing systems, that calibration of such a complex system is difficult, and accurate load cells are expensive, and temperature sensitive, and that the propellant is rapidly boiling away."

Heald had developed a more practical technique:

"Calibrate the vessel so that the volume is known for a given liquid height; then knowing the density and level, the propellant load can be calculated."

This still leaves the problem of boil-off, but even that has been partly taken care of by a LOX tanking computer that **Servomechanisms, Inc.,** put into production around a year ago. SMI says the tanking computer meas-



SIGNIFICANT advancement in the transportation of fluorine both in liquid and bulk was made by General Chemical which designed this trailer transport.

ures, controls, and indicates the level of LOX in tanks.

Loading is rapid and accurate, SMI says, due to a two-mode control system. The first mode permits high pumping rates until 98% of tank capacity is reached. Then the second mode takes over and controls a proportioning valve which adds the LOX necessary to fill the tank to within 0.1% accuracy. The second mode also provides continuous topping during standby to compensate for boil-off.

• **High-speed effort**—The problems involved in handling cryogenic liquids are at the bottom of most valid arguments against liquid-fueled ICBM's. Thanks to these problems, liquid fueling times are longer than we can afford in case we need to use missiles for retaliation.

In 1955, the Air Force asked **Arthur D. Little, Inc.,** to study fueling time problems and try to develop a reliable high-speed fueling system. A. D. Little's R. B. Hinckley and R. E. Kendall described the resulting system at the San Diego meeting of the American Rocket Society in June.

The system had to meet these requirements:

(1) Be capable of loading an *Atlas* within the available reaction time (interval between detection of a hostile ICBM in flight, and the time of its impact on target). This meant it would have to be capable of LOX transfer rates up to 5000 gpm, and fuel transfer rates up to 3500 gpm.

(2) Be fully automatic to eliminate human error and relieve control personnel of routine detail.

(3) Use only standard, off-the-shelf industrial components.

(4) Load the missile to an accuracy of 0.5% by volume.

A. D. Little discovered that the largest proven LOX pump available had a capacity of only 500 gpm—10 pumps in parallel would be required.

The research firm decided not to use pumps at all, but to use a pressure transfer system instead. Thus, the key to the system involves transferring the LOX under a pressure head of gaseous oxygen. Helium was ruled out because of the then national shortage which is being slowly alleviated. Nitrogen was ruled out at the time because of the unknown effect on LOX of nitrogen contamination due to nitrogen condensing in contact with the LOX. Subsequent studies at A. D. Little show the nitrogen contamination not to exceed 0.5%, Hinckley and Kendall report.

• **Good results**—Tests were run at Edwards AFB. A dummy missile LOX tank was used. Here are the results:

The system demonstrated fully automatic loading, topping and draining. LOX flow rates were greater than 5000 gpm, and transfer pressures were lower than expected. The system was controlled to an accuracy of 0.5%. The system could be cooled down in the time available—critical parts of the system were cooled sufficiently for transfer in less than three minutes. The topping system maintained the LOX level, and even changes in wind velocity resulted immediately in a new topping valve position. The system is fail safe as proved by deliberate malfunctions.

The system is applicable to fuels as well as LOX. It probably will be applicable to other oxidizers, too. However, it may be a decade or more before anybody has to start worrying about wide-spread operational transfer systems for other oxidizers. In the past year, whenever the matter has come up, industry leaders and top military officials have said, or strongly hinted, that LOX will be the operational oxidizer in our missile program for some years to come. It still is the safest, most economical, most readily available oxidizer for missile use. It is stable, non-toxic, non-corrosive and, in an emergency, it's easy to get rid of.

• **Future and fluorine**—However, surveys of this sort always end with a look at the future. That which has been said about LOX does not den[y] that fluorine someday will find use [as] an oxidizer for some missions. Th[at] day is coming closer, thanks to **Be[ll] Aircraft's** continuing study of fluorin[e] and thanks to **Allied Chemical's** ne[w] developments in fluorine handling (s[ee] M/R May 11, p. 42).

Allied makes it possible to sh[ip] liquid fluorine almost as readily [as] LOX. However, it still is a dangero[us] substance when it escapes, calls f[or] special handling techniques at launc[h] sites, and is corrosive. But NASA [is] hard at work trying to develop ne[w] materials that can take the punishme[nt] of liquid F_2—materials immune [to] gaseous F_2 already are available.

Fluorine may someday be one-ha[lf] of a system already touted as the gre[atest] chemical propellant system we'll ev[er] have—fluorine-hydrogen.

Just as the past year has seen r[e]markable advances in fluorine handlin[g] techniques, so have many of hydrogen['s] problems been conquered. **Linde Com[pany's]** new super insulation techniqu[es] make liquid H_2 storage easier. Ho[w]ever, the real breakthrough has be[en] discussed in M/R's Propulsion Eng[i]neering many times. That is the ne[w] National Bureau of Standards proce[ss] for converting unstable hydrogen [to] stable hydrogen, thus eliminating bo[il] off due to heat released in the natur[al] transition from the unstable form [to] the stable form.

Converted liquid hydrogen stor[ed] in Linde Company's new super ins[u]lated tanks almost never boils away.

The theory is there. Now we ne[ed] hard-headed engineering and we'll ha[ve] an unbeatable propellant system. Har[d] headed engineering, money and time

OUTSTANDING cryogenic research is being undertaken by the NBS-AEC Cryogen[ic] Engineering Laboratory in Colorado.

BRITISH ASTRONAUTICS

• Pye Ltd. Develops Tank Missile
• Corporal Fired from New Missile Range
• Scorpion Engines Extending Aircraft Life

by G. V. E. Thompson

LONDON—One of Britain's leading lectronics manufacturers, **Pye Ltd.** of ambridge, has developed a powerful hort-range guided missile intended to eplace the armour-destroying heavy un currently carried by tanks. The 0 lb. missile has a 5 ft. tailless body tted with cruciform wings, and is jet-eered. Simple and robust in construc-on, it is also easily stored and has a ong shelf life.

The size chosen is thought to be he best compromise possible between he requirements of ease of handling nd high chance of kill per hit. The issiles can be transported in quantity a light vehicle, from which they can e fired. Alternatively, it can be car-ed by one or two men for short istances and ground-launched, firing nd control needing only one man.

In either case, launching is from lightweight, zero-length launcher built om tube. Line-of-sight command con-ol is employed; the controller can use noculars or a periscopic monocular hich can be switched instantaneously om low to high power magnification ithout loss of target reference as the issile travels away from the launcher.

The control is a simple hand-held ystick. Its signals are shaped in a) lb. ground control unit and trans-itted to the missile by a wire link. he control unit can launch and con-ol several missiles consecutively. Op-ation of the joystick needs little skill; simulator is being developed as a aining aid, but one of the advantages the weapon system is that only a ort practice time is needed to achieve oficiency.

• New missile range opened—A w British guided weapons range has en opened. It is situated in South ist in the Outer Hebrides, a group islands off the West coast of Scot-nd. There was considerable contro-rsy when the establishment of the nge was first suggested, most of the jections being on account of the anges in the primitive way of life on e island that would follow. However, any of the crofters themselves seem to have welcomed the employment that the construction of the range has provided.

The first missile to be fired from the range was a *Corporal*, supplied in 1956 by the U.S.A. for use with the British Army. Apart from two civilians from the American manufacturers, all the personnel taking part in the firing were drawn from the Army: and had been trained at the School of Artillery, Larkhill.

The first *Corporal* carried an inert warhead and travelled for more than 50 miles over the Atlantic Ocean. In wartime, Britain's *Corporals* would be fitted with nuclear warheads supplied from America.

• Napier's rocket engines—The *Scorpion* series of rocket engines built by **D. Napier & Son Ltd.**, members of the **English Electric** group, are being used as powerplants for both missiles and aircraft. They work on the "thermal ignition" principle: high-test peroxide is catalytically decomposed into superheated steam and oxygen; this mixture enters the combustion chamber at high temperature and pressure, kerosene is injected and ignition occurs spontaneously.

Single, double and triple-chamber engines are in production; all have the advantages of compactness and low weight. Routine testing of pre-production engines at altitudes of up to 70,000 ft. and temperatures of –70° to +40°C has been done in a Canberra jet bomber fitted up as a flying test bed.

The flexibility and precise control overthrust possible with *Scorpion* makes it ideal for powering target missiles. It is also suitable for air-launched short to intermediate-range missiles, such as the "stand-off" bomb.

Single *Scorpion* engines are installed as boosters in present-generation interceptor fighter aircraft, the HTP being carried in nitrogen-pressurized underwing tanks. For the "last-generation" all-weather fighters (such as English Electric's Lightning), Napier's have designed a rocket power pack that is interchangeable with the standard long-range kerosene tank carried by the aircraft.

The pack attaches to the aircraft at two points, is of skin and stringer construction and incorporates a Double *Scorpion* engine. HTP is carried in an integral tank forming the front part of the shell of the pack, and kerosene is drawn from the tanks of the aircraft. On the top of the pack is a kerosene inlet, a nitrogen-charging connection and the electrical connections to the control panel in the cockpit.

In combination with the advanced air-to-air missiles now being developed, this power pack is expected to give the semi-obsolescent fighters a new lease of life.

• Short *Seacat*—For many years the standard close-range weapon of the Royal Navy has been the 40mm gun. This is now to be replaced by the surface-to-air missile *Seacat*, now being developed by **Short Brothers & Harland Ltd.**, of Belfast, Northern Ireland.

News that Short had been awarded a development contract for *Seacat* was first released in April, 1958. Two months later, speaking in the House of Lords, the First Lord of the Admiralty described *Seacat* as a most ingenious weapon with a novel type of direction which gave very high promise. In Dec. 1958, the Parliamentary Secretary to the Admiralty indicated to the House of Commons that there would be a considerable number of these missiles in service by the early 1960's.

Security on *Seacat* is still strict, but a full-scale model of the missile and a film of a test firing were shown for the first time at the recent Paris Air Display.

Powered by a solid propellant motor, *Seacat* is designed to be instantly ready to repel attack and is highly maneuverable. Apart from its use by the Navy, it will also provide an anti-aircraft armament for small ships.

A variant of the missile is being developed for use by land forces as a replacement for light field artillery. This is to be known as *Tigercat*. Several Commonwealth and N.A.T.O. countries have expressed interest in both missiles.

Detection of Nuclear Explosions in Space Possible by Optical Means

Two spectroscopes mounted in satellite proposed as method of surveillance

by Savo Ćorić

KOBLENTZ, GERMANY—Were it not for the existence of Van Allen radiation belts and solar flares, detection of nuclear explosions in space by means of orbiting satellites equipped with radiation-measuring instruments would be relatively simple. For space is a near-void in which radiation and fission products from such an explosion expand freely without any hindrance—unlike the earth's atmosphere, where they remain confined to a limited area.

In the radiation belts, however, any man-made radiation may pass unnoticed because of the very high level of radiation of the belts themselves. For this reason, an existing project, designed to supervise space with orbiting satellites in case an agreement on a nuclear test ban is reached among the nuclear powers (U.S.A., Great Britain and U.S.S.R.), would not attempt to send satellites into the radiation belts.

It plans instead to orbit six satellites below radiation belts (under 600 miles) and six others above the belts—in a 40,000-mile orbit. Each satellite should be equipped with Geiger-Mueller and scintillation counters to pick up gamma and neutron radiation produced in a nuclear blast. The satellites' radio transmitters would then broadcast the findings to an international network.

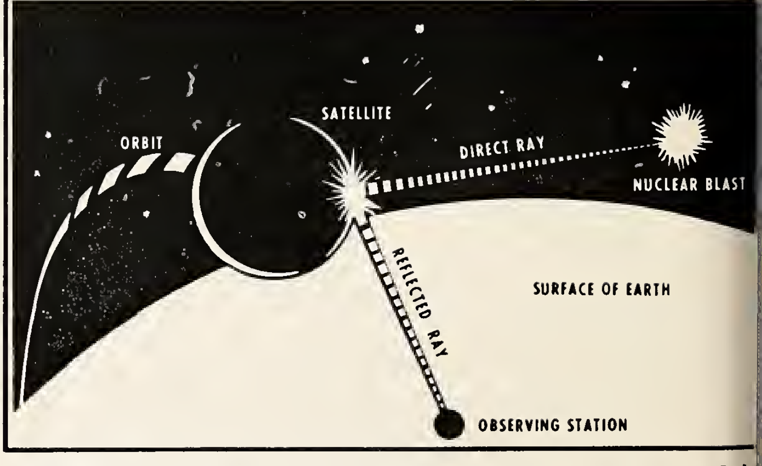
But a nuclear explosion produces many other phenomena which might possibly be used for more reliable and efficient detection. If, for example, the radiation-counting instruments of the aforementioned and similar projects were replaced or supplemented with optical instruments using spectral analysis to analyze the optical phenomena particular to a nuclear blast, the detection of such blasts would be by no means hampered by radiation belts.

• **Advantages**—The proposed optical detection would have following advantages over radiation-counting methods:

1. Blast-monitoring satellites could be launched into much lower orbits, that is with much less fuel and by much smaller rockets;
2. Reliability. Radiation-measuring instruments would be swamped, even above the radiation belts and at auroral latitudes up to any altitude, by charged particles hurled into space by solar flares. So it would be easy for a would-be violator to carry out undetectable nuclear-weapons tests one or two days after such a solar flare has been observed on the sun—when the oncoming solar gases reach the vicinity of earth. The proposed optical detectors would, of course, not be affected by such radiation; neither would they be optically fooled by such flares or any other light flashes unrelated to a nuclear blast;
3. Aided by favorable atmospheric conditions (i.e., a good visibility) th[e] optical detectors would also detec[t] nuclear blasts taking place in the atmos[s]phere and even on the ground.

• **Details**—The optical-detectio[n] equipment would be mounted in [a] spinning satellite. It would consist o[f] two spectroscopes viewing the spac[e] through the same slit. Each spectro[-]scope would be followed by a scree[n] and a photoelectric sensor (a photoce[ll] or a solar battery).

One screen would be pervious onl[y] to such Fraunhofer lines of the sola[r] spectrum which would be identical wit[h] the lines of the emission spectra of th[e] most abundant chemical elements o[f] the nuclear bomb or its fission prod[-]ucts (uranium, plutonium, barium, etc.)[;] the other screen would let pass to it[s] sensor only those Fraunhofer line[s] identical with spectral lines of som[e] chemical elements not to be foun[d] either in a nuclear bomb or among it[s]



EXPLOSIONS far off under the horizon could be detected by receiving the flash[es] reflected by the outer surface of the satellite.

ission products in appreciable quantiies (the Fraunhofer lines are not dark, hey only appear so in relation to much righter continuous solar spectrum).

Furthermore, the Fraunhofer lines eaching both sensors must be selected o prevent detection equipment from he influence of either atmospheric or errestrial light sources, natural or rtificial, which emit line spectra aurorae, lightnings, ionized vapors of lisintegrated meteors, extended fires, as-discharge lamps). Thus these Fraunofer lines will not be identical—at sual temperatures of the light sources —either with the spectral lines of the onstituents of the atmosphere or with he lines of the chemical elements to e found in meteors, in organic comounds or in the plasma of a glow amp in appreciable quantities.

This means that both sensors will e sensitized by solar spectrum and he spectra of terrestrial and atmospheric light sources which emit a coninuous spectrum (incandescent lamps, ncandescent solid meteors), while only ne sensor will respond to the line pectra of the nuclear bomb components and its fission products.

The outputs of two sensors are mplified and connected to a differential ircuit where the pulses provoked by he solar spectrum—as well as those enerated by the continuous spectra of errestrial and atmospheric light sources —cancel and only such pulses which re produced by the spectrum of a uclear explosion pass to the transitter. They are either transmitted imediately to earth or stored on a magetic tape for later transmission.

The differential circuit could conist of a simple transformer with two rimary windings connected in phase pposition. Each sensor would feed one primary winding and all pulses which are common to both sensors, that is those produced by the solar spectrum, cancel while only the pulses generated by the nuclear explosion would be transmitted to the secondary winding of the transformer.

By this means, changes in the luminosity of the received sunlight, caused both by the changing attitude of the spinning satellite and the optical phenomena on the sun itself (i.e., sunspots and solar flares), would not influence this detection equipment for their effects would always cancel in the differential circuit, and only the pulses produced by the spectrum of a nuclear explosion would be recorded.

This detector will be influenced not only by the emission but also by the absorption spectra of the nuclear-bomb components. The emission spectra will be provided by the flare of the explosion itself and by the subsequent glow of the ionized vapors of the nuclear-bomb components and its decay products. The absorption spectra will appear when the detector is receiving the sunlight which passed through a "cooled-off," non-glowing cloud of such vapors.

This cloud will absorb only the light of the Fraunhofer lines of the solar spectrum which are particular to the elements to be found in the cloud. These lines will, therefore, appear darker in the detector than the other Fraunhofer lines which are not affected by the vapor cloud. As the former lines are received by one sensor and the latter lines by the other sensor an unbalance will appear in the differential circuit and this unbalance will produce a signal which will be transmitted by the transmitter.

The absorption spectra will thus make it possible to detect later the nuclear explosions which took place while the satellite was out of sight, far off under the horizon. When the satellite is orbiting in the shadow of the Earth this type of detection will be, however, ineffective.

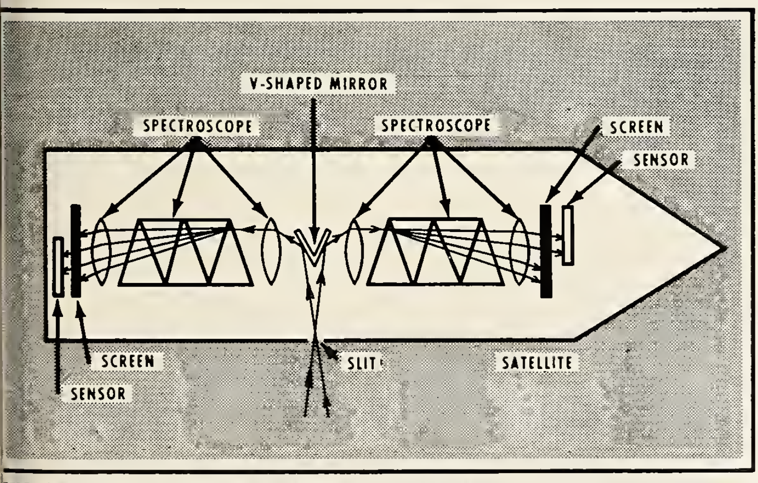
• **Looking around corner**—The same equipment—plus a telescope and a spectrograph—could be used in a ground installation to observe orbiting satellites in quest of nuclear-explosion flashes reflected from the surface of the satellites.

In this case the resulting signal, produced by a nuclear blast in the differential circuit, would trigger the photographic camera of the spectrograph so that the entire spectrum of a nuclear-bomb explosion would be photographed. This would make it possible not only to detect a nuclear explosion but to identify the nuclear device itself—A-bomb or H-bomb. The same spectrogram would also reveal the construction of the nose cone as well as its constituents.

In favorable weather conditions, this method could detect all nuclear blasts in space above and below the satellite itself as well as above the tangent drawn from the satellite to the earth's surface away from the observing station. When visibility was bad, the equipment could be taken up by planes.

All big satellites can be used advantageously for this type of detection and especially the big balloon-satellites (they have the largest surface to weight ratio). The moon itself might be included.

Finally, both types of detection could be used for spotting big forest and prairie fires in remote areas. All that would be necessary would be to replace the screen pervious to the spectral lines of the nuclear blast with a screen transparent for the spectral lines of an element which is found in any organic compound. This is the element carbon.



WO SPECTROSCOPES with associated screens, sensors and circuits would suppress nlight signals and transmit only nuclear blast signals.

Lockheed's X-7 Missile Enshrined at AFMDC

ALAMOGORDO N.M.—The **Lockheed** *X-7* ramjet-powered test missile has been enshrined at the Air Force Missile Development Center in New Mexico where it set the Free World's speed and altitude records for air-breathing vehicles.

It was over the New Mexico desert test range of the AFMDC that members of the Lockheed-designed and developed *X-7* family flew in excess of four times the speed of sound—in the neighborhood of 3000 miles per hour—and reached a record (still classified) altitude at the edge of the upper atmosphere.

Magnetic Tape Recording Sales Booming

This year should see 700,000 units sold but most promising future application will be in astronautics for photo-reconnaissance

by Robinette E. McCabe*

REDWOOD CITY, CALIF.—One of the fastest growing industries in the United States is the magnetic tape recording industry. Since the appearance of the first tape recorder on the American market just twelve years ago, few devices have spread so far so fast.

Its success is attested by today's status of the industry, which has mushroomed into a multimillion-dollar business, with gross sales for 1958 exceeding $72,000,000 for 410,000 units, according to the **Electronic Industries Association.** Although future estimates vary, it has been predicted that between 650,000 to 700,000 recorders will be marketed in 1959, boosting overall sales to $140,000,000.

First adopted for radio and home entertainment purposes, the tape recorder has spread in all directions until now it is a basic tool for advanced scientific activities, contributing heavily to research and military programs in missile development, satellite tracking, and related laboratory instrumentation procedures. Less known than for its brilliant entertainment contributions, this complex area holds great promise for the future of magnetic tape recording.

Tape equipment manufacturers refer to this area as the "instrumentation" field. These applications have been a major factor behind the recent burgeoning of the industry, and current trends indicate that the next few years will bring even more extensive progress in this direction.

The fertility of this field can be shown from the growth of the **Ampex Corporation** whose concentration in this area accounted for 50% of the total instrumentation sales in the United States in 1958. Less than ten years ago, the company was doing a gross annual volume of $350,000 a year. In 1958, the company's volume was $44 million.

• **Forces behind use**—Like any major development, the application of the magnetic tape recorder in such a spectacular manner has been the result of a practical as well as theoretical expediency. By the end of World War II, a storing element—a "gadget with a memory"—was badly needed: scientific, industrial, and defense agencies were swamped with data vital for emergencies and the solution of immediate problems.

The technical advantage of magnetic tape as a recording medium is attributable to:

1) Its capacity to record any phenomena which can be converted to an electrical impulse, over a wide frequency range with minimum distortion.

2) It will store more information per unit length than any other medium.

3) It requires no processing (no chemicals are required to *develop* it), and thus immediate reproduction is possible.

4) The time base can be altered—which is something no other medium provides. This permits events to be recreated on playback either faster or slower than they actually occurred (using a 10:1 contraction rate, for example, an hour of missile test recording can be reproduced in 6 minutes).

In many cases, these four characteristics of the tape recording process permit the attainment of results which cannot be achieved in any other way.

• **From wire to tape**—The first magnetic-recording device was demonstrated experimentally at the Paris Exposition in 1897 by Valdemar Poulsen, a Danish scientist. Acclaimed the electrical marvel of the age, it nevertheless remained relatively obscure and undeveloped until World War II.

During the war, both U.S. ai German scientists attempted to repr duce magnetic recorders suitable f military use in recording sound ai coded messages. The Americans co centrated on developing a wire ı corder, but the Germans concentrat on magnetic tape. When Germany sı rendered, Allied technical teams d covered magnetic tape recorders many of the enemy's military and gc ernment broadcast installations.

Several units were shipped to t United States where it was demc strated that magnetic tape had 1 greater versatility than wire. For o thing, tape can be edited. This is r feasible with wire since it cannot spliced without distorting the magne signal. And, where ease of manipu tion is a major factor, the reason 1 tape's popularity is obvious.

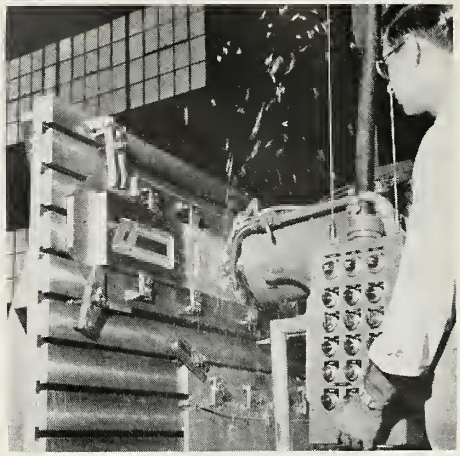
The first practical recorders 1 audio use were introduced in t United States in 1948. The units we immediately successful and thousar of machines were installed in broadc and sound studios.

• **Instrumentation next**—Almo simultaneously, missilemen recogniz the potential of magnetic tape. In l 1948, the Naval Air Missile Test Ce ter at Point Mugu, California, had audio-type recorder modified for te metering and used as a "back-u or check, for strip-chart recorders. soon became the primary method recording the missile flight test data acceleration, fin flutter, rate of fi consumption, flight curves, tempe tures, and a dozen other vital elemen

The problem in the missile fi was clearly defined: more and mc information in less and less time. T manufacture of tape and other recoı ing components was sufficiently a vanced to meet the need. Magne tape's pre-eminence for this testi rests in its ability to capture millio

* Ampex Corporation.

← **AMPEX MR-100 tape survived *Thor* flight and nine days exposure in Atlantic.**



→ **RECORDERS are being used extensively for machine control. Here's close up of Giddings & Lewis Profiling Machine.**

f separate measurements in relatively hort periods of time. Receiving the utput of dozens of transducers on and vithin the system, it can be used to neasure almost any variable at any oint.

• **Development**—To accommodate nissile requirements, an intensive deelopment program (which is still gong on today) was undertaken. Because he amount of information that can be tored per unit length of tape depends n the width of the tape and the numer of tracks on which the data is nscribed, bandwidths were increased rom the normal 15 kc, which is satisactory for audio use, to 100 kc and eyond.

Tape widths were increased from ¼ to 1 inch, which is the width of nost computer tapes. (For most instrumentation purposes, 100 kc and 1" ape is satisfactory, although in teleision recording bandwidths as high as megacycles can be recorded successully, and 2" wide tape is used.)

The upward trend in channels of nformation increased from a single hannel, to 7 channels, to 14 channels, o 16 channels, and to 32 channels per nch of tape.

The tape speed was increased for wo reasons. First, because the amount of data that can be inscribed per unit of time depends upon the speed of the ape and, secondly, because high ransfer rates for computer and telemery applications demand higher speeds. Although the speed at which tape noves past the recording head in home nachines is generally 7½ or 3¾ inches per second, tape handler speeds are as high as 150 ips for computer and elemetry use.

The result of the improvements is n evidence at missile testing installaions. In a typical use, a single facility for handling test data transmitted from *Atlas* and *Thor* ballistic missiles, utilizes 23 laboratory-type instrumentation recorders and is capable of correlating as many as four million measurements in three days' time.

Additionally, it has proven to be an instrument of immense scope in the missile field for it is used in several ways.

• To guide the missile. It activates electronic devices which control the path of the missile.

• To recover information from space. Miniature missile recorders ride in the missile nose cone and radio outer-space information back to receiving stations.

• For data reduction. The recorder is used with computers and other automatic data-handling devices to reduce the data to usable form.

Sizes and weights of these recorders vary according to their specialized purposes, but all of them are rugged. One sturdy little missile recorder recently survived a U.S. Air Force missile flight and 9 days in the Atlantic Ocean, yet was able to perform perfectly when retrieved from the water and tested. Used on a *Thor-Able* missile flight that carried a **General Electric**-developed plastic sphere, the recorder was imbedded in the nose cone. Before the cone struck the water, the recording unit was thrown free to fall independently.

Surviving the tremendous vibrations and shock of the launching and re-entry periods, as well as exposure to the water, it performed to specifications as soon as a new tape reel had been installed.

• **Flight testing**—Magnetic tape nearly revolutionized data acquisition for aircraft flight testing programs. In the early days of flight tests, the pilot would read the instruments on his control panel and note his observations on a pad strapped to his knee.

As design techniques were refined, test engineers required more extensive data and introduced more automatic methods of data acquisition to free the pilot from his primary mission of flying the plane. Measurements were brought to dials mounted on a panel which was photographed by a motion-picture camera. Pen-and-ink graphic recorders and other devices permitted continuous recording of high-frequency information, such as vibrations and flutter.

Many of these techniques are still in use today and serve a purpose. But, as in the missile industry, the demand for more and more measurements and a more rapid reduction of these measurements to usable physical quantities upon completion of the flight, required the use of more modern techniques.

Tape's ability to store over 8 million measurements during a 2-hour test flight on one standard 10½" reel of tape proved so appealing that tape recorders are now used in all major aircraft laboratory and test facilities, both commercial and military. **The Boeing Aircraft Company,** in employing it in the KC-135 jet tanker flight testing, samples each of 420 separate measurement points at the rate of 2.5 times/sec.

If these measurements were to be recorded on photo panels, or on oscillographs, several weeks of concentrated effort, involving large numbers of persons, would be required to reduce the data by manual means before the design engineer would have the significant numbers to either correct or improve the design. In accelerated aircraft programs, time lags of this magnitude are too costly to be tolerated.

• **Machine control**—Also, recorders are being used extensively in the aircraft and missile industries in quite another way. This is for machine control. Because you can electronically record motion on tape, many milling machines

no manual control required . . .

and profilers now take their cues from recording systems.

If you were to walk into a spacious bay at **Convair Division** of **General Dynamics Corporation's** big San Diego Plant 2, you could see a massive skin miller gnawing methodically at a 10′ by 30′ plate, removing 25 pounds of metal in 15 minutes flat. Down the road a few miles at **Rohr Aircraft Company's Chula Vista works,** a horizontal profiler makes metallic mincemeat of a rough aluminum forging.

There is no manual control at either machine, but there is nothing haphazard about the paths followed by the cutting tools. It is instead precision machine tooling, called "numerical control"—or machining by numbers. Like the roll that controls a player piano, magnetic tape provides an accurate system of guidance. Through digital recording, information can be transferred at rates up to 90,000 characters per second, permitting machining techniques far beyond the capability of human hands.

• **Video tape**—But the refined and accurate recording of sound was but the first step. An event almost as great as development of the tape recorder itself occurred in 1956 with the addition of a picture to tape.

The first machine was demonstrated in Chicago at the National Association of Broadcaster's Convention. Despite the fact that the machine was priced at $50,000, it received an immediate welcome in the television industry and now stations equipped with these units are able to reach 95% of the television sets in America.

The addition of a picture to tape was pioneered by the Ampex Corporation which, as of now, is still the only company to deliver production units of television recorders to the television industry.

But even more interesting is the fact that even before the machine was in production for commercial television purposes, the prototypes were sold for instrumentation purposes. One of the first three prototypes went to the White Sands Proving Ground where the Army Signal Corps is using it to track missiles. A highly classified project when it was first proposed, the U.S. Army recently announced its successful use on hundreds of missile firings.

The radar signals are picked up at five stations strung out over the 4000-square-mile range. Because radar signals are in a frequency range still too high to be recorded by any known means without conversion, a radio receiver converts them to a lower frequency. Yet the amount of conversion that can accurately be accomplished is limited, and this leaves the high-frequency radar signals still out of range of most recorders. A Videotape (TM Ampex Corp.) recorder, with a frequency response up to 4 mc, does the job. In the period since this first prototype was pressed into use, many other Videotape recorders have been sold for instrumentation purposes.

Taking a cue from colleges and universities across the country, rocket and missile installations are using them for educational purposes, too. At the Redstone Arsenal in Huntsville, Alabama, for instance, twice each month by means of closed-circuit television, senior Army officers are taught the complicated business of rocketry—a teaching program produced for the Army by the **TelePrompTer Corporation.** One end of the classroom is in Huntsville, and the other end is 278 miles away at Fort Knox, Kentucky.

• **Its future**—Applications involving telemetry (the transmission of measurements), static testing of rockets and missiles, laboratory research, medical recording, and machine tool control form the foundation of today's instrumentation business. For the future, it is expected that it will continue to serve in all of the categories where it is presently being used. Also, it is envisioned that it will radically expand in some of the areas as the government moves toward more missile and space projects, with vast research and development programs geared to these activities.

One of its most exciting future applications will be in space. And the new tape method—magnetic photography—is certain to be used. Even now, plans are being considered for a space recorder for a proposed flight involving photo-reconnaissance of Mars. This test envisions the launching of a rocket from the earth that will take a little over two years before its return. During this time, it will circle Mars, with the recorder photographing the surface as the space vehicle passes by. The photographic information will be radioed back to earth as the space vehicle returns near the earth's atmosphere.

However, the airborne picture recorder will not have to wait for a trip to Mars to prove useful. Equipment is now being built that will permit tape's use for operational missions which include intelligence reconnaissance, weather reconnaissance, and infrared photo-mapping. Since these will be airborne recorders, with recording ability only, there will be a corresponding increase in ground reproduction and data processing equipment for these missions. Even conservative studies indicate that this field may dwarf all previous applications.

It is assured that the testing of military and commercial aircraft—with its attendant use of the recorder—will continue over the coming years. In addition, the arrival of the commercial jets for public transportation, brought more business for the recorder. The Federal Aviation Authority has asked for a jet performance and crash recorder, designed to withstand the intense heat and shock of an accident, for all jet airliners. Also, the FAA may use tape to activate electronic devices used in new air traffic control systems.

• **Problems**—Future space recording will require surmounting hundreds of problems, but today two of the biggest appear to be improved system fidelity (accuracy of performance), and miniaturization of equipment.

Fidelity limitations of the recording system are primarily centered around the tape. The mechanical features and electronic component reliability of the tape recorder can also limit the system, but by far the biggest drive for improvement is centered on the tape, and on the record, reproduce, and erase heads which come in contact with the tape. For it is felt that the steady improvement of the magnetic heads may help to overcome some of the inherent characteristics of the tape.

To discuss the problem requires some elaboration on the structure of magnetic tape and the recording process. All tape consists of a non-magnetic base which supplies mechanical strength. Since the thickness of the base material varies from 0.0005″ to 0.0015″, it must be of considerable strength or it would support no stress at all.

Favorite base material for instrumentation uses is Mylar, a **Du Pont**-manufactured plastic. Chemically, it is polyethylene terephthalate, formed by the condensation reaction between ethylene glycol and terephthalic acid. A polymer with an oriented molecular pattern, it exhibits a smooth surface, uniform thickness, and a resistance to high temperatures and humidity. To this Mylar base is added the magnetic iron-oxide particles, ground to a microscopic size. They are combined with a binder and applied to the base with precision equipment.

The tiny magnetic heads in a recording system perform three vital functions. The record head converts information—in the form of encoded electrical signals—into a pattern of magnetization upon the tape. The reproduce head reconverts this magnetization pattern into electrical signals again, to be decoded and put to an array of practical uses. The erase head obliterates old information, leaving the tape clean for further use.

It is an extremely sensitive technique, and herein hides the problem. For, in spite of all reasonable precautions, the surface of the tape does not end up entirely smooth and homogeneous. Small defects manifest themselves by instantaneous lapses or reduction in signal level, which are referred to as "drop-outs."

The most serious of these are "nodules" or clusters of oxide particles which form along the surface of tape. As these nodules pass across the head, they cause the tape to be lifted away from the head and result in defective recording. A similar difficulty will occur if a foreign particle of dust is permitted to find its way onto the surface of an otherwise perfect tape.

Illustrative of the reliability problem are the difficulties experienced with Videotape. The extreme fidelity demanded of Videotape, which must accept ten times more information per unit area than audio tape, produced an inordinately high rejection rate when the tape was first introduced.

In addition to achieving a reliable, flawless surface, positive steps will have to be taken to extend tape's environmental limits. The physical properties of Mylar are relatively unaffected throughout the temperature range of -20° to +80°C. It remains flexible without signs of embrittlement at temperatures as low as –60°C.

But as the temperature is increased above 80°C, it behaves like an elastimer, finally melting at about 250°C. Several new resins that appear to be potentially useful have appeared recently. For example, polyurethane, an isocyanate derivative, can be produced in forms not unlike conventional plastic products, and some manufacturers claim its useful range to be as low as –60°C and as high as +200°C (the magnetic iron-oxide material presents a problem only at about +400°C when it reverts to non-magnetic form).

As might be expected, the size and weight of mobile recorders for missiles and aircraft has been ever downward. Completely transistorized systems, lightweight metals, and miniature mechanical components have been used. These techniques have helped, but equipment will have to be shrunk much further.

There no longer appears to be a question of whether the magnetic tape recorder can serve as a useful tool in rocket and missile applications, but rather how it can serve the best.

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Defense Electronic Products

New Techniques Aid Electronics Cooling

Basic methods of heat dissipation in components are the same but the applications can vary. Here are the principal cooling methods.

by Hal Gettings and Charles D. LaFond

WASHINGTON—Electronic components cooling is a part of equipment overall cooling design that must complement the system or it might just as well be eliminated. Where system cooling transfers heat to the ultimate sink, components cooling transfers unwanted heat in such a manner that it can be picked up by the greater heat exchange mechanism.

Basic methods of heat dissipation are the same—only the applications vary:

- Cold plate mounting (air, liquid or evaporative)
- Direct forced air convection
- Free convection to ambient air
- Radiation heat transfer

Other methods, such as direct liquid cooling, could be used but these are the most commonly encountered.

• **Cold plate cooling**—A common and often quite satisfactory method of cooling electronic equipment is by conduction or cold plate cooling. In a recent paper by Mr. J. R. Baum, a senior staff member of the **Motorola, Inc.**, Mechanical Engineering Laboratory at Phoenix, Ariz., the application of cold plate cooling to an airborne radar receiver/transmitter was described. It was emphasized, however, that the design method provided the same general approach employed in all cold plate cooling of electronic equipment.

The method was chosen in this instance for several reasons. Pressurization of the unit for electrical reasons was a requirement. The most severe temperature—altitude requirement established for the equipment was 131°F at 10,000 feet. The equipment had a total power dissipation of 430 watts and was designed for operation in ambient temperatures up to 131°F for continuous operation and 160°F for short periods of time.

It was estimated that if no cooling provisions were made in the equipment design the unit would have at least a 100°F rise over the ambient temperature in the external surface. In addition, the maximum electronic component temperature rating was 185°F. Because of pressurization, direct forced-air cooling through the equipment could not be used.

To support the cold plate conduction cooling, forced air was to be employed for cooling the component mounting structure. This was accomplished by employing a split casing mounting bulkhead. This was installed horizontally and separated to provide the space through which ambient air could be forced by means of small external blowers. To better utilize available space and for better air distribution two small blowers were employed rather than one large unit. To increase the efficiency, a series of fins parallel to the air flow were used to provide maximum heat transfer.

• **Forced air convection**—The term "forced air convection," usually refers to the use of blowers or externally supplied cooling air for circulation within the electronic equipment. Thus a source of moving air is available for cooling, but without the refinements of cold-plate construction.

Air velocity over a dissipator can be increased by the use of baffles or ducting to direct and increase the local velocity of the available air over the desired area. A short dimension in the flow direction is desirable and this may dictate the baffle orientation.

Where no central forced air circulation exists, it may still be necessary to provide for high rates of local heat dissipation by use of small blowers. A number of miniature blowers are available to meet a variety of situations. The choice would be based on the required velocity, space, and other requirements.

• **Free convection**—Probably the most common method of getting rid of heat in electronic equipment is by free convection. Where components are mounted on metal chassis of larg area, in room ambients, usually no ser ous problem exists. With higher am bients and denser packaging, the prob lem can become acute.

One common decision to be mad in orientation of the dissipator i whether it should be mounted hor zontally or vertically.

In general, Motorola has foun that vertical surfaces with the shor dimension vertical are the most de sirable. A series of short vertical fin very close to the component i effective. This configuration also mini mizes the distance from the componen to the dissipator and reduces th accompanying internal thermal resist ance of the dissipator. Because of th extremely low value of convection hea transfer, there is a need for providin maximum dissipating area and mini mizing thermal resistance up to the dis sipating area.

• **Radiation heat transfer**—Radia tion heat transfer is important with fre convection, since it can be of the sam order of magnitude as the convectio term. In considering radiation hea transfer, emissivity and shape factor are the only terms capable of being in creased.

The shape factor is fixed by th overall orientation of the dissipato with respect to its surroundings. Thi is a function of the particular con figuration and cannot be easily altered

The emissivity factor is a direc function of the finish, or radiatin "color," of the dissipator and the re ceiving surfaces. A highly emissiv finish such as flat black is desirable Surface finish is one factor often over looked where the heat transfer can b increased with practically no effort. T attain the best possible surface fo radiation, a high emissivity surfac should be provided on both the dissi pator and receiving surfaces.

• **Electron tube cooling**—Majo cause of failure with miniature electro tubes, revealed by exhaustive investiga ions by many manufacturers and the ;overnment, is excessive operating tem-)eratures. To reduce this failure cause, ι number of cooling methods have)een utilized.

Where component density is not a problem, an airflow directly over the ubes has been successful.

In high-density packages adequate :ooling is a great problem. In addition, he metal tube shield used for electrical hielding tends to add to the problem.

Motorola has determined after ex- ensive testing that the use of heat dis- ipating shields and inserts can help to ninimize this difficulty. A substantial mprovement in thermal performance esults. Also, the investigation showed hat horizontal types were considerably nore efficient than vertical types.

The most common method of uti- izing these tube heat dissipators is to employ some form of clip, shield, or nount to grip the tube envelope. This provides a means of conducting heat o the chassis, cold plate, etc.

• **Power transistor cooling**—Gen- erated at the collector, heat in a power ransistor must be transferred to the ultimate sink through a thermal path between the sink and junction. Thus it behooves the design engineer to under- stand the limits of various mounting methods.

The design of most power trans- stors provides for the best possible nternal thermal path between junction and base. Also, the base is provided with sufficient area for proper heat ransfer to the dissipating device.

Of the various methods of heat ransfer, cold plate cooling offers the ewest problems in transistor mounting. f the transistor is mounted without an electrical insulator, only the bare sur- face contact resistance is present. Addi- ion of an electrical insulator such as nica or Mylar will further increase the esistance to heat transfer.

For various insulators, the contact esistance is the governing factor rather han the insulator thickness. In general, he mating surfaces should be as smooth as possible with maximum con- act pressure. Minimum insulator thick- less should be used, consistent with electrical requirements. If possible, a conductive grease should be applied in he joint. The use of a surface-treated hin metal washer, such as anodized luminum, appears to have some merit.

The use of a highly thermal-con- luctive material is the best method of ıssuring efficient dissipator perform- ınce. Consistent with weight and space equirements, a large enough cross- ectional area should be used to in- crease conductance. When weight limi- ations are involved, thermal conduc- ivity and material density must be con- idered together. On this basis, it has been found that for the same weight the conductivity of magnesium and aluminum are superior, in that order, to copper. This is true in spite of the fact that magnesium and aluminum have a lower thermal conductivity than copper. Where space alone is a consideration, then thermal conductivity will govern.

The distance between the transistor base and the midpoint, or average temperature point, of the dissipator should be kept to a minimum consistent with the thermal conductivity and thickness. This particular point must be considered, together with the necessity for having sufficient dissipator surface area. For example, if an increase in horizontal dissipator area is required in a particular case, then the thickness or material conductivity must be increased proportionally. Failure to do this can increase the resistance to heat transfer in the dissipator at the same rate that heat transfer from it is being increased —with no net gain.

One approach to this problem is to provide a dissipator configuration (such as vertical finning) so that the distance between base and average temperature point may be kept short with no loss in area.

In some cases the designer can choose the method of dissipating the heat to the ultimate sink. If this is the situation, the selection of dissipator and cooling methods go hand in hand. It is assumed that the dissipator provides the conductive link to the final method of dissipation to a sink. So-called conduction cooling still requires final dissipation to the ambient air or to a coolant fluid at some point.

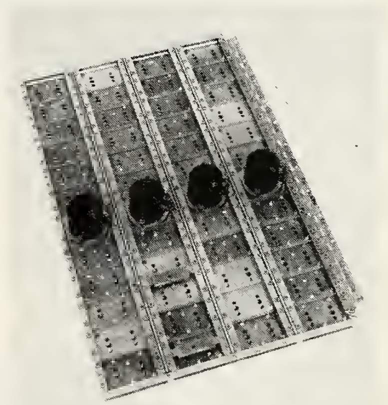
• **Miniaturized IR cooler—Arthur D. Little, Inc.,** of Cambridge, Mass., has developed a tiny cooling device which super-chills infrared detection equipment to 60° Kelvin (−350°F). It employs a new refrigerating technique which may prove to be a significant scientific achievement.

The eight-ounce min-IR cooler resulted from a two-year research project into extreme low temperature equipment conducted by Dr. Howard O. McMahon and William E. Gifford at Arthur D. Little, Inc. Cambridge research and engineering company. It was unveiled at the 1959 National Missile Industry Conference in Washington, D.C.

Development of the system for infrared applications is being conducted by ADL and **Hamilton Standard, Division of United Aircraft Corp.,** Windsor Locks, Conn.

The heart of the system is the cooling head which is inserted into or preferably made integral with the IR cell dewar. System operation is based on regenerative precooling of

THIS Arthur D. Little-developed min-IR-cooler is a low-pressure, closed-cycle refrigeration device developed for use with IR detection equipment.



THIS environmental conditioning system by AiResearch utilizes a series of modules to serve as a cold plate.

WEIGHING two pounds, this Dunham-Bush ethylene glycol-to-air heat exchanger has capacity of 5460 BTU/hr (1600 watts).

relatively low pressure gas and performance of work by the gas during expansion.

The closed system consists only of a compressor and the cooling head. The cooling head contains inlet and exhaust valves, expansion piston, regenerator, and cylinder.

In operation, helium gas expands from 300 psi in a ¼″ diameter cylinder, 2″ long. A tiny plastic piston is the only moving part of the unit below room temperature. The cold end of the tube refrigerates an infrared cell to 60° Kelvin. (Cooling infrared detectors to extremely low temperatures increases their sensitivity and makes them responsive to a wider range of IR wave lengths.)

Since gas cooling is achieved through an expansion work cycle and not through the Joule-Thomson effect, porous plug clogging difficulties are eliminated and maximum system pressure (and thus component size and weight) is greatly reduced. Hamilton has stated that the closed system presents no limitations on stand-by or service operative periods and is logistically simple.

This device is considered to be the first satisfactory miniature refrigerator for extremely low temperatures.

The same principles used in the min-IR-cooler are being applied by ADL to other areas of low temperature.

• **Peltier cooling**—The practicality of applying Peltier cooling to a telemetry package has been shown by Ray Marlow of **Texas Instruments, Inc.,** in a paper presented at the American Rocket Society's Semi-Annual Meeting in San Diego in June.

To optimize performance in a missile-borne telemetry system, components must be protected against extreme or sudden temperature variance. The operating characteristics of transistors and diodes are particularly influenced by operating temperatures.

If the package is provided with thermal insulation, heat build-up resulting within the system must be controlled by some means of disposal. This is particularly true in a satellite having a long flight time. Also, during long pre-flight checkout operation of missiles, this problem is manifest.

Marlow suggests that here Peltie cooling and heating appears to offer solution in airborne or missile elec tronic equipment.

The Peltier effect is achieve through the direct conversion of elec trical energy to thermal energy by pass ing an electrical current through tw semiconductors in series. One junctio of the thermoelectric element become cold and the other hot, depending o the direction of the current. The col or hot junction will provide an environ ment in which the electrical compo nents will operate with increased reli ability in a telemetry package.

The great advances in semiconduc tor materials in the past years hav permitted improved performance o the Peltier effect. The use of thi method of component cooling coul provide a thermal environment tha would lengthen component life expec tancy. Reliability is inherently hig since there are no moving parts in volved.

Marlow indicated that the limitin factor of Peltier cooling is the materia itself used to make the thermoelectri thermo-elements. But, he believes th use of Peltier cooling and heating wil increase with the advance of the state of-the-art in semiconductor materia fabrication.

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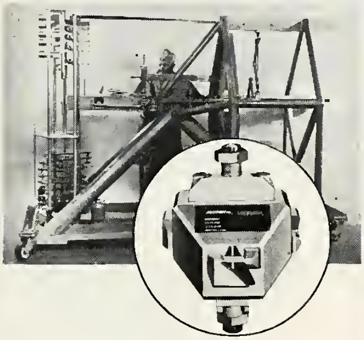

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propulsion engineering

By M/R STAFF

Solar sail propulsion. . .
will be a reality "fairly soon." T. C. Tsu, advisory engineer, mechanics department, **Westinghouse Research Laboratories,** believes that a solar sailing project can be "realized fairly soon without extensive research and development." He discusses the characteristics and advantages of "Interplanetary Travel by Solar Sail" in the American Rocket Society Journal, June. Tsu presents solutions to the equations of motion and optimization of sail tilt angle. He also computes travel time and general performance compared with chemical and ionic propulsion.

Think of a solar sail vehicle . . .
as a rocket with unit mass ratio and an infinite propellant reserve, says Tsu. He refers to R. L. Garwin's paper, "Solar Sailing—a Practical Method of Propulsion within the Solar System," Jet Propulsion (ARS Journal), March 1958, for figures on cost and feasibility. "The solar sail is of negligible cost," Tsu summarizes, "and is perhaps more powerful and less difficult than many often-cited and competing schemes." A solar sail operates by the pressure of sunlight falling on a sail made of ultra-thin aluminum foil or aluminized or silvered plastic sheet. This is the radiation pressure principle, known to physicists and parlor trick fans for many years.

Advantages of solar sails are numerous . . .
The ship's mass remains constant; sail force is available for the ship's entire journey; neither fuel nor other propellant is needed; no powerplant is needed, and consequently there are no waste heat disposal problems. Although the force is very small compared with that available from chemical rockets, Tsu points out that the force is available for as long as it is needed.

"A trip to Mars or Venus can be made . . .
in less time by solar sail than by chemical rocket," says the Westinghouse engineer. A solar sail can return to earth or make in-flight navigational corrections whenever necessary. Since it moves at a non-uniform speed under a non-central force system, the sail's contents are not entirely weightless. However, the weight of a load would be much less than on earth.

New oxidizer data handbooks . . .
are available from a leading manufacturer of rocket propellant oxidizers, **Allied Chemical's** General Chemical Division (40 Rector St., N.Y.C. 6). Allied offers a 29-page bulletin on fuming nitric acid, both white and red, properties, corrosion data, storage and handling directions. The company also offers a bulletin on both gaseous and liquid fluorine, and a work on chlorine trifluoride, which also includes data on the other halogen fluorides. These data booklets supplement the existing Allied library on oxidizers: Handling elemental fluorine gas in the laboratory, liquid fluorine unloading procedure, chlorine trifluoride vapor pressures.

USSR is bragging about chemical progress . . .
made since the Communist Party central committee meeting a year ago last May. That was the meeting at which Russia decided to accelerate chemical industry development, especially production of synthetics. The Soviet Embassy (Washington) says the industry has "overfulfilled the 1958 plan for gross output." Production was 13% over 1957 production, and the first five months of 1959 show production up 11% over 1958, the embassy statement says. Included among the items cited, are jet engine compressor blades.

Alcohol from crude oil . . .
is up, the Russians say. Last year, the USSR produced 26 million decaliters of alcohol from crude oil. Although the Embassy release does not spell it out, there is a strong hint that the majority of Russia's alcohol in the past had been produced by the fermentation process.

(*Continued from page 9*)

ffort to make space . . .

ehicles invisible to radar and other acking techniques is picking up steam. epublic Aviation has placed contracts ith **General Applied Science Laboraories, Flight Support Inc., ANTALAB ic., Fluidyne Engineering Corp.** and **ynametrics Corp.** as part of its proram to develop design techniques. Proram almost certainly involves use of lastics, since no metals are transparent electro-magnetic radiation.

• • •

lavy will spend $12 million . . .

1960 FY to develop special ASW etection system—believed to be kind f a "wet DEW line" for submarine etection.

SPACE MEDICINE

apsule "K rations" . . .

hich would be propelled into astroaut's mouth while in space by a slot achine device is suggested by **Southest Research Institute** scientists as alrnative to squeeze bottles. Shell as ell as filler of the pills would have utritive value.

MANUFACTURING

Army Engineer R&D Laboratories, ort Belvoir, has new AC-DC inert gas c welder for working on very thin auge metals such as those used in *edstone* . . . Successful flight of **Temp Aircraft Corp's** prepackaged liquid opellant *Corvus* came only after hardon victory over troubles with spun etal propellant tanks . . . **Beech Airaft Corp.** has received $1.5 million ontract for KDB-1 Army drones . . . 54,000 cubic foot seamless nylon raom capable of standing winds up to 0 mph and temperatures –65°F to 35°F has been developed by **Aviation roducts Division, Goodyear Tire and ubber Co.** . . . **Bowmar Instrument orp.** has $65,000 contract to produce *ershing* transmission unit . . . Twoory missile assembly building containg 40,000 square feet of space and oom for test and checkout of two *tlases* is now being built at Vandenrg AFB. A&E is by **Welton Becket & ssociates** . . .

Satellite clock and time programmer being developed by **Waltham Precion Instrument Co.** under **McDonnell ircraft Corp.** contract for *Mercury* psule. Device will set into motion lit-second schedule of 13 important activities, including re-entry . . . New entry in liquid missile and rocket fuel business is **Frontier Refining Co.,** Denver . . . Upcoming soon: Army contract award for *Mauler*, self-propelled missile system capable of providing allweather air defense to forward troops . . . **Aerojet-General Corp.** has Army Engineers contract for design of 6 million pound thrust rocket test stand at Edwards AFB . . . $3.5 million production contract for *Guardian II* pre-packaged rocket engines has been awarded **Reaction Motors Division of Thiokol Chemical** . . . **Stromberg Carlson Division of General Dynamics Corp.** is holder of Rome Air Development Center contract for design and development of 15 antenna assemblies for the Air Force's highly classified Ground Passive Electronic Reconnaissance Facility.

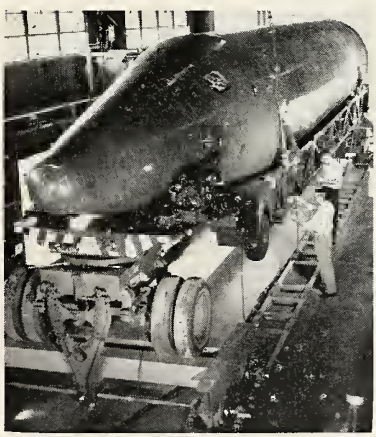
Sonic Burning Control Sought for Solids

Resonance burning, a phenomenon that has bothered rocket engineers for years, may be put to good use. **Acoustica Associates Inc.** of Plainview, N.Y., says it has received a $85,188 contract from NASA to study the possibility of controlling the burning rate of solid rockets through high-intensity, ultra-high-pitch sounds.

David Gross, an Acoustica engineer, said a threshold effect indicates that the control might become operative at a pitch upwards of 10,000 cycles a second. This is a just barely audible note than can be produced on a violin but is about 1½ octaves above the highest note on a piano. The human car is sensitive to pitch up to about 15,000 cycles.

Gross said research by the Russian T. M. Kurbansky and Americans at Georgia Tech seems to show that the burning rate of typical solid propellants can be increased 3 to 10 times by such sonic mixing. At present, the only control available for solid rockets is the on-off type.

Acoustica is a developer of ultrasonic sound equipment used for industrial cleaning and liquid gauging.



ABMA technicians have come up with their own version of "rock and roll." This shake table can put 30,000 pounds through a rotary action providing up to 90,000 pounds gross vibrating force. The facility is about 10 ft. in width and can accommodate vehicles with wheel bases up to 50 ft.

New Regulations Up On Operational Status

New regulations now in the process of coordination by Air Force headquarters will give major weapon system management responsibility to the Deputy Chief of Staff (Operations). Under the new rules, "general operational requirements" will be abandoned in favor of "required operational capability documents" which will be the responsibility of Deputy Chief of Staff (operations).

Since there is still a necessity to evaluate the technical requirements of proposed weapon systems, Deputy Chief of Staff (Development) will issue "system development requirement (SDR)" and subsystem development requirement.

After that it will be up to the Deputy Chief of Staff (Operations) to determine the feasibility of producing a new weapon system, after first determining that the proposal meets both the required operational capability and the system development requirement. At this point, he will order a new system into production by issuing a new "Specific Operational Requirement" and "Operational Support Requirement" document.

By this new method, AF hopes to establish tighter AF management control over new weapon systems. However, official statement indicates that there will be no change in procurement practices.

E-B Gets Contract

Electric Boat Division of General Dynamics Corp. has been given a contract to build the aiming system for the nation's largest radio telescope being constructed by the National Radio Astronomy Observatory in Greenbank, W.Va.

Aerojet-Stauffer Make Alloys

Development of a "new family" of metals for solid rocket casings has been achieved by **Aerojet-General Corp.** and **Stauffer-Temescal Co.** of Richmond, Calif., M/R has learned. The new alloys, of tantalum and tungsten, can be produced cheaply, machined normally, and still withstand the tremendous heat of solid rocket motors.

Aside for the rare metal rhenium, the two components of the new alloys have the highest melting points of any known metal. The joint-effort program carried out by Aerojet and Stauffer-Temescal has produced ingots measuring 5" in diameter and 42" long, from the electron-beam furnaces at Stauffer-Temescal.

The alloys have a melting point which falls between 5430 and 6150 degrees F. The melting points of pure tantalum and tungsten. The tensile strength of the worked 90% tantalum, 10% tungsten alloy at room temperature is 150,000 psi, and at 4500° F. the strength is still about 15,000 psi.

The tantalum/tungsten alloys are very resistant to chemical attacks because of the extreme purity imparted to the alloys during electronic-beam melting. The ingots are worked and fabricated using conventional steel-mill equipment and methods, and are machined by Standard Machine Tools.

Direct re-cycling of scrap has reduced costs of the finished shapes of the alloys. The development program was headed by J. A. Griswold and C. L. D'ooge, project engineers in Aerojet's program of developing solid-fueled propulsion for *Polaris* FBM. Stauffer-Temescal Company is owned by Stauffer Chemical Co. and Temescal Metallurgical Corp.

Centaur Guidance To Be Pure Inertial

Minneapolis-Honeywell has won a $5.4 million contract from **Convair** to develop and produce a pure inertial guidance system for NASA's *Centaur* space vehicle. System will incorporate a variation of Honeywell's "mig" (miniature integrating gyro) that must be capable of putting either 9000 pound payload in 300-mile orbit or "soft" land 1000 pounds on the moon.

One of the companies now engaged in DOD's GLIPAR (Guide Line Identification program for Anti-Missile Research) program is **Technical Operations Inc.**, which has $127,000 contract to develop any "unorthodox" long-term anti-missile approaches. Program is studying everything from "death rays" to anti-gravity devices.

New milling technique utilizing chemicals—but different from conventional chemical milling processes—is disclosed by United States **Chemical Milling Corp.** The company says tolerances of sheet metal can be improved through its "Chem-Tol" method so that the variation of metal thickness is less than ±0.001 inches.

15 *Delta* Engines

Multi-million dollar contract for 15 liquid powered engines for NASA's *Delta* deep space mission rocket has been awarded **Aerojet-General Corp.** by **Douglas Aircraft Co.** Deliveries of the second-stage engines will extend over a two-year period and will be similar to those used in *Vanguard* and *Thor-Able* program. Aerojet says while associated with these programs this particular engine has had a perfect record of nine for nine to date.

NASA is buying 20 modified Navy pressurized flight suits for $75,000 from **B. F. Goodrich Co.** for its *Mercury* astronauts. Evaluation team members wore the suits for as long as 24 hours before the selection was made.

Standard Tests Methods For Relays Proposed

The American Standards Association has virtually completed a proposed industry-wide code establishing standard test methods for relays. The code, first ever to be drafted by industry, will be circulated for comment and approval following a review meeting in New York in September.

Hazeltine Acquires Wheeler Laboratories

Hazeltine Corp. of Little Neck, N.Y. has acquired **Wheeler Laboratories, Inc.**, in a move to double its engineering department. The Laboratories now are wholly-owned subsidiary of Hazeltine.

Wheeler Laboratories' experience has been in microwave, antenna and related fields in the *Nike-Ajax*, *Nike-Hercules*, *Titan*, *Thor*, *Nike-Zeus* and *Terrier-Tartar* projects.

Hazeltine recently established a test and engineering center in Indianapolis and started construction of an engineering laboratory in Greenlawn, N.Y.

contracts

MISCELLANEOUS

$324,000—Consolidated Systems Corp., Sub sidiary of Consolidated Electro-dynam ics Corp., Monrovia, Calif., for an auto matic data recording and monitorin system to be installed at Thermo Struc tures Laboratory at Sunnyvale, Cali (Subcontract from Lockheed Aircra Corp.).

NASA

Aerojet-General Corp., has received "multi-million" dollar contract for th production of 15 liquid powered en gines similar to those used in *Vanguar* and *Thor-Able* programs for use i varied NASA space experiments.

$100,000—Applied Science Corp., Princeto N.J., for airborne statistical telemete ing equipment for project *Mercury* cap sules. (Subcontract from McDonne Aircraft Corp.).

NAVY

$3,500,000—Reaction Motors Div. of Thiok Chemical Corp., Bristol, Pa., for pro duction of the *Guardian II* pre-pacl aged rocket engine.

$2,000,000—Pratt & Whitney Aircraft Div. United Aircraft Corp., East Hartfor Conn., for development of nuclear ai craft engine hardware.

$1,921,672—Convair Div. of General Dynam ics Corp., Pomona, Calif., for *Terrie Tartar* shipping containers and han dling bands.

$100,332—Aerojet-General Corp., Sacr mento, Calif., for 5KS-4500 X112A rocket engines (reloads) and 5KS-450 X112A3 rocket engines (new).

AIR FORCE

Scaife Company, Oakmont, Pa., has re ceived a contract for additional *Falco* missile motor cases, bringing the cu rent orders on this item to almo $400,000. (Subcontract from Thiok Chemical Corp.).

$3,596,026—Gas Industries, Inc., Allentow Pa., for oxygen, nitrogen. (three con tracts).

$875,000—Summers Gyroscope Co., San Monica, Calif., for spare parts on th Phase II Vertical Gyro Indicator.

$740,250—Lewyt Mfg. Corp., L.I. City, N.Y for coordinate data monitor.

$299,906—Melpar, Inc., Falls Church, Va for weather data record viewer, spa parts, and special test equipment an applicable data (ground support equi ment).

$234,646—Stanford Research Institute, Men Park, Calif., for design and constru tion of parabolic antennas.

$117,208—Union Carbide Corp., Linde C Indianapolis, for liquid oxygen co verters and engineering and maint nance data.

$105,169—Thompson Ramo Wooldridge, In Cleveland, for nuclear regenerative fu cells.

$97,350—Plasmadyne Corp., Santa Ar Calif., for investigation of the produ tion of millimeter and sub-millimet electro-magnetic waves.

$95,985—Convair Div. of General Dynami Corp., San Diego, for spare parts f center missile bay door equipment a sembly.

$88,823—Barnes Engineering Co., Stamfo Conn., for radiation measurements fro major missiles.

$88,748—American Institute for Researc Pittsburgh, for development of optim methods of organizing and presenti SAGE operator job information in se training equipment.

$74,739—Schulz Tool & Mfg. Co., San Ga riel, Calif., for operational developme of nozzles and adapters for pressu serving advanced missiles and aircra

73,677—Parker Aircraft Co., Los Angeles, for operational development of missile propellant servicing couplings for use on advanced missiles and aircraft.

68,326—Stanford Research Institute, Menlo Park, Calif., for research directed toward the use of satellite radiation observations in numerical weather prediction techniques.

56,414—General Communication Co., Boston, Mass., for radar beacons.

51,948—Elkton Div., Thiokol Chemical Corp., Elkton, Md., for *Cajun* rockets.

49,626—Aerolab Development Co., Pasadena, Calif., for component parts of the *Nike-Cajun* rocket system.

39,935—Lowell Observatory, Flagstaff, Ariz., for research directed toward the study of the property of the planets.

34,982—North American Aviation, Missile Div., Downy, Calif., for research directed toward study of geophysics of the moon.

34,531—Regents of the New Mexico College of Agriculture and Mechanic Arts State College, N. Mex., for rocket instrumentation engineering services.

ARMY

erojet-General Corp., Azusa, Calif., has been named the prime contractor for the design of a six-million-pound-thrust rocket test stand to be constructed at Edwards AFB, Calif. (Amount not disclosed.)

14,320,690—Sperry Rand Corp., Sperry Utah Eng. Lab., Salt Lake City, for *Sergeant* missiles.

5,347,428—Convair, Div. of General Dynamics Corp., Pomona, Calif., for feasibility study. (Two contracts).

3,569,388—Douglas Aircraft Co., Santa Monica, Calif., for repair parts, launching equipment and missile technical representative services. (Three contracts).

2,000,000—Aerojet-General Corp., Downey, Calif., for further flight testing of two SD-2 Drone systems including design improvements and manufacture of AN/USD-2 surveillance drones.

1,973,000—California Institute of Technology, Pasadena, Calif., for research and development. (Two contracts).

1,504,250—Western Electric Co., Inc., N.Y., for development of production equipment for the mechanized production of semi-conductor devices for the *Nike-Zeus* program.

924,717—Cubic Corporation, San Diego, Calif., for electronic measuring system.

890,582—General Electric Co., Cincinnati, for fabrication, static and wind tunnel testing of tip turbine, liftfan propulsion system and design and fabrication of wind tunnel model.

373,269—North American Aviation, Inc., Canoga Park, Calif., for design and development.

356,265—Paul Smith Construction Co., Orlando, Fla., for construction of G/M launch facilities.

306,775—Consolidated Systems Corp., Monrovia, Calif., for digital acquisition system.

274,015—Radioplane Co., Div. of Northrop Corp., Van Nuys, Calif., for supplies and services re missile targets.

234,614—Aerojet-General Corp., Azusa, Calif., for warhead.

221,858—Biltmore Construction Co., Clearwater, Fla., for construction of FPS-26 radar tower and facilities at MacDill AFB, Tampa, Fla.

215,816—Domestic Film Products Corp., Millersburg, Ohio, for air supported tents for *Nike-Hercules*.

195,114—RCA, Moorestown, N.J., for research and experimental work in connection with radar parameter measurement and improved operation of instrumentation radar sets.

190,391—U.S. Amalgamated Constructors, Inc., Tampa, Fla., for construction of flight simulator training building at MacDill AFB.

189,000—Electro Plastic Fabrics, Pulaski, Va., for air supported tents for *Nike-Hercules*.

187,900—Irving Air Chute Co., Inc., Lexington, Ky., for air supported tents for *Nike-Hercules*.

$179,529—The Berger Bros. Co., New Haven, Conn., for air supported tents for *Nike-Hercules*.

$154,927—Motorola, Inc., Scottsdale, Ariz., for telemetry sets.

$110,250—Bomac Laboratories, Inc., Beverly, Mass., for electron tubes.

$99,431—Aeronutronic Systems, Inc., Glendale, Calif., for study ground effects air-cushion vehicle.

$99,428—General Electric Co., Syracuse, for research and development work to perform modes of failure and reliability prediction studies of pulse cables.

$86,050—Radio Corp. of America, Harrison, N. J., for electron tubes.

$82,583—Raytheon Co., Waltham, Mass., for electron tubes.

$80,635—Tung-Sol Electric, Inc., Newark, N.J., for electron tubes.

$68,598—Aerojet-General Corp., Azusa, Calif., for analysis of fuel developments and rocket engine designs.

$66,776—Minneapolis Honeywell Regulator Co., N. Hopkins, Minn., for *Honest John* adaption kit components.

$60,000—Unit Research, Inc., Cambridge, Mass., for study of wind shear measurements.

$48,103—Bridgeport Brass Co., Hunter-Douglas Div., Riverside, Calif., for redesign of rocket and launcher.

$45,750—Wallace O. Leonard, Inc., Pasadena, Calif., for transducers.

$44,990—North American Aviation, Inc., Missile Div., Downey, Calif., for study of satellite rendezvous.

$44,800—Firestone Tire and Rubber Co., Los Angeles, for guided missile.

$30,800—Firestone Tire and Rubber Co., Los Angeles, for guided missile.

BIDS

Purchasing and Contracting Div., White Sands Missile Range, N. Mex., ORDBS-P&C-A: Mounts for camera, single precision axis, capable of supporting cameras up to 300 lbs. Contractor shall furnish all labor and material in construction of the mount—9 ea.—IFB-ORD-29-040-60-34—Bid opening 16 Aug. 1959. Bid sets available through 16 Aug. '59.

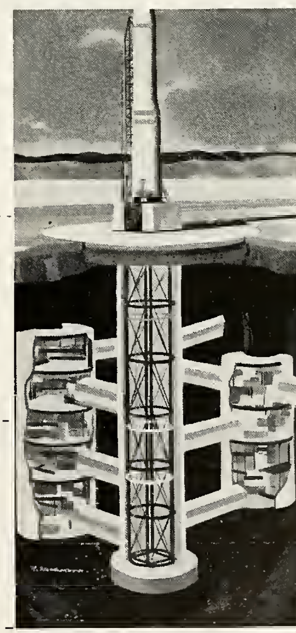
Dayton Air Force Depot, Gentile Air Force Station, Dayton, Ohio. Att: Directorate of Procurement and Production:
Tube electron Klystron type 6BM6A in A/W Spec MIL-E-1D, dated 31 Mar. 58 and ISS MIL-E-1/746C dated 30 Nov 56 S/N 5960-355-7269—3000 ea.—IFB 33-604-60-131B—Bid opening 7 Sept. 59.
Capacitors fixed and variable identified by manufacturers part numbers, 24 items—various quantities—IFB 33-604-60-121B—Bid opening 7 Sept. 59.
Tube electron transmitting RETMA type 673 S/N 5960-669-6864, 275 ea. Tube electron planar triode type 6280/416B in A/W MIL-E1/366A (Navy) Except that qualification approval is not required S/N 5960-NSL, 3400 ea.—IFB 33-604-60-8B—Bid opening 12 Aug. 59.

U.S. Army Engineer District, Norfolk, Ft. of Front St., Norfolk, Va. Construction of Langley *Bomarc* facilities, flight "B" Langley AFB, (A) Twenty-eight launcher storage buildings on piling: Buildings are about 62'x23' with structural steel framing and combination of metal and precast concrete panel siding. These buildings have a sliding roof and required mechanism to open them in a short time. (B) Composite building: Metal building about 160'x160' on piling; (C) Electrical distribution and communication systems; (D) Distribution systems for hot water, low pressure compressed air; (E) Water distribution system; (F) Roads and hardstands; (G) Chain link fencing (2150' plus or minus); (H) Site prep. grading and seeding; (I) storm drainage system.—IFB ENG-44-110-60-1—Bid opening 28 Aug. 59.

1939
Ets-Hokin and Galvan installed "Mousetrap" rocket launchers on U.S. Navy sub-chasers.

1956
EHG pioneered in the installation of electronic systems of test and launching complexes for Intercontinental Ballistic Missiles.

1959
EHG has now installed or serviced the electrical and electronic phases on most of the ICBM complexes in the United States.



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Wilmington, San Diego, Stockton, Monterey, Oakland, Sacramento, Vandenberg AFB, San Mateo and Downey, California; Cape Canaveral, Florida; Denver, Colorado; Phoenix, Arizona; Cheyenne, Wyoming; Las Vegas, Nevada.

Burt Ramsay, chief engineer, technical, has been named director of Engineering, Amelco, Inc. with **Roger R. Boy de la Tour,** assistant chief engineer, technical, succeeding Ramsay at the electronics firm. Ramsay joined Amelco two years ago after leaving the Canoga Corp. where he worked on development of various missile support systems, solid state amplifiers and power supplies. Boy de la Tour came to Amelco in December 1958 from Lear, Inc.

David A. Young, who was Aerojet-General's first employee when the company was founded in 1942, and recently chief of ARPA's space technology program, has been named director of Corporate Long Range Planning Division by Aerojet. Young, a graduate of CalTech, served in various positions at Aerojet, including chief of the Rocket Physics Department of the Research Division and assistant chief engineer of the Liquid Engine Division in charge of nuclear projects.

Charles C. Goodrich, as Douglas Aircraft Co.'s representative at the Army's Redstone Arsenal, will operate from a new Douglas office to be established in Huntsville, Ala. He will maintain technical liaison with the Army Ordnance Missile Command and the Army Guided Missile Agency. Goodrich has been at White Sands Missile Range for the past five years and, since last fall, has been project engineer for the *Nike* series at that location.

Dr. Leonard S. Sheingold of Sylvania Electronic Systems, division of Sylvania Electric Products Inc., has been named a member of the U.S. Air Force Scientific Advisory Board. Dr. Sheingold, who is manager of Sylvania Electronics' Applied Research Laboratory, has held many active and advisory appointments to governmental scientific groups including DOD's Weapons Systems Evaluation Group, the Operations Research Office of Johns Hopkins University and the Office of Naval Research.

Russell A. Kimes, director of American Machine & Foundry Co.'s General Engineering Laboratories, has been appointed a divisional vice president of AMF's Government Products group. He will also continue as director of engineering, responsible for the operation of AMF's Alexandria division in Alexandria, Va., the Greenwich Engineering division, and the Mechanics Research division in Chicago. He will work out of G.E.L. headquarters at Greenwich, Conn. Kimes came to AMF in 1946 as assistant works manager of the Buffalo plant.

Fred Rauschenbach, former sales manager of Martin-Baltimore, has joined United Electro Dynamics, Inc. as manager of Development Planning in charge of company expansion and market development. Rauschenbach, whose 16 years in the Marine Corps includes work in guided missile development, was later assistant project engineer on the *Lacrosse* missile for Martin-Baltimore and also spent a year with ACF Industries, Avion Division, directing the weapons systems department.

Dr. John M. Salzer has joined the technical staff of the vice president, Engineering, Ramo-Wooldridge Division of Thompson Ramo Wooldridge Inc. Formerly director of systems at the Magnavox Research Laboratory, Dr. Salzer worked in systems investigations, promotion of military products, supervision of projects in missile guidance, control computers, data processing, communications systems, and special studies. Prior to that he was with Hughes Aircraft Co.

David I. Margolis, former assistant treasurer of the Raytheon Manufacturing Co., has been named assistant to the president of International Telephone and Telegraph Corp. From 1952 to 1956 he was security analyst for Josephthal & Co. of New York City. Three engineers have been promoted to senior scientists at ITT Laboratories, Nutley, N.J.: **Richard E. Gray,** former senior project engineer o the Radio Communication Laborator and **Henry F. Herbig** and **Malcolm C Vosburgh,** former executive engineers o the Wire Communication and the Avioni Systems Laboratories. They will work o development and application of ne scientific theories and laws.

Dr. Ray P. Dinsmore, authority o natural and syn thetic rubber an vice president c research and deve opment for th Goodyear Tire & Rubber Co., ol served his 45th yea with the firm re cently. Dr. Din more's colorful ca reer in research ha been highlighted by award of the Colwy Gold Metal for 1947, awarded by the In stitution of the Rubber Industry for h work in synthetic rubber research and i development and application to product and the Charles Goodyear Medal for 195 by the Rubber Division of the America Chemical Society.

Appointment of **Julian J. Kliolz,** vic president, to serv on the board of d rectors, was an nounced by Asso ciated Gaskets, In Other appointmen by the firm: **Josep J. Locastra,** pla superintendent ar **Paul Gordon Am brose,** productic manager. Kliolz b came a vice president in 1948 when h came to the firm from the H. O. Canfie Rubber Co., where he was assistant pro duction manager. Locastra also came fro Canfield, starting there in 1923 and worl ing in almost every department of th organization. Ambrose has been assista production manager at Associated Gaske since 1957.

Robert E. Lehman has been appointe manufacturing ma ager of Pulse E gineering, Inc., ele tronics firm, aft 12 years at Lenku Electric, where h was variously tran former productic foreman, transforr er design enginee manager of th transformer desig group, and manager of the transform standards group.

—letters

)uality Important

o the Editor:

We have read with interest the ex-ellent article, "Notch Sensitivity Wall /ill Crack," which appeared in the June 2 issue, page 15. The article, however, iakes little mention of the importance f the quality of the basic materials used ι rocket cases.

While **Allegheny Ludlum's** role has een as a basic supplier of special clean-ness air melt and more importantly, onsutrode vacuum melt plate, sheet, and orging billets, and we have not entered ito the fabrication or testing of com-leted casings, it is our understanding iat there is increasing verification that ie cleanliness and freedom from even iinute internal flaws is extremely im-ortant in insuring maximum bursting rengths. We are also informed by our ustomers that the high-strength, low-lloy grades melted to extreme cleanli-ess standards and consutrode vacuum ielted to very low inclusion counts offer onsiderable advantage in the ability to orm such materials in the severe spin-ing operations involved in certain de-gns.

J. B. Henry
Manager, High Temperature
Alloys & Valve Steels
Allegheny Ludlum Steel Corp.

We will deal with this in future rticles.

)verindulged?

'o the Editor:

Your editorial, "Wake Up and Live," ı the June 22 issue was a superb sum-iary of what has happend in the air-raft industry to cause the current rash f symptoms. It's like the man who has aten the best rich food for years—and ow has the gout.

Keep up the good work. It takes guts) tramp on people's toes, but it is neces-ary and good at times.

Larry L. Booda
CDR, U.S.N.R.
Navy Department
Washington 25, D.C.

Clarification Pleases

To the Editor:

"New England's Missile Boom," by William E. Howard, in the July 6 issue of M/R, was another fine article that helps clarify this thing called the "missile industry . . ."

W. E. Green
Metal Fabricators Corporation
73 Pond Street
Waltham 54, Mass.

New Missile 'Bible'

To the Editor:

Your superb July 20 issue—the Third Annual Engineering Progress Issue and World Guided Missile Encyclopedia . . . will forthwith become our "bible" as we continue to work with manufacturers of missile and rocket components . . . You and your staff are to be congratulated on a major contribution to the dissemination of knowledge in this field.

D. J. Duffin
Duffin-Hughes Associates
Public Relations
1518 Walnut Street
Philadelphia 2, Pa.

Congrats on Editorial

To the Editor:

May I be permitted to compliment you on your outstanding editorial in the July 13 issue of MISSILES AND ROCKETS, of which I am a subscriber, headed "Components Reliability: What's Needed?"

Perhaps I am so keenly enthusiastic about your editorial for the reason that I have sung the same song for many, many years—frankly, without too much in the way of results. Your editorial provides much needed ammunition for designers in the missile field, to say nothing of highspeed supersonic aircraft.

As a designer of switches and thermal controls, mostly in the aircraft and missile fields, for the past 30 years, I feel that today we know how to make our respective components right, but there never seems enough time to do the job; and if it is approached, our companies who are naturally commercially minded are appalled at the cost of such devices. Generally speaking, they listen politely and agree in principle but very little is done towards authorizing the research and engineering necessary to do the job with a component that simply will not fail.

It is my feeling that if it is necessary to use a three karat diamond to do the job, we certainly should use the diamond for it is most assuredly impossible to compromise on materials or engineering structure where the minute components necessary are all the more needful of the type of work that goes in an ultra-precision timepiece.

I am trying to get together as many articles on this subject as I possibly can to provide a scrapbook of information and I hope influence on others. Therefore, if possible, I would like to receive as many reprints of this marvelous editorial as you could possibly send me. Also if you have any data along these lines; that is, other reprints of a similar nature, I would very much appreciate receiving it.

L. W. Burch
Consulting Engineer
Metals & Controls
34 Forest Street
Attleboro, Mass.

Omission

To the Editor:

The article, "Boston—'Hub' of space research" by William E. Howard in the July 13 issue fails to note that the "Golden Semicircle" of missile/space manufacturing becomes nearly a full circle when you consider the contribution of General Electric's plant in Lynn, Massachusetts, eight miles northeast of Boston.

Surely, the men who build the accessory power system for the *X-15*, the turbopumps for the *Vanguard* first-stage engine and who are now at work on equipment for future space vehicles, deserve a place on the wheel of the Boston area's space industry.

Paul Schratter
Manager, Product Information
Aircraft Accessory Turbine Dept.
General Electric, West Lynn, Mass.

We regret the omission.

P S

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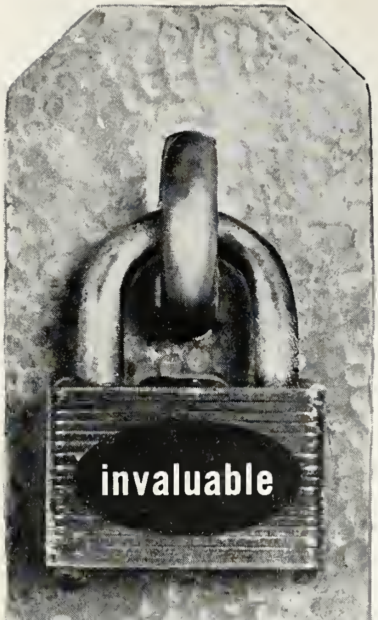

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missile business . . .

By WILLIAM E. HOWARD

Very quietly the Small Business Administration is casting a hard look at the "fee" end of DOD cost-plus-fixed-fee research and development contracts. Some strong complaints have been voiced by small firms over DOD policy on fees. They claim the profit margin is too little—in some cases non-existent. The SBA wants to know the extent of the problem; how many small firms are being squeezed out of military R&D competition simply because they can't afford to risk going into the red.

Some small outfits get caught in a jam . . .

They take on R&D projects knowing that they are potential money losers. But they also know that if they don't take them, they will be cutting off their source of work and in the end will have to shut up shop. There is always a chance that a losing proposition may turn into a more lucrative follow-on contract or a bigger related research project. When a company hits a string of losers, however, merger with a big corporation with a strong cash position sometimes becomes the only way out.

The SBA is against the merger trend . . .

now prevalent in the missile industry. The main purpose of this Federal agency is to play mother hen to a brood of small businesses. It wants to see small business thrive—to help little ones grow into big ones.

SBA now is wondering whether DOD is thwarting its mission. M/R has learned that SBA has hired some outside consultants to look into the situation. One problem investigators are up against from the start is finding out precisely what DOD's policy is on fees; who fixes them and why they vary.

Recent Congressional testimony by Perkins McGuire . . .

assistant secretary of defense for supply and logistics, indicates that fees fluctuate rather widely from a token fee of $1 to 10%. A DOD survey shows that the average for all the armed services is somewhere between 6% and 7%. For a small firm working on a $100,000 contract, the fee would run to $6000 or $7000. This doesn't yield much of a profit after taxes and operating overhead are deducted.

Where the SBA inquiry will lead, and what it will turn up, is still a matter of conjecture. But it is a safe bet that any pertinent findings will wind up in the hands of the small business lobby to press for action by either thc Administration or Congress.

Historically, Congress has always regarded . . .

anyone who does business with the Government with suspicion. The idea seems to be prevalent that any industry's pockets are automatically lined with gold as soon as the ink dries on a contract. The SBA is going to run into this fixation if it tries to bring about any revision in present policy toward fees.

Why it is perfectly legitimate for a manufacturer to make 15% or all he can in the consumer market, yet practically criminal if he nets more than 2% on a military contract is difficult to understand. Congress has never explored this "double standard" from the viewpoint of how it may affect our research effort and technological progress. And it will be interesting if someone can convince lawmakers that this might be a fruitful field of investigation.

SBA might do well to build a case on the importance . . .

of small company R&D in the missile/defense effort. Contributions from this segment of industry are truely impressive. And there is plenty of evidence to support the thesis that some of the country's best brains function most efficiently when they are in a small company—and when the profit motive is strong.

AUGUST

Association of the U.S. Army, Annual Meeting, Sheraton-Park Hotel, Washington, D.C., Aug. 3-5.

American Astronautical Society, Second Annual Western Regional Meeting, Ambassador Hotel, Los Angeles, Aug. 4-5.

William Frederick Durand Centennial Conference, The Problems of Hypersonic and Space Flight, Stanford University, Stanford, Calif., Aug. 5-7.

American Society of Mechanical Engineers, American Institute of Chemical Engineers, Third National Heat Transfer Conference & Exhibit, University of Connecticut, Storrs, Aug. 9-12.

Metallurgy Division, Denver Research Institute, Eighth Annual Conference on Applications of X-Ray Analysis, Stanley Hotel, Estes Park, Colo., Aug. 12-14.

Institute of Radio Engineer's Professional Group on Ultrasonics Engineering, First National Ultrasonics Symposium, Stanford University, Stanford, Calif., Aug. 17.

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

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

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

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

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

Army-Navy Instrumentation Program, Annual Meeting, Symposium and Industry Briefing, Statler Hilton Hotel, Dallas, Texas, Aug. 31-Sept. 2.

International Astronautical Federation, 10th Annual Congress, Church House, Westminster, London, Aug. 31-Sept. 5.

SEPTEMBER

Air Force Office of Scientific Research and General Electric Company's Missile and Space Vehicle Department, Conference on Physical Chemistry in Aerodynamics and Space Flight, University of Pennsylvania, Philadelphia, Sept. 1-2.

University of California, 1959 Cryogenic Engineering Conference, Berkeley, Calif., Sept. 2-4.

Air Force Association and Panorama: Send Reservations to AFA Housing Bureau, P.O. Box 1511, Miami Beach, Sept. 3-6.

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 53, New York, Sept. 14-15.

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

Standards Engineering Society, Boston Section Eighth Annual Meeting, Hotel Somerset, Boston, Sept. 21-22.

Instrument Society of America, 14th Annual Conference and Exhibit, Chicago, Amphitheatre, Chicago, Sept. 21-25.

Industrial Nuclear Technology Conference, Sponsored by Armour Research Foundation of Illinois Institute of Technology and Nucleonics Magazine and Atomic Energy Commission, Morrison Hotel, Chicago, Sept. 22-24.

Institute of Radio Engineers, 1959 National Symposium on Telemetering, Civil Auditorium, San Francisco, Sept. 28-30.

Institute of Radio Engineers, American Institute of Electrical Engineers, Eighth Annual Industrial Electronic Symposium, Mellon Institute, Pittsburgh, Sept. 30-Oct. 1.

OCTOBER

Anglo-American Aeronautical Conference, Institute of the Aeronautical Sciences, Hotel Astor, New York, Oct. 5-7.

Society of Automotive Engineers, National Aeronautics Meeting, Aircraft Manufacturers Forum and Aircraft, Engineering Display, The Ambassador Hotel, Los Angeles, Oct. 5-10.

Radio Interference Reduction and Electronic Compatibility Conference, Sponsored by the U.S. Army Signal Research and Development Laboratories, Conducted by Armour Research Foundation of Illinois Institute of Technology and Institute of Radio Engineers Professional Group on Radio Frequency Interference, Museum of Science and Industry, Chicago, Oct. 6-8.

Electronics Industries Association Conference, University of Pennsylvania, Philadelphia, Oct. 6-7.

Aeronautical/Astronautical Problems of High Speed Flight Meeting, Sponsors: AFOSR/Aero Sciences Directorate, ONR, OOR, NSF, and Stanford University, Stanford University, Stanford, Calif., Oct. 6-8.

Stanford Research Institute, First High Temperature Symposium, Asilomar Conference Grounds, Monterey Peninsula, Calif., Oct. 6-9.

AFOSR/Propulsion Research Division, Aeronautical Sciences Directorate and Avco, Second Advanced Propulsion Symposium (classified), New England Mutual Hall (tentative), Boston, Oct. 7-8.

National Electronics Conference, Sponsored by American Institute of Electrical Engineers, Illinois Institute of Technology, Institute of Radio Engineers, Northwestern University and University of Illinois, Hotel Sherman, Chicago, Oct. 12-14.

Armour Research Foundation, 15th Annual National Conference, Hotel Sherman, Chicago, Oct. 26-30.

Institute of Radio Engineers, Professional Group on Electron Devices, Shoreham Hotel, Washington, D.C., Oct. 29-30.

NOVEMBER

Institute of the Aeronautical Sciences, Annual National Midwestern Meeting, Wichita, Kansas, Nov. 2-4.

41st National Metal Exposition and Congress, International Amphitheatre, Chicago, Ill., Nov. 2-6.

Mid-American Electronics Conference, 11th Annual Meeting, Kansas City Municipal Auditorium and Hotel Muehlebach, Kansas City, Nov. 3-5.

Fifth International Automation Exposition and Congress, New York City, Nov. 16-20.

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NASA Budget Cut is Dangerous Economy

If some pollster were to query the 436 members of the House of Representatives with a question which would read like this:

"Do you want the United States to have a space program commensurate to her place in the world of nations and second to no other country on earth?"

The replies undoubtedly would add up to virtually a unanimous "yes."

Why then did the House cut $68 million from the budget of the National Aeronautics and Space Administration early this month before sending it to the Senate? In the words of NASA Administrator T. Keith Glennan:

"During the hearings on our fiscal 1959 budget request, some members of Congress raised serious questions about our not having requested far greater sums than we felt, after careful study, that we needed to organize NASA and initiate the (space) program.

"What has happened since then to give anyone a sense of complacency? For I can only interpret the action of the House as an indication of a lessening in the sense of urgency which has been expressed so often on the floor and in Committee.

"Have we—who started serious work in the space field six or seven years *after* the Soviets were pouring unlimited funds and their best brains into the drive to dominance in space—suddenly achieved some enormous advantage?

"If so, I would like to know about it. I would sleep better at night."

NASA is requesting a fiscal 1960 budget of $485,300,000. In addition NASA has requested $45,000,000 in supplementary funds for 1959.

The House Committee on Appropriations cut the combined requests by $45.5 million.

The House itself, on points of order, further reduced both requests by $22,725,000—a reduction of $68,225,000 in all.

What could these cuts mean to NASA? In the words of the administrator and his qualified associates:

Vega—drastically cut back. *Vega* is a modified three-stage *Atlas* capable of putting a 5800-pound satellite in orbit to make television surveys of the moon, among other things. It is an essential preliminary for moon flight. Budget funding: $42.5 million.

Centaur—retarded. *Centaur* is similar but more powerful than *Vega*, designed to put 8000 pounds in orbit or to soft-land a 730-pound scientific load on the moon. Budget funding: $41 million.

Nova—eliminate or drastically reduce. *Nova* is the 1½-million-pound-thrust, single-chamber engine, producing in time a 6 million-pound-thrust cluster necessary to carry manned expeditions to the moon. Budget funding: $30.2 million.

Rover—reduce. *Rover* is the nuclear rocket for space travel.

Mercury—probably slowdown. *Mercury* is the manned satellite project.

Tracking and data acquisition networks—delayed. As necessary to space probes as precinct support to a Congressman.

New personnel—reduced by 15%. People are skills and training and competence. Without them no project can be accomplished.

What is likely to happen in the Senate or in Senate and House compromise?

The $22,725,000 lost on the points of order technicality will probably be restored. But the $45.5 million cut by the House Appropriations Committee will probably be lost entirely or at best partially restored. And, in the words of one high NASA official, the loss of even $20 million would affect the projects listed above.

The NASA budget request seems to us more than ordinarily reasonable. Some $100 million of it goes to support NASA research centers. Less than $375 million is new money for the space field. Compare this to a $40-plus *billion* defense budget in these days of a cold war where Russia uses her space exploits as an instrument of power politics; when she has convinced much of world opinion that success—or failure—in the space field is a measure of a nation's scientific progress.

At the risk of stepping on Pentagon toes, we would say—and earnestly—that the value of the United States of placing a man in space first, or of making a landing on the moon first—that either of these things is of more value to this nation in the cold war than a squadron of intercontinental missiles —which costs just about $100 million.

We believe that Administrator Glennan and his associates at NASA are doing a good and conscientious job. They don't pretend to have a magic formula for space exploration. If someone has such a formula they would like to see it.

Furthermore, we believe the NASA budget is honestly and tightly prepared. If for no other reason —and there are other reasons—the budget is too small to be otherwise.

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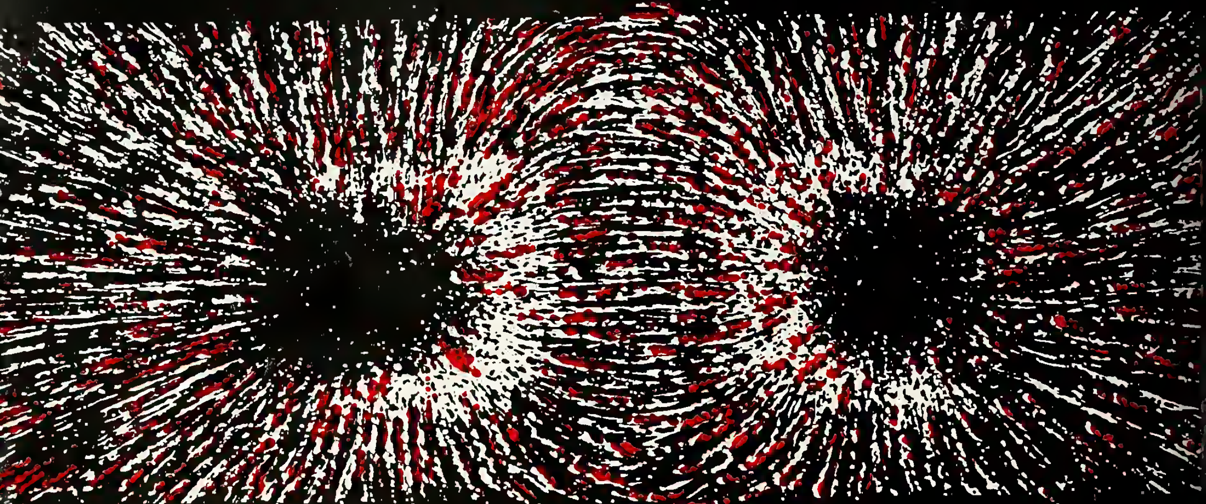

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