JUNE 22, 1959

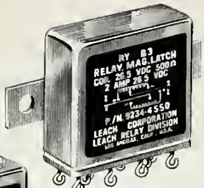
MARINE AND TERRIER MISSILE

missiles and rockets

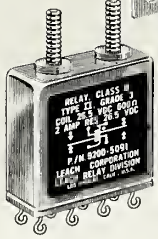
MAGAZINE OF WORLD ASTRONAUTICS

AN AMERICAN AVIATION PUBLICATION

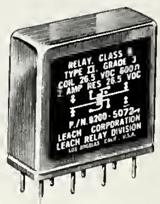
TYPE 9234-4550 2POT, 2AMP, MAGNETIC LATCH RELAY (BRACKET MOUNTING, SOLOER HOOK TERMINALS, HERMETICALLY SEALED)



TYPE 9200-5091 2POT, 2AMP, RELAY (STUD MOUNTING, SOLDER HOOK TERMINALS, HERMETICALLY SEALEO)



TYPE 9200-5072 2PDT, 2AMP, RELAY (PLUG-IN OR PRINTEO CIRCUIT MOUNTING, HERMETICALLY SEALED)



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missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS

JUNE 22 HEADLINES

ASTRONAUTICS ENGINEERING

MISSILE SUPPORT

MISSILE ELECTRONICS

THE MISSILE WEEK

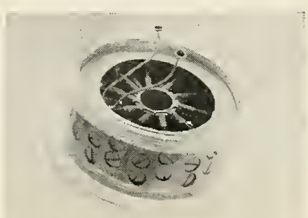
DEPARTMENTS

COVER: Leatherneck is backed by Convair's *Terrier,* used for ground support as well as at sea.

EXAMPLE of brittle failure in hydrotest of solid rocket motor case (see p. 15).

MODEL of satellite drag brake proposed by Avco as alternative to retro-rockets (see p. 18).

RE-ENTRY heat and temperatures are duplicated at Avco's Everett, Mass., Laboratory (see p. 22).



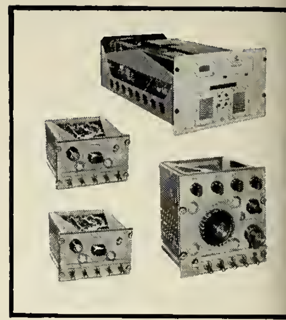
SNAP III generator offers hope that small electrical sources can live long in space (see p. 29).

COMMUNICATIONS...

Radio Set AN/ARC-57 . . . designed and developed by *The Magnavox Company*, in conjunction with the Air Force, is an essential UHF communications system, providing the utmost in performance and reliability for the CONVAIR B-58.

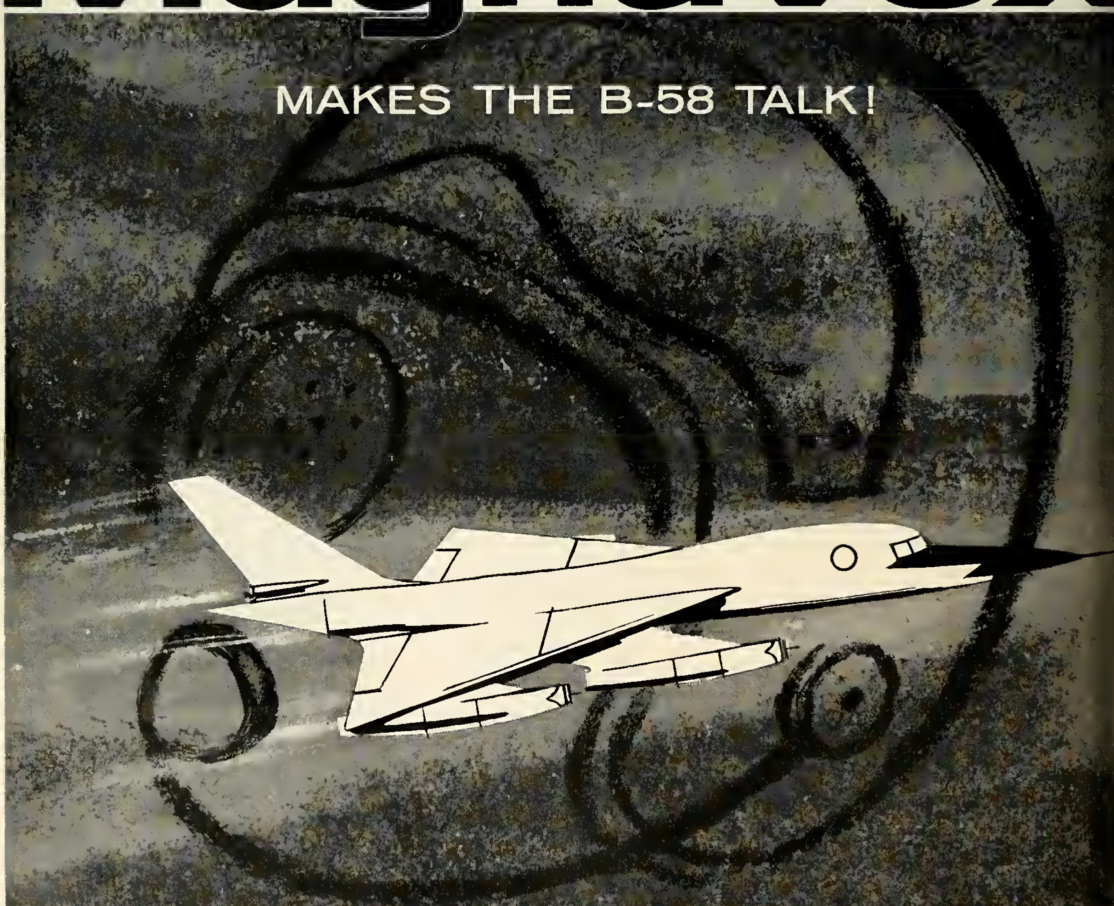
It clearly demonstrates *The Magnavox Company's* ability to produce and work as a prime contractor on a complex weapons system.

MAGNAVOX capabilities are in The Fields Of Airborne Radar, ASW, Communications, Navigation Equipments, Fusing and Data Handling . . . your inquiries are invited.



PRODUCTS THAT SPEAK FOR THEMSELVES

Magnavox



THE MAGNAVOX CO. • DEPT. 82 • *Government and Industrial Division* • FORT WAYNE, IN

Wake Up and Live

These are troubled days for the aerospace industry, once known as the aircraft industry. Individually and collectively its member companies are taking a beating on Capitol Hill, in the Pentagon and in their once-excellent public relations to the point where they are now being alluded to by the President as a munitions lobby.

And it is largely their own fault.

They have only recently witnessed the embarrassing sight of one of the most powerful men in Congress, Chairman Carl Vinson of the House Armed Services Committee, mercilessly chastising the industry in a relentless attack on their renegotiation position.

The military leaders, once staunch allies, have not rallied to the industry's support. The daily press has played the news straight from government releases and the result has not been kind.

The truth is that the aerospace/aircraft industry is no longer the protected darling of the gods in Washington and it is time that its members faced up to this fact.

The days when an aircraft company president—if he didn't like the way things were going for his company—called up the chief of staff and set matters right, are gone forever. So are the days when the aerospace/aircraft industry didn't have to fight its battle on the Hill because the military fought it for them.

The aerospace industry is the biggest manufacturing industry in the world (753,500 employees against 741,900 for automobile at last count) and its members must learn that it's a tough world with very tough competition for the breaks. Most other major segments of U.S. industry faced up to it a long time ago.

The aerospace industry will probably not always remain largest as an employer, because the articles it makes tend to become more expensive in cost and fewer in numbers. (What effect this will have on the national economy is worth thinking about.) But most certainly in the foreseeable future it will rank among the most important, both in dollars and national security.

From a position not quite so close to the forest, we would like to suggest to the industry that it consider certain actions:

Take active steps to avoid being classified as a chosen, favored, captive or kept industry. The once-accepted fact that the country had to maintain a base for mobilization is a lot less true in these days of instantaneous warfare. Companies stay alive these days only on their competitive skill, diversification, ingenuity and courage.

Agree on a legislative program and unite behind it. Congressional battles can be won on the home front a lot easier than in Washington. Renegotiation appears to be a lost cause for the moment. Indemnification for unusual risks is bottled up in Congress and probably won't emerge at this session. Revision of the NASA patent inequities will come only when Congress is convinced they are really inequitable. Look to Washington for guidance and cohesion, but don't leave it all up to the people there.

Forget the fact that relationships with the Pentagon were once a matter of personal friendships forged in the canvas-winged biplanes of World War I combat or in the barnstorming days of the Twenties. There's a new crop of men making the decisions these days in the Pentagon and at Wright Field, Huntsville, BuAer and BMD. And a new crop flying your planes and guiding your missiles. Most of them don't know the company presidents and don't expect to. But these are the men who have to know your product and believe in it, because they are the ones who, in the long run, really dictate the purchase and use of it.

As for Congress, getting industry's story over to them is a matter of proper communication. And in this field, whether it involves Congress, the military or the public, perhaps the most important requirement visibly lacking is a strong central policy or philosophy. What is the industry's philosophy on the team concept, especially, if two or more major primes must join on a contract to achieve the best possible product? What is the industry's position on government versus private ownership of facilities? What has the aerospace industry done about explaining the financial and economic facts of life to its biggest customer—the military, especially the younger generation of military officers? Has a real effort been made to inform Congress of industry's position on the negotiated versus the advertised contract and the reasons therefore? Or that negotiated contracts are really based on competitive bids, with the losers forfeiting time, work and tremendous sums by competing?

Right now, many of the decisions themselves are no more important, it seems to us, than the fact that the industry must unite on them. And match its philosophy with the needs of a changing world.

Clarke Newlon

HOW SAC's "HOUND DOG" SCENTS ITS TARGET

The crew of the B-52G starts up the jet engine of the sharp-nosed GAM-77 Houn Dog missile hung under its wing... gives its inertial autonavigator the location of the targ

On a "for-real" mission, the Hound Dog would leap toward its target at supersonic spe —very likely a ground-defense center hundreds of miles away. Its guidance system can't jammed... can't be decoyed.

Purpose of the GAM-77 air-to-ground jet-powered guided missile is to increase the striki power of Boeing's B-52. Sling a pair of Hound Dogs under the wings of the new B-52G—a you have what amounts to a brand-new weapon system.

The GAM-77 program was started in August, 1957. The missile has been put into accelerat development. It already is in its early flight test phase... will be deployed by 1960.

Weapon system contractor: the Missile Division of North American Aviation.

MISSILE DIVISION NORTH AMERICAN AVIATION, INC., DOWNEY, CALIFORNIA

washington countdown

The Navy has decided to go along with development of a medium range ALBM—probably with a *Polaris* second-stage configuration.

Leading frame manufacturers are being asked or will be asked to submit proposals. Already under consideration are **Martin's** *Bold Orion* (M/R Dec. 1, 1958) and **Lockheed-Convair** and **McDonnell** proposals submitted to AF during ALBM competition won by **Douglas.**

Insiders are speculating on whether the Office of Secretary of Defense will allow two almost parallel programs.

The **Douglas** ALBM will have a range of from 1000 to 1500 miles. The 750-mile range Navy ALBM would be launched from carrier-based-jets—possibly the Mach 2 Vigilante A3J under development by North American.

IN THE PENTAGON

The long-range significance . . .

of the compromise "master plan" for U.S. air defense is that the advocates of the offense have won a victory. They have contended that the Soviet bomber threat is on the decline and the ICBM threat is rapidly mounting. Therefore, they argue that every available dollar must be spent on the one defense-in-being against the ICBM—the offensive power of SAC.

• • •

Both the Western Electric . . .

Nike-Hercules and the **Boeing** *Bomarc* suffered with greater acceptance of offense advocates' viewpoint. But *Nike-Hercules* suffered less because it is already here. *Bomarc-B* is about two years away. Therefore, it took the bigger slashing.

• • •

The Pentagon sought . . .

to sweeten the "master plan" with the extra $137 million for *Nike-Zeus.* And more sweetener may be on the way in the form of Pentagon agreement to spend extra millions on ICBM's—specifically the **Convair** *Atlas* and the **Boeing** *Minuteman.* But the mood of Congress is still sour. The end of the battle is nowhere in sight.

• • •

The next shot . . .

in ARPA's *Discoverer* series is expected this week—the second shot this month. The *Discoverer IV* will not carry animals in its biomedical capsule. But an attempt is expected to be made to recover the capsule from orbit.

• • •

Australian observers believe . . .

the Woomera range may soon become second only to Cape Canaveral in the firing of satellites and rockets. Already, British, American and Australian scientists are gathering in Salisbury, near Adelaide, South Australia, for more *Black Knight* tests and what may be Britain's first satellite launching attempt within several months.

ON CAPITOL HILL

The big congressional furor . . .

over the so-called "munitions lobby" is expected to grow warmer with the summer. But whether it will stay warm enough to be served up during the 1960 presidential campaign will depend on the forthcoming House investigation into the hiring of retired military officers by defense contractors.

• • •

Meantime, here are a couple of . . .

related developments to watch for on capitol hill:

. . . Rep. Leonard Wolf (D-Iowa) is considering introduction of a bill that would ban private industrial patents on inventions developed with Federal defense funds.

. . . The Hébert Subcommittee probably will complete hearings on its weapon system concept investigation before beginning the new investigation about July 6. But don't look for a report until after the retired military men are heard.

AT NASA

An attempt to launch . . .

Vanguard III is scheduled for sometime this week. The 20-pound satellite will carry instruments to measure the effects of lightning and the radiation-heat balance between the earth and the sun.

AROUND TOWN

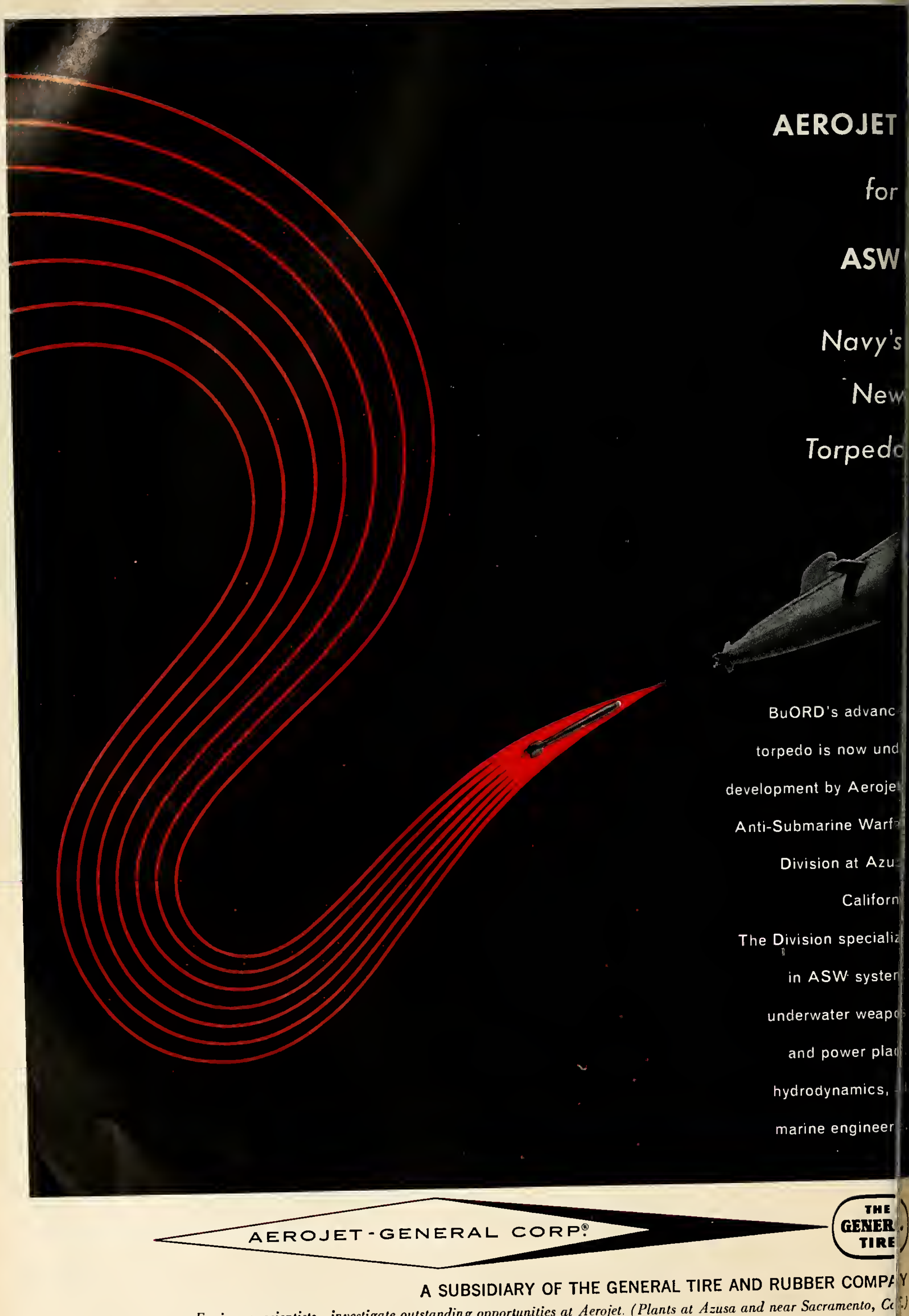
Some of the reports . . .

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

. . . Rep. Victor Anfuso's House Space Subcommittee which was set up to look into space developments in foreign parts won't be doing any travelling for a long time.

. . . The Russians may have tried but failed to launch a space vehicle to Venus during the optimum period early this month.

. . . The White House is reverting to its old pre-Sputnik attitude toward science.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industry countdown

STRUCTURES

Construction is about . . .

to begin on second hardened *Titan* base at Lowry AFB, Denver. Low bidder to build the nine-silo complex within 770 days was **Morrison-Knudson & Associates** at $26.9 million. M-K is building the first base. The two contracts total $69 million.

• • •

There are reports . . .

second stage of the **Lockheed** *Polaris* is being seriously studied by Navy as an air launched ballistic missile. System would have aircraft carrier capability.

• • •

Navy has publicly confirmed . . .

that it is developing the nearly 20-foot long *Astor* torpedo. It forgot to mention that the **Westinghouse** development has more than twice the 10,000-yard range of the Mk. 39 and that it's a real achievement in wire-guided torpedos because some of the wire's negative buoyancy characteristics have been eliminated. The 20-knot *Astor* has more range than sonar capabilities of detecting submarines. Density layers still can't be penetrated to detect subs beyond 4000 yard range even though Navy is experimenting in low frequency and one report has it that 30-foot transducers (which slows one target ship considerably) still won't transmit an appropriate signal.

• • •

In-house study . . .

of launcher and other MSE to fire *Minuteman* from mobile railroad car (M/R June 1, p. 18) is underway by **American Machine & Foundry.** AMF called in **American Car & Foundry** to develop design of the missile train cars, which may be camouflaged as standard-appearing freight trains.

• • •

DOD will be responsible . . .

for NASA industrial security. Idea behind agreement worked out by the two agencies is to eliminate duplication and unnecessary confusion in contractor plants.

PROPULSION

Replacement of metal nozzles . . .

on solid-fueled rocket motors with plastic is being actively considered by **Aerojet-General.** Possible switch comes from A-G's own research in plastics and partially from "breakthrough" on *Nike-Zeus* plastic rocket nozzle disclosed recently.

• • •

New design for missile . . .

auxiliary power units by **Garrett Corp.'s Air-Research Division** uses single block to house all operating valves and reduces valve number from 18 to seven. Turbine APU operates on either ethylene oxide, hydrozine or, with modification, a solid propellant. The 85-pound unit can deliver 5 hp for 7½ minutes.

ELECTRONICS

A 100 million-mile . . .

digital communication system reportedly has been developed for use in deep space probes. **Space Electronics Corp.'s** "Digilock" more flexible and sophisticated—though smaller—than others presently in use, reportedly can vary sample rate from 100 to 25,000 sps and trade off between transmitter power and amount and accuracy of data. With addition of demodulation circuitry, existing telemetry receiving equipment can be used with the system. Built for JPL, system should provide communication efficiency close to maximum possible under information theory.

• • •

For *Atlas* guidance . . .

General Electric has come up with "Hi-Fi" precision radar tracking antenna capable of measuring an angle of one foot at 25 miles. Tolerances in mechanical components of antenna and its pedestal and driving mechanisms are comparable to those in a fine watch and unprecedented in manufacture of large units.

• • •

ARPA $600,000 contract . . .

for comprehensive study of feasibility of tracking and intercepting enemy space satellite is in hands of **RCA.** Scheduled for completion in six months, study will provide information on requirements for further R&D to design system for operational capability in 1965-70 time period.

ASTROPHYSICS

Study contract for $50,000 . . .

has been awarded **Republic Aviation** by ARDC to find efficient means of keeping track of man-made satellites. Study will analyze trajectory of dog-carrying *Sputnik II,* which was launched Nov. 3, 1957, and came down April 14, 1958.

• • •

"Space trainer" is proposed . . .

by **Convair,** using *Centaur* rocket to orbit a four-room satellite. Two-man glide rockets would ferry crewmen to the trainer for conditioning and orientation to prepare for long space trips.

rockets and missiles

Componentry capabilities of the Kelsey-Hayes Company as a supplier of precision propulsion assemblies, structu parts and exotic high temperature materials for first and second generatior rockets and missiles include—

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How Big A Missile Support File?

AF list will start with some 2500 data sheets but opinions differ on how much longer it will get

by William E. Howard

WASHINGTON—Air Force supply ınnels are bulging with roughly 1.5 ion pieces of equipment—from ominiature transistors to multi-mil- dollar LOX generators. Each day to 500 more items are being added upport new missile/aircraft, com- ications and warning systems. (In 2 there were 725,000 items in the ply system.)

This enormous quantity, reflecting inually changing strategic require- ts and advancement in state-of-the- ile-art, is creating a king-size prob- for AF compilers of the "Technical Information File"—a first attempt to catalogue the fast-expanding missile/aircraft support equipment field.

Last in a Series on Missile Support

The first installment of this unusual reference guide being published July 1 will contain nearly 500 data sheets describing equipment in inventory. Later sheets will include equipment under development. But the question that is confronting TIF editors already is: How big should TIF be when complete?

A prime goal of the catalogue is to stem the birth rate of unnecessary equipment. For new weapons coming along, the AF wants gear listed in TIF to be utilized whenever possible by contractors, either as it stands or with modifications, rather than continue on with wasteful duplication that has already bloated AF inventories (M/R June 15, page 21.)

Can TIF become a really useful instrument in bringing about some order and standardization in the missile support field without listing the hundreds of thousands of handling, test and checkout items that already exist?

TIF Data Sheet

MIL-D-19731A

(Date of this Data Sheet)

(ITEM NAME)
(TYPE OR MODEL DESIGNATION)
(Approved Nomenclature, if Available)
(Functional Classification)

Cognizant Service

FEDERAL STOCK NUMBER

	USA	USN	USAF	USMC
TATUS OR TYPE CLASSIFICATION				

anufacturer(s): Name or Code Number

ILLUSTRATION

(Include Approximate Over-All Dimensions and Weight)

UNCTIONAL DESCRIPTION:

Give a brief functional description of the item.

This information shall be presented in paragraph form and shall escribe specifically what the equipment does, what it is used for, hat it is used with, application, and where it is used.

The description shall support the functional class assigned nd include general operating and design characteristics.

(ITEM NAME)
(TYPE OR MODEL DESIGNATION)

MIL-D-19731A

RELATION TO SIMILAR EQUIPMENT:

Describe differences and/or similarities to other equipment of the same general type and function.

This information shall be presented in paragraph form and include the nomenclature and type or model designation of the equipment discussed.

TECHNICAL DESCRIPTION

The following information, as applicable, shall be listed in tabular form:

Frequency range.
Power output and/or input (to include amperage, KVA, number of wires, phase, type of receptacle or plug, length of cable, etc).
Output signal characteristcs, range as rated, accuracies, sensitivities.
Pertinent electrical and mechanical characteristics and individual units of major importance (such as calibration, size, accuracy, type, etc of test indicators).
Dimensions (if for fixed installation, give necessary data for installing; for example, 1 in. lag bolt at each corner for concrete imbedment, etc).
Wheel size(s) and type(s).
Towing capabilities or restrictions.
Lifting capacity, rated and ultimate.
Lunette details.
Weight (dry and ready for operation).
Tie-down provisions.
Hydraulic and/or pneumatic characteristics (to include input/output pressure, flow, fluid/gas type and characteristics, receptacle or connector type, hose length, etc)
Other equivalent information applicable to special or unusual equipment.
If self-propelled automotive type equipment, include dimensions, tread, wheel base, turning radii, angles of approach and departure, minimum ground clearance, data relative to fuel system, clutch, transmission, transfer case, axles, frame, suspension, steering, brakes, electrical system, performance, cab, winch, etc.
List, in tabular form, the types and quantity of each type of electron tube, crystal and/or transistor used in the equipment.

REFERENCE DATA AND LITERATURE:

To the extent known, list the following information in tabular form:

Service and/or commercial instructional publications (give title and publication numbers).

Engineering test report (report number and date).

Specification: (number) - Drawing: (number) - Etc.

REPRODUCTION of a typical TIF data sheet, to be inserted loose-leaf volume. Pages will number 2500—for a beginning.

REVERSE of the same page, giving more detail space. An EIA spokesman says some sales sheets might be made identically.

No restraint on trade likely . . .

Both AF and industry officials who collaborated on the creation of the file firmly believe it is an important step forward, although viewpoints may differ as to what and how many items TIF should include.

Air Materiel Command officials assembling TIF at Wright-Patterson AFB believe that to achieve its goal of standardizing equipment in use, the contents must be highly selective, and restrictive. Accordingly, they are proceeding—with the approval of industry steering groups—to limit TIF initially, at least, to 2500 data sheets.

On the other hand, some industry experts believe that eventually the book will have to get much bigger—perhaps listing 100,000 or more items.

"We feel that the catalogue will lose its value to the contractor if it is too big," says one high official in AMC's Office of Cataloguing and Standardization. This officer explains that TIF is being put together as a "designer's guide." Its objective is to let contractors know what is in AF inventories, and flag them on what the AF wants designed into new weapons.

• **Sales effect?**—AF officials hasten to make clear that TIF is in no way likely to act as a restraint on trade.

Information given on TIF data sheets relates only to performance specs of the desired equipment. Also listed are makers of an item who have previously sold to the AF.

However, OCS authorities say that TIF will not be utilized as a procurement directory. Buying of spares and re-procurement of items will be done in the customary fashion.

In some respects, perhaps, TIF will amount to a sales brochure for the companies whose products are contained in it because their names will be continually before contractors, who are buyers. Unique specifications of one piece of equipment listed in TIF also might be designed into a weapon system, giving one supplier an advantage over competitors.

In its initial listings, OCS is limiting TIF to items of equipment which were designed specially to military specs and which cost $2000 or more per unit. As the number of data sheets approaches the 2500 total, AF and industry representatives from AIA, EIA, SAE and NSIA will make an evaluation as to proceeding further.

The $2000 minimum criterion is expected to be relaxed to permit the inclusion of items—particularly electronic—which have a unit cost lower than that figure, but which are purchased in large quantities.

TIF listings fall now strictly into the first of four AF procurement categories or classifications. These are: 1) military-designed equipment now in use or under development; 2) commercial-designed (off-the-shelf) items in the military supply system; 3) commercial items suitable, but not yet being procured; and 4) equipment which must be designed new.

Class two items may be included later.

• **EIA viewpoint**—In the opinion of Henry E. Bernstein, military engineering coordinator of EIA, TIF will have to be comprehensive—reaching around 100,000 entries. Otherwise, he says, contractors will not have enough information at their fingertips to keep them from redesigning an already existing piece of hardware.

"The cost of cataloguing is small compared to the cost of redundant redesign," observes the retired Navy captain.

On this point, however, AMC officials say they don't want TIF to become a catch-all with the AF footing the bill for what they believe would amount to a lot of free advertising.

Bernstein suggests that as an alternative manufacturers of items in the third procurement category—those without status—make up their sales sheets in a format identical to TIF data sheets (see illustration).

TIF is to be loose-leafed. Pages will be removable and inserts can be made to keep the file up to date.

Manufacturers who follow Bernstein's suggestion would send their equipment sales sheets directly to contractors—leaving it up to the contractors to evaluate the product and decide whether they should insert it in TIF for consideration by their designers.

Bernstein points out, for instance, that one firm may make a cathode ray oscilloscope designed in-house that is several grades better than anything listed in current AF performance specs. The present system for inclusion in TIF would keep the piece out. But suppose a new weapon system required precisely such a 'scope?

"The contractor wouldn't know that it exists and would proceed to design it at a waste of money—just what we don't want to happen," says Bernstein.

He adds: "Improper standardization is the enemy of progress. There is a danger of retaining something beyond its obsolescence. TIF can be a help to progress if it is kept up to date and is kept fluid."

Fluidity will, as a practical matter, be largely in the hands of contractors. They will be the medium of contacti[ng] suppliers, who will be requested to f[ill] out TIF data sheets on equipment th[at] is being incorporated into a missil[e or] aircraft support system. Any changes [in] the system eliminating equipment [or] changes in the equipment will neces[si]tate updating of TIF data sheets.

On equipment that is under develo[p]ment, data sheets, must be revised [as] the item progresses to the operatior[al] stage. Printing and distribution to abo[ut] 2600 contractors and AF procureme[nt] officials is handled by OCS.

AMC officials feel that TIF shou[ld] have a chance to be tried for seve[ral] months before any revisions are ma[de] in the approach, particularly as [re]gards the number of listed items.

"The reason we got together on T[IF] in the first place," comments one, [is] that contractors complained that [AF] stock lists were too unwieldy to wo[rk] from. Let's keep the catalogue sm[all] and see what happens."

X-15 Is Powered by Two Novel Generators

SCHENECTADY, N.Y.—Two unus[ual] 40-hp generators furnish the o[n-board] power aboard the *X-15* space resea[rch] plane during glide tests. The u[nits] operate completely independent of [the] plane's rocket engine and furnish p[ow]er to keep the pilot alive and cont[rol] the vehicle during descent and landi[ng]. For fuel, they use hydrogen peroxi[de] which decomposes into steam and o[xy]gen to drive a high-velocity turb[ine] producing both electric and hydrau[lic] power.

Electric power from the Gene[ral] Electric units is used to energize [the] plane's instrumentation, provide ca[bin] and pressure suit heat, power [the] inertial guidance system and comp[ut]ers, and operate communication, t[ele]metering, and recording equipme[nt]. Hydraulic power operates speed bra[kes,] landing flaps and control surfaces.

Whirling Gas Gouges Nose Cones, Meteorites

SCHENECTADY, N.Y.—A Gen[eral] Electric scientist has come up wit[h a] convincing explanation of why s[ome] iron meteorites contain deep cavi[ties] that appear to have been made [with] a cutting tool.

Dr. R. H. Johnson says that stu[dies] of nose cones at hypersonic spe[eds] show that whirlpools of hot gas f[orm] in imperfections in the surface of [the] cone (or meteorite) and cut like h[igh]speed tools to gouge out deep cavi[ties].

He contends, too, that this could [ac]count for the fact that some meteor[ites] fly apart during atmospheric entry.

Notch Sensitivity Wall Will Crack

Large diameter rocket motor cases with 300,000 psi min-yield strength may be in production within a year through use of promising metallurgical techniques

WASHINGTON—If claims could fly, e'd be all manner of high-strength, -wall solid rockets in the air—each a motor case strength-to-weight in excess of 1 million inches. Not that, but there'd be a free and al choice of materials including doz- of alloys of aluminum, titanium steel—each better than the others. nd the fabrication methods! All ld be "best" and would include d and welded, girth welded, stacked s, deep drawn, deep drawn and ded, hogged out, cold spun, hot , convolute wrapped, spiral pped, press extruded, sprayed metal, We'd be in missile heaven if claims d fly.

But they can't. And, by themselves, can't win contracts either. It used e that a company with a name, a n and an adeptness at the fine of pitchmanship could almost be red of a development contract to eve that shining 240,000 psi mini- n-yield-strength "next goal"—which in those days, more than we ded, "just for good measure."

Now, as many a sadder (cancelled and wiser motor case manu- urer can attest, those days are gone ver. Years and millions of dollars , the "next goal" is down to a erate 220,000 psi. Yet the need is er to 300,000 psi. We're talking imum yield strength in large di- ter production cases—flight hard- —not midget motors or the occa- al research program freak.

• **200,000 psi to be exceeded**—The ,000 psi min-yield barrier to solid et motor case development is going e cracked within months. After that ,000, 230,000 and 240,000 will fol- in rapid succession. And, before her year is passed, large-diameter ,000 psi min-yield cases may well moving into the production phase.

Claims, tricks and fancy talk won't what does it. Rather, it will be ac- plished with a sound understanding of the problems involved; by a better-than-ever knowledge of the finer points of metallurgy; and with a craftsman-scientist-artist's approach to fabrication.

It won't be job-shop metal-working or a big-dollar scatter factor that turns the trick. Gone are the days when the gross approach to technology was all it took to cop new honors in metallurgy. Instead it will take the same intimate understanding of this art as that which has enabled such great strides to be made in other phases of missilery, such as guidance, control, re-entry, etc.

No one can detail for sure just what form the breakthrough will take when it comes, even though the alloy(s), treatment and fabrication method(s) may now be in the development stage. There are promising results already, but nothing has been proved out.

Importantly, however, the arsenal of basic do's and don't's and promising metallurgical concepts is not only growing rapidly, but beginning to take coherent form and point the way to a breakthrough.

• **Notch sensitivity concept**—Perhaps the most elementary of these is the concept of notch sensitivity (M/R, June 8). This says, in effect, that high-strength alloys heat-treated to their optimum high strengths will have a very low tolerance for even very small flaws. It goes on to say (based now on a great variety of experimental research and testing) that if, on the other hand, an alloy is heat-treated to a lower smooth tensile strength (and more ductile condition), its toler-

HERE IS an excellent example of brittle failure during hydrotest of a solid rocket motor case. Failure in this case was at less than one-half the values of the tensile coupons that accompanied the chamber through heat-treat. It burst at 1000 psi hydro pressure. The material, a 5% chrome hot-worked die steel, exhibits all the characteristics of a notch-sensitive failure.

ance to flaws will be greater, and the material in the notched condition will be stronger. It is against this basic concept that current motor case development is proceeding.

No material tested so far shows a notch strength in excess of 210,000 psi. Most are below 200,000 psi. The mean is 190,000 psi. This would seem to rule out any chances of breaking the 220,000 mark without developing materials that either weren't notch-sensitive or had notch strengths in excess of that mark. Fortunately, however, this isn't so.

• **Two assault forms**—The assault on notch sensitivity takes two basic routes:

The assumption is made that, on a production run, flaws are inevitable, and efforts are being made to design and fabricate accordingly.

Considerable effort is being expended both by steel-makers and motor case manufacturers to develop basic materials and fabrication techniques to minimize the possibility of flaws in the finished product. Simultaneously, efforts are being made to develop inspection techniques (unavailable now) to reliably detect these flaws—which take many forms and need not exceed a maximum dimension of 0.010" to prove fatal.

Accepting notch sensitivity as inevitable requires a more highly refined approach to stress analysis, if the 200,000 psi mark is going to be topped. This is the first step in designing to high notch sensitive strength in motor cases, and is an approach that apparently is still not too widely appreciated.

Most material min-yield and ultimate tensile strengths are stated on the basis of results obtained from pull tests on straight strip samples of the material—notched or not, depending on the test. In this test, the strip is grabbed by jaws at either end, and tensile stress is applied until (a) the material exceeds its elastic limit (min-yield stress) and (b) it fractures (ultimate tensile strength).

Traditionally, motor-case design procedure had been to take these simple coupon strengths and put them into the formula $s=pd/2t$, where s is the hoop stress; p, the hydrostatic test pressure; d, the motor case diameter: and t, the motor case wall thickness. (Formula for longitudinal stress is $s=pd/4t$, which makes longitudinal stress just half of hoop stress). Motor case wall thickness is determined by hoop stress only.

With a certain chamber pressure dictated by propellant chemistry and burning geometry and with a material of a given min-yield strength (based on the simple pull test), the motor case designer for the most part has simply added his safety factor (say, 20% higher pressure) and solved for wall thickness. And that's how his specifications have gone to the case manufacturer.

• **Why it costs**—But this is the gross approach to both motor case design and stress analysis, and, in part, it's one of the things that has cost us so much money, time and frustration.

It also may be why so many cases that were heat-treated to a hardness of $R_c=53$ burst as though they had been heat treated to $R_c=74$. The condition of the material is not the same under bi-axial stressing as from the combination of hoop and longitudinal stress—as it is under uniaxial loading, as in simple pull test stress. Under stress a material tends to strain (stretch). This means the cross-sectional area is reduced. However, apply a second stress 90° (normal) to the first, and it resists natural strain tendencies.

In effect, biaxial stressing appears to have the same result as a te porary embrittlement. Though this not a conclusive fact yet, work date supports the concept, and mo case development work is proceed accordingly.

For example, in comparative t between uniaxially loaded pull-test c pons and biaxially loaded cylindri pressure vessels, cylinder min-yi strengths have consistently excee those of the coupons. Also, the yi to-tensile strength ratio of the cylin has increased, meaning that the cy der's min-yield strength has gone more than its tensile strength—a ch acteristic of embrittlement.

• **Here's secret**—It is in this hig min-yield strength for cylinders t the secret of designing around n sensitivity lies. It makes use of the Mises-Henckey Maximum Strain ergy Theory which, in effect, says the minimum yield strength of a cy der will be 1.15 times that of a test sample of the same material h treated to the same unstressed hard as the cylinder. The formula for thi $s_0^2 = (s_1 - s_2)^2 + (s_2 - s_3)^2 + (s_3 -$ where s_0 is the coupon min-y strength; s_1 is hoop stress; s_2 is lo tudinal stress ($s_1 = 2s_2$); and s radial stress (and in a thin-wall ch ber equals zero).

What all this means is this: If take a material with a maximum n

Steels Researched for Solid Cases

Here are various steel alloys now being researched as best candidates for use as solid rocket r case materials. Note the generally low carbon content of most of them; and the often-high silicon tent—both representing approaches to low notch sensitivity.

Alloy and Stainless

	C	Mn	Si	Cr	Ni	Mo	W	Co	Al	Cu	V	Cb	Ti	N	P
Vascojet 1000	.40			5.0		1.30					.50				
Lapelloy	.30	1.05	.30	11.5	.25	2.75					.25				
12 MoV	.25	.50	.50	12.0	.70	1.0					.30				
422 MOD.	.27	.85	.25	12.0	.20	2.25	1.75				.50				
301	.15*	2.0*	1.0*	17.0	7.0										
201	.15*	6.5	1.0*	17.0	4.5									.25	
Tenelon	.10*	14.5		17.0										.40	
TRC	.08	16.0	1.0*	16.0	1.0									.20	
16-1-17	.12	17.0		16.0	1.0									.15	
2021	.10	15.0	.62	16.0	1.0						.23				
Am 355	.12	.95		15.5	4.5	2.75								.10	
Ph 15-7 Mo	09*	1.0*	1.0*	15.0	7.25	2.50			1.15						
AFD 183	.35	18.0	.60*	12.5		3.0					.80			.20	
Stainless W	.10*	1.0*	1.5*	17.0	7.0				.50*				1.50*		
Armco 1	.07	.60	.48	11.0	7.0	5.5			1.15	.75					
Armco 2	.07	.60	.40	15.0	6.0	2.5			1.15	3.0					
Armco 3	.05	.40	.40	13.0	4.0		3.0			3.5					
HNM	.30	3.5		18.5	9.5										.23
HTX	.45	8.5		21.0	8.5	1.50									.23

*Max.

Carbon and Low Alloy

	C	Mn	Si	Cr	Ni	Mo	V	
AISI 1055	.55	.60-.90						
AISI 4130	.30	.40-.60	.20-.3S	.80-1.10		.15-.25		
AISI 4135	.35	.70-.90	.20-.35	.80-1.10		.18-.25		
AISI 4340	.40	.60-.80	.20-.35	.70- .90	1.65-2.00	.20-.30		
AMS 6434	.3S			.80	1.80	.35	.20	
Air Steel X-200	.40		1.5	2.0		.50	.03 Min.	
MBMC *1	.4S		1.5	1.0			.01 Min.	
Hy-Tuf	.25	1.30	1.5	.3S	1.80	.40		
UHS 260	.3S	1.25	1.5	1.25		.35	.20	
Tricent	.38	.80	1.5	.84	1.80	.35	.10	.1
17-22 AS	.30	.55		1.25		.50	.25	

ngth of 200,000 psi (of which there several), fabricate it into a motor , and then heat-treat it to a maxi- n notch coupon min-yield strength),000 psi), you will have a 230,000 -yield motor case (1.15 times 200,-). This comes from substituting 200,- for s_0 in the above formula and ing for s_1.

• **Choice is steel**—In choosing ma- ls to meet high-strength motor requirements, with certain specific- ication exceptions, the big choice teel—any one of over two dozen ys (see accompanying tables). Of e maybe half a dozen have usable h strengths in excess of 200,000 None has been proven to exceed 000 psi.

Aluminum for the most part hasn't considered for large diameter rocket motor cases because of its ively low modulus. However, on trength-to-weight ratio basis it's ost an even-Steven competitor with . And Alcoa's new X-2020 alloy bits very favorable strength prop- ts at elevated temperatures. With fabrication techniques being pro- d, aluminum may yet get in the ing.

Titanium apparently is way out of field, not only due to the diffi- y in fabricating it, but also be- e it is very inconsistent in its re- se to heat-treatment. And, at the ngth levels being considered, all als must be heat-treated.

Two of the most promising alloys being tested in solid rocket motor s are X-200, a low carbon air- ening steel, and MBMC 1. Both U.S. Steel developments, and give minary promise of much improved h sensitive characteristics, i.e., high h strengths.

One thing to watch out for: make ain heat-treat temperature exceeds designed environmental operating perature of the motor case. This ns, almost without exception, heat- ing to a hardness of under $R_c=50$, desirable in obtaining high notch ngths.

Efforts to eliminate flaws, and thus around notch sensitivity by ending with no notches, concentrate pri- ily around fabrication techniques. erally speaking, the more a ma- l is worked, as in rolling or spin- , the more flaws tend to be worked It's rather like getting large air bles out of bread dough by knead- it. If the metal is worked enough, cusions and inclusions, local brittle s and other discontinuities can be ded out and made homogeneous the parent metal.

• **Success in spinning**—This is the n reason such marked successes e recently been achieved by spin-

Rate of Change

This table shows typical rate of change of the notch tensile to smooth tensile strength with increased strength in the smooth coupon test sample. X-200, 300-M and UHS-280 are three typical steels being tested now for use in solid rocket motor. cases.

Yield Strength —psi @ 0.2%	Sharp Notch to Tensile strength ratio	Test grain Direction	Tempering Temperature
X—200			
180,000	0.95	L & T	1175°
210,000	0.81	L & T	1075°
225,000	0.43	L & T	975°
240,000	0.31	L & T	830°
300—M			
180,000	1.00	L	1160°
210,000	0.41	L & T	850°
225,000	0.47	L & T	775°
240,000	0.49	L & T	700°
240,000	0.40	L & T	500°
UHS—280			
180,000	0.89	L & T	1100°
210,000	0.41	L & T	650°
225,000	0.39	L & T	650°
240,000	0.36	L & T	500°

ning motor cases. Typical procedure here is to start with a forged (and perhaps machined) blank whose inside diameter equals that of the finished case, whose length is half and whose wall thickness is twice that of the finished product. Then, in one-to-three passes with spinning equipment (Hydrospin, Hydroform, Flo-Turn, etc.), the metal is literally pushed into the desired configuration. Though greatest success so far has been achieved with cold spinning, impressive results have recently been reported by at least one contractor with hot spinning—where the blank is heated before each pass.

Spinning used in combination with other fabrication techniques (which unfortunately cannot be detailed at this time) has produced the best results. One Navy (*Polaris*) engineer is convinced the best cases for both *Polaris* and *Minuteman* will be spun.

The old, well established technique of either cold or hot working welds goes a long way towards minimizing the notch effects of under-bead cracks and normal cracks in welding.

Care should be taken to determine the cracking tendency of the material being welded (whether under-bead or normal), in order to align the crack direction normal to the longitudinal (lowest) stress vector and design the case (or pick materials) accordingly.

Insofar as notch sensitivity is concerned, a notch is any discontinuity in the body of the material or in its contour. For this reason, it is almost mandatory in welded cases that the weld bead be ground flush with the rest of the case.

Sharp corners in design should be avoided wherever possible. Anything that tends to produce a bending moment when the case is pressurized is dangerous. This includes ovality in the unpressurized case, which wants to "bend" into the round configuration under pressure, or a dent. The latter can cause local stresses double those in the undented case.

In some instances the material supplier tries to take the notches out before it ever gets to the fabricator. One approach to this is U.S. Steel's sandwich rolled sheet where several layers of plate are rolled as a laminate. Advantages claimed for this technique are: cross rolling; reduction in directional differentiation of grain structure; minimization of inclusions in any direction; high surface density; freedom from normal surface flaws; better decarburization control; closer tolerance control (thickness held to 0.0205" to 0.0215" in 130" wide sheet). Burst tests with small welded cylinders are being conducted now.

Controlled decarburization has, itself, been suggested as a means of minimizing notch sensitivity—particularly due to surface flaws and scratches. Theory here is that more ductile surface makes it easier for stress relieving plastic deformation to take place.

• **Here are "buts"**—One final word of caution: minimize hydrotesting. If there is any tendency towards notch failure—crack propagation—hydrotesting will intensify it. Ideally, it would be best to inspect all flaws out of a motor case and thus make even one hydrotest cycle unnecessary.

But this not being possible, the compromise generally being adopted is three static tests of three minutes each. Value of a dynamic (surge) test is seriously questioned, since materials at the strength levels being considered generally are not strain-rate-sensitive.

Obviously, a lot more is being done to eliminate or get around notch sensitivity. But basically all specific approaches fall within the general parameters outlined above. Little has been said about strip (spiral) wrapping with very thin (0.015" thick), high-strength (300,000-to-500,000 psi ultimate) strips, since serious problems remain in attaching forward and aft closures, and current organic bonding techniques make spiral wrap cases subject to strength failure under aerodynamic heating.

Drag Brake Proposed for M-I-S

Avco says ICBM research and aero-medical progress have made possible design with advantages of simplicity along with lightweight and reduced production expense

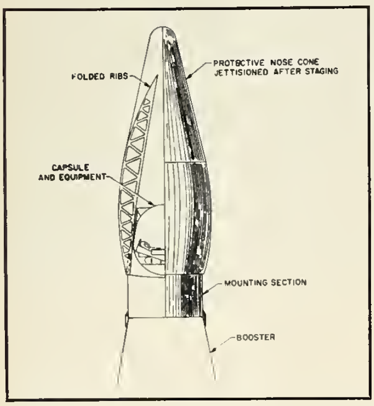


FIG. 2—Drag brake satellite vehicle mounted on *Atlas* booster for launching.

EVERETT, MASS.—Details of a manned satellite design based on a drag brake—rather than retro-rockets as planned under NASA's Project *Mercury*—have been revealed by Avco's Everett Research Laboratory.

Under Avco's system, which has been under research for three years, the drag brake would perform all functions now in a retrorocket system: orientation of vehicle, retrorocket with autopilot, heat shield, and a sequence of decelerating parachutes.

In announcing the system, Avco scientists pointed out that manned satellite designs which have been discussed publicly are adaptations of airplane or nose cone technology, and that the re-entry heating problem and the deceleration which must be faced by a human passenger have domina most manned satellite discussion.

However, Avco said that prog made during the ICBM program allowed the company to design a hicle without over-emphasizing re-en heating considerations. Furthermore added, progress in aero-medical search makes it clear that the 8 g celerations which must be faced i tangential constant drag re-entry not a serious problem either, should not dominate the design.

While the retro-rocket design proach to Project *Mercury* was cited in research details furnished Avco, retro-rocket systems were u as a comparison.

• **Advantages**—In summarizing advantages of the drag brake sate recovery system and its space fl potential, Avco said its "multipli of functions" leads "to several adv tages over other recovery syst which all require separate subsyst to perform each function."

These advantages were cited:

1. The system—when operatio—will, because of its simplicity, sl a greater reliability because the ability of any system can be only large as the product of the reliabil of all its subsystems.

2. Since there is only one m component, the development will quire less time and will be less co than the development of the sev subsystems of other satellite reco systems.

3. The operational aspects of orbital flight with a drag vehicle be far less complicated. Avco po out that a retro-rocket system requi a device which maintains accurate entation of the vehicle; a retro-ro plus its auto-pilot; a heat shield w may or may not need to be jettiso and a final landing system consis of a sequence of parachutes which

FIG. 1—Model of Avco drag brake. Mechanical engineering and structural design by All American Engineering Co. in cooperation with the Avco-Everett Research Laboratory.

ving the vehicle down at about)00 ft.

4. Control aspects of a drag brake cle will not require accurate wledge of the orbit, and the tracking requirements are much reduced n those of a retro-rocket system.

5. The drag brake has inherent useess in the circularization of highly tic orbits, and

6. The vehicle will have a distinct ght advantage over other re-entry cles. Avco said the weight required a drag brake vehicle to recover a n payload is less than half that ired by a retro-rocket system, and use of a good ablating heat shield the retro-rocket design would ree the drag brake vehicle weight intage by 100 to 200 lbs.

• **Details**—Here are design details urnished by Avco:

The manned satellite design is built nd a stainless steel drag brake (Fig.)pening and closing the structure rbit results in a 20:1 drag varia- This variation causes a correding change in the rate of descent rbital lifetime.

Controlled variation of the drag rding to a preset program will nit landing at a pre-selected point an accuracy of ± 150 nautical s. The extended structure has a low ing, 1½ #/ft², and consequently vehicle decelerates high in the atphere, radiating the heat away at peratures which never exceed ent gas turbine practice.

The drag brake also yields a terl velocity low enough so that no tional parachutes are required for ing at ground level.

During launch the drag brake satels mounted on the booster in the d position (Fig. 2). The man lies e recommended supine position on ntoured couch inside the capsule. flexible drag brake covering mal is folded inside the ring of ribs. tractor type escape system is nted at the forward end of the The drag brake is covered by a ctive nose cover. At staging, when vehicle is essentially out of the e part of the atmosphere, the nose r and escape system are jettisoned.

• **105-mile orbit**—The booster ve- accelerates the satellite until the er velocity vector has been ved. At this point the satellite booster are separated and the drag e vehicle starts its journey in space.

The satellite would be launched a 105-n. mile near-circular orbit, ing a lifetime of two days in the drag or closed position of the brake—and permitting emergency very in two hours.

Avco pointed out that emergency very times of less than the orbital period "do not make sense" because recovery must be effected at a specific point in every orbit in order to minimize the vast problem of location after landing.

At 105 n. miles, the small but distinct amount of residual atmosphere will exert forces on the vehicle. Because of the large extended structure, even in the closed position these forces are sufficient to exert the necessary movements to orient the vehicle into the air stream, Avco said. The period of this motion at 105 n. miles altitude is several minutes.

For a drag brake satellite, re-entry is made up of a number of distinct phases. First, the satellite descends from the orbital altitude to the region from which a controlled re-entry is made.

Next, the drag is controlled accord-

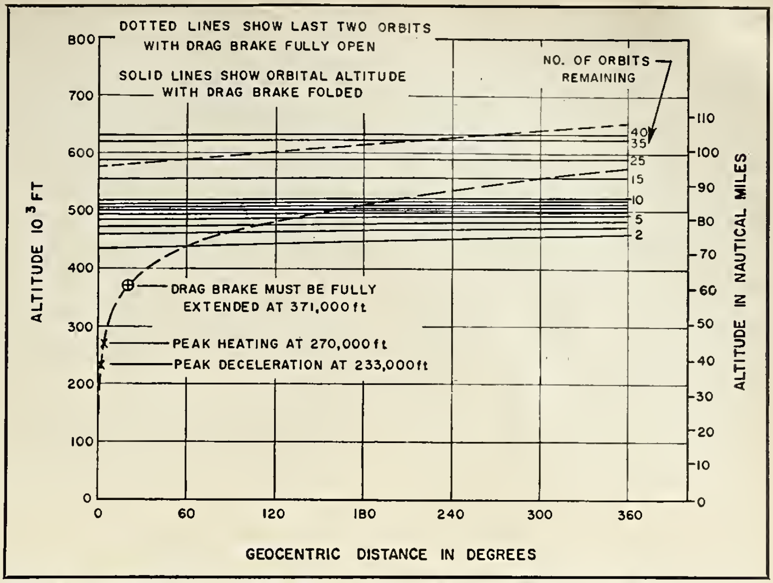
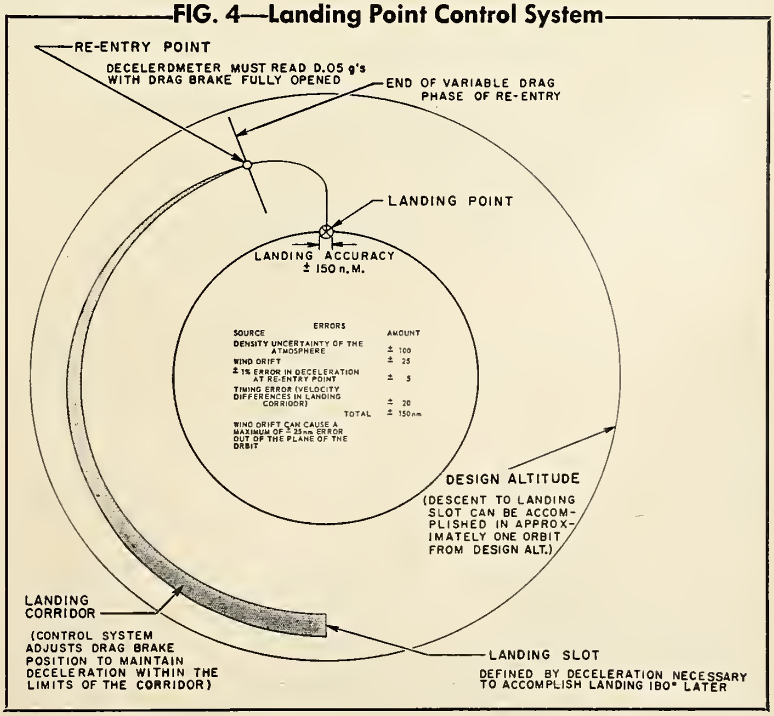


FIG. 3.—Landing point control by drag variation. The difference in descent rate or orbit decay is shown for a 20:1 drag variation from W/C_DA ± 1.5 to 30.

FIG. 4—Landing Point Control System



ing to a preset program for about ½ orbit in order to achieve a given velocity vector at a particular point. Finally, the drag brake is fixed in the open position at the onset of serious heating and the vehicle passes through the heating and deceleration peaks and achieves terminal velocity at about 200,000 ft. From here down the vehicle drifts at terminal velocity and lands at 50 ft./sec. at sea level.

The principal of operation of the variable drag landing point control is shown in Fig. 3. Concept is that the descent rate or lifetime of decaying satellite orbits can be changed significantly by changes in the vehicle ballistic parameter, W/C_DA.

For instance, from an altitude of about 90 n. miles one can re-enter in as many as 15 orbits or in less than one orbit, depending on the drag brake position, i.e., ballistic parameter, W/C_DA.

In fact, Avco said, in the geometric mean drag brake position, and only 3000 n. miles from the landing point, the landing point can be altered by approximately plus 2000 and minus 1500 n. miles.

• **Control philosophy**—A detailed control system philosophy which operates on the above-stated principle has been developed. The system depends on two simple measurements: time and acceleration. The time serves to locate the vehicle with respect to the landing point.

As long as the satellite is still in a nearly circular orbit, the orbital period is essentially invariant with the small ellipticities due to drag and drag variations. Thus the timing from either th insertion point or from a later fix lo cates the satellite accurately. This rela tionship holds until the onset of larg deceleration forces. Thus ideal or nom inal drag variation with time can b established for the controlled dra phase of re-entry.

A body-mounted acceleromete measures this drag and compares it t the measured drag and to the nomina value desired. The control system ca thus sense whether the drag is correct too high, or too low, and can produc signals which vary the drag brake posi tion so as to eliminate the differenc between the nominal and measure values. Avco said this system does n require accurate information about th orbit and therefore tracking require ments are simplified.

According to Avco, the system i capable of correcting the effect of elli ticity, altitude error at the start of th controlled phase, errors in the know edge of the upper atmosphere an density variations of either the latitud or diurnal type.

The result of an error analysis fix a density range from which the contr system can achieve a landing poi accuracy of plus or minus 150 miles in the orbital plane. This indicated by the "landing slot" show in Fig. 4. During the controlled pha the satellite flies within the "landi corridor," correcting the drag bra position in accordance with the contr system dictates, until it achieves t proper velocity vector at the re-ent point.

• **500°F temperature**—From th re-entry point to final touchdown further functions are required, Av said. The nose of the capsule will he up to a temperature of about 500° when the vehicle is only 1000 n. mil from the final landing point. Up to th point the linear relationship betwe distance and time will have been acc rate to 20 n. miles. At the low dr parameter, W/C_DA, of 1.5 peak hea ing occurs at a very high altitude a consequently the heat transfer ra and the radiative equilibrium tempe tures will be relatively low.

The maxium temperature encou tered by the structure at the capsu nose surface will be less than 1500° assuming an emissivity of 0.85. T drag brake surface, which can radia from both the front and rear surfac should not exceed an equilibrium te perature of 1200°F.

At peak heating, at 270,000 ft. al tude, the deceleration will be abo four g. After peak heating the decele tion will continue to increase a should reach 8.2 g at 233,000 ft. T time above eight g will be aproximat 20 seconds and should be well with

FIG. 5—Drag Brake Re-entry Conditions

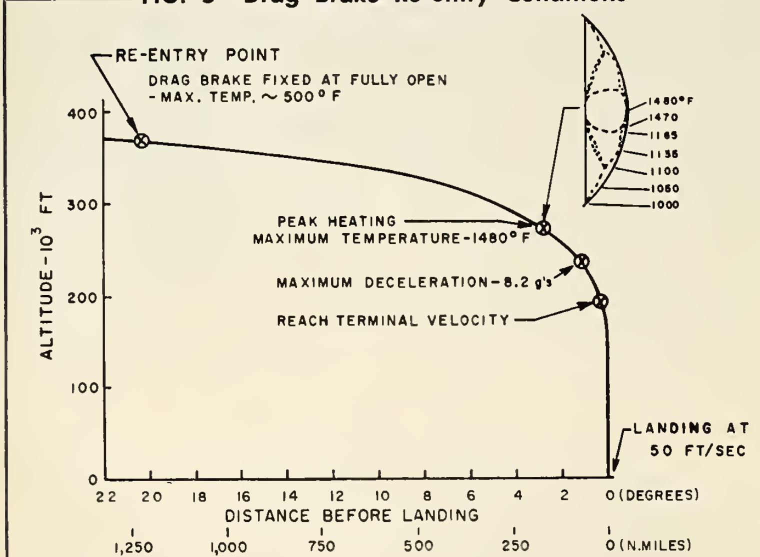
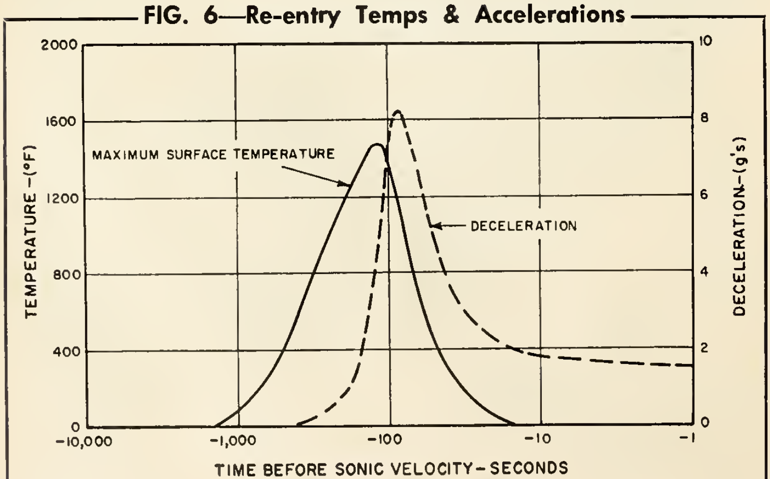


FIG. 6—Re-entry Temps & Accelerations



established limits of human en- rance. At peak deceleration the max- im temperature will have decreased 1130°F (Figs. 5 and 6).

Avco said the relative time of oc- rence of the peaks of heating and eleration points out an interesting sibility for future drag brake ve- les. If at the instant of peak heating ., 4 g) the acceleration is held con- nt by retracting the drag brake htly, then the peak re-entry g can reduced to four—without any in- ase in maximum temperature. The k heating condition would merely held for a somewhat longer time, ich does not penalize a radiating entry vehicle structure.

The drag brake will continue to elerate and will approach terminal ocity just under 200,000 ft. The ter- nal velocity will decrease with in- asing air density until at sea level vehicle will land at 50 ft./sec. Dur- the terminal descent, which takes roximately 15 minutes, the large tallic surface should be an excellent ar target for tracking and locating vehicle at the landing.

• **Mechanical details**—The mechani- problems of building a drag brake ellite system have been faced in ne detail. The device consists of four ic components, i.e., the ribs, the ering material, the actuating mech- sm and the capsule. Of these the s represent over 50% of the total ght of the drag brake.

The total weight of the ribs could reduced by decreasing their number, co said. However, the consequent arture from a true spherical surface to the scalloping effect of the cov- ng between the ribs would increase heat transfer on the ribs. The ribs .020" stainless steel beams with nforcing cap strips. Buckling due to npression of the cap strip is the st critical design condition.

The covering material should be as nt as possible, Avco points out. inless steel cloth made of .001 wire ven into a close, 400 x 400, mesh commercially available, and this ma- al meets all the requirements except t it is somewhat porous. Even a all amount of porosity increases the t transfer on the drag brake signifi- tly due to the removal of the cool ndary layer air blanketing the sur- ing.

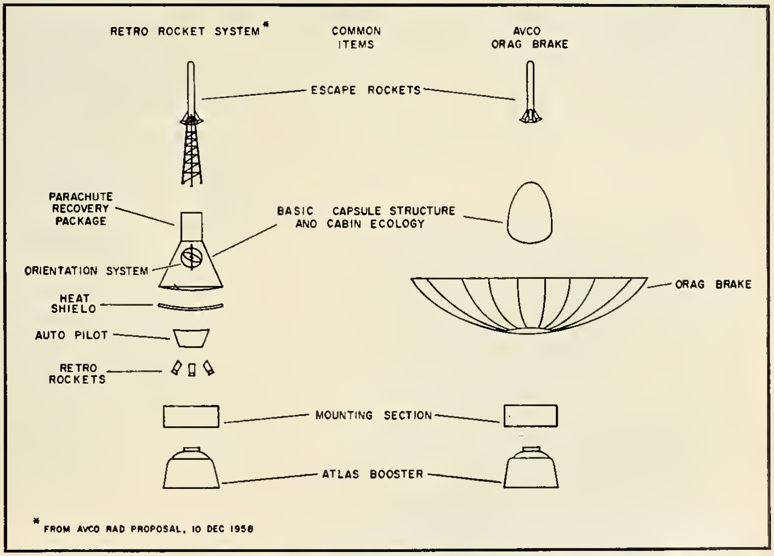
Several methods of reducing the ectionable porosity are under con- eration. It is presently possible to ld up a drag brake skin out of a er of the above cloth, a layer of thin 005 inch) solid sheet but cut into cumferentially aligned ribbons or ngles, and another layer of cloth of oarser mesh.

The shingles will eliminate the porosity, yet are flexible enough to satisfy the folding requirements. The two layers of cloth maintain the shingles in place and prevent tearing. The air loads can actually be transmitted to the ribs by any one of the three layers alone.

• **Actuation choices**—The actuating system and capsule do not represent serious design problems, Avco said. It is mostly a question of arriving at the lightest and simplest structure for each. Actuation can be either pneumatic, electric or mechanical. A two-way pneumatic system is proposed.

• **Would-be sphere**—The optimum pressure vessel, i.e., a sphere, is very nearly a compatible shape for the drag brake vehicle. Only a slight conical section need be interposed between the spherical top and bottom halves. The conical section is extended both up and down to form the hinge points for the drag brake. This capsule weighs only a few percent more than an equivalent spherical vessel.

Avco said that in this design the configuration was dictated by the orbital, re-entry and escape conditions, rather than by the sea level landing speed. The resultant landing velocity of 50 ft./sec. is somewhat higher than has been proposed in other satellite designs. However, Avco believes that the decelerations on the passenger can be kept at a level equivalent to a 30 ft./sec. landing by a shock-absorbing structure similar to aircraft arresting gear. This can be accomplished, Avco said, at the cost of far less weight than would be needed to reduce the landing velocity by geometrical changes or by adding recovery parachutes.



FUNCTIONAL comparison of the Avco drag brake and a typical retro-rocket system. Company says brake's "multiplicity of functions" gives it "several advantages."

Weight Comparison of Systems

Retro Rocket System		Avco Drag Brake	
1. ADDED STRUCTURE	133 lbs.	1. 0	
2. BERYLLIUM HEAT SHIELD	398	2. 0	
3. AUTOMATIC ORIENTATION SYSTEMS	137	3. LOW TORQUE SYSTEM	25.5
POWER	66		
4. RETRO ROCKET	207	4. 0	
5. RECOVERY SYSTEMS	165	5. 0	
6. 0		6. DRAG BRAKE	425
7. 0		7. SECOND STAGE ESCAPE	50
	1106 lbs.		500 lbs.
LAUNCH WT.	2902 lbs.		2297 lbs.
ORBITAL WT.	2207		1527
RE-ENTRY WT.	1914		1399

Common Items for Both Systems

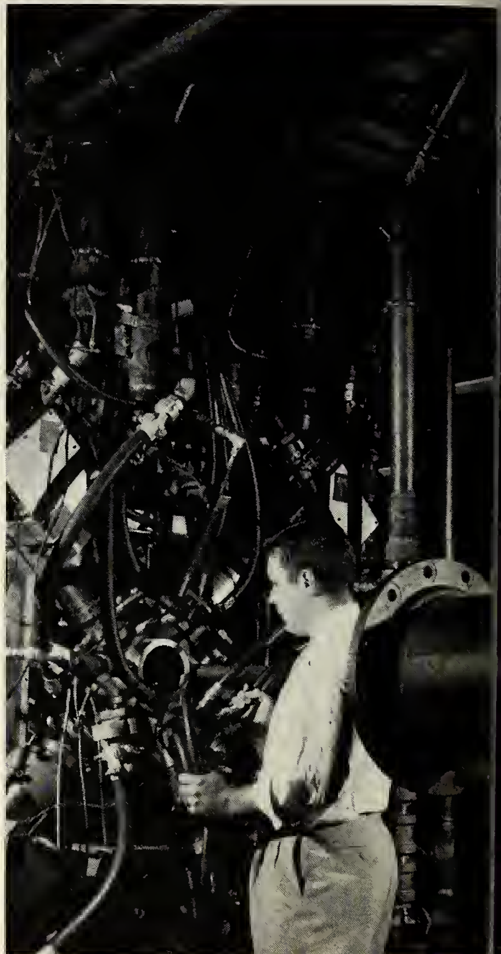
BASIC STRUCTURE	167 lbs.	PILOT SUPPORT	46	INSTRUMENTS	15.
INHABITABLE CAPSULE	133	COCKPIT	17.	RECORDING EQUIP.	24
ESCAPE SYSTEM	695	NAVIGATION AIDS	41.	POWER SUPPLY	157
ENVIRONMENTAL EQUIP.	70	COMMUNICATIONS EQUIP.	212.0	PROGRAMMER	9
				MAN AND SUIT	210
					1796 lbs.

Re-entry Stresses Simulated in Lab

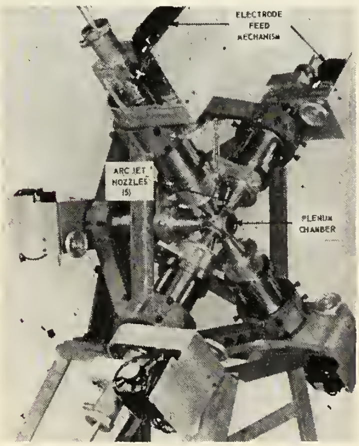
EVERETT, MASS.—A 10-megawatt high-pressure arc plasma generator which realistically duplicates the pressures and temperatures met by ICBM nose cones and satellites on re-entering the atmosphere has been developed by Avco's Everett Research Laboratory.

The unit uses five arcs instead of the usual one to generate this tremendous power. Each of the five nozzles is separately powered and water-cooled. The giant generator itself is powered by 2000 12-volt truck batteries.

The facility was developed by Avco as part of its research and development program on ICBM nose cones. Models are subjected to the high-velocity, 15,000-degree plasma jet to evaluate the performance of ablating materials and heat sinks under re-entry conditions.



AVCO technician prepares the arc wind tunnel for firing. Confusion of pipes, tubes and cables supplies the device with water, air and power.



JET NOZZLE assembly. Each of the five jets, powered by arcs from water-cooled graphite cathodes, discharges hot plasma into central copper plenum chamber.

TEN MEGAWATT arc jet in operation. The jet, containing five to six million watts of energy, issues through supersonic nozzle.

NASA Space Lab Plans Outlined

ARS meeting also hears debate on the long-term value of Project Mercury 'holding facility' and reports on ramjet, ion engine and APU developments

by Frank G. McGuire

San Diego—Planned as a "sounding board" for practicable ideas rather than a mere exchange of technical information, the American Rocket Society's 1959 semiannual meeting, June 8-12, provided an extremely well-managed forum for all types of astronautical ideas and problems.

The meeting, marked by attendance of some 2000 members and presentation of 115 papers, covered such broad topics as the economic impact of space technology, politics in the Space Age and the influence of astronautics on contemporary thought. But it also fulfilled its original role as clearinghouse for treatment of more technical subjects.

Scattered throughout the activities were such names as Whipple, Stuhlinger, Medaris, Yates, Douglas (Donald, Jr.) Stapp, Kaplan, Dempsey, Ehricke, Urey, Silverstein—almost all of whom presented papers.

A keynote was the solid reality characteristic of most papers. There was little "wild, wild blue yonder" speculation on imaginary or insignificant academic problems. Instead, there was a down-to-earth approach keyed to actual operational requirements, logistics, and costs. One of the first sessions, that on Logistics and Operations, was aimed at making R&D personnel aware of logistical and operational problems involved in space vehicles and weapon systems.

• **Balance demanded**—Most papers presented at this session were highly critical of our pouring millions of dollars into missile performance, while spending only a fraction of that amount in appropriate instrumentation. "Supporting facilities, such as are provided by our range and its instrumentation, are too often taken for granted," according to Maj. Gen. Donald N. Yates, commander, AFMTC, Patrick AFB, who added: "We have been driven into a frantic race with missile performance in our job to provide instrumentation of commensurate performance."

Other speakers echoed the general's remarks and pressed for a more balanced program, rather than one stressing only the "bird" itself. "We are now at the bottom of the barrel . . . in instrumentation development," Yates said. He declared that instrumentation has become the bottleneck of a development program, as far as time is concerned.

• **Solid-state future**—The electronics segment of astronautical engineering was warned that it, too, is approaching the "point of diminishing returns" in one phase of its field—component microminiaturization. "Fortunately," said Donal B. Duncan of Autonetics, "there is an extensive research effort which . . . can replace, not existing components, but existing circuits," with solid-state circuits.

These units, packaged as one, replace present devices in which components are packaged individually, then connected by wiring or printed circuitry. Duncan predicted an accelerated development of these solid-state circuits, bringing a major technological breakthrough within a few years.

The time will come, he predicted, when a small digital computer, now requiring decision, memory, and other circuits, will consist of a single block of material incorporating all these elements.

"The material might consist of a single thin crystal of a semiconductor with dimensions on the order of inches, which is modified by depositing on the surface various elements to change the lattice structure of the semiconduct or to modify in other ways the surfa characteristics. It is possible that t deposit of these various thin filn can be made by some automatic pr cess and that the time to modify th crystal so that it is a complete dig tal computer can become a matter minutes," Duncan said.

• **Space observatory**—The propos launching of a 2500-pound orbiti space observatory by NASA came for some attention. The platfor mounting six telescopes up to 36 inch would be placed in a 500-mile orbit a two-stage configuration of *Vega* not less than two years. The prelimi ary planning stages of the progra have been funded, and several int mediate steps are in the works, su as orbiting a solar observatory satell of several hundred pounds at abo 300 miles.

The unmanned platform will designed to aiming accuracies of o second of arc, relying on a flywh system instead of control jets. T high accuracy would drop if men we put aboard—even the heartbeat of crew member could conceivably distu it. "Actually," commented Dr. Fr Whipple, "we're not even aware what disturbing influences on the pl form might be introduced by the blo flow of a crew member."

Objectives of the orbiting obser tory are several: to make a compl map of the sky; locate "cold" st presently not visible; and locate p sible planets in "nearby" space (wit 10 light years).

Aiming of the platform would by radio control from earth. The f wheels would be set in motion in desired direction at the proper tin then stopped at the correct point. destruct system would quite likely ıilt into the platform, or at least its dio, to eliminate it from the com- unications spectrum and to prevent ; becoming a hazard to future navi- ıtion.

The six telescopes would all point the same direction, but use different ters. This would eliminate the need ır a mechanical filter-changing sys- m which might cause reliability prob- ms if just one telescope were used. fe of the platform was estimated, pre- ming realization of plans, at over 00 years.

• **"Holding facility"**—A not-previ- ısly-publicized facet of the Project *ercury* program was brought out at e meeting in several technical papers. nis was the "holding facility" concept volving pre-launch and post-launch olation of astronauts for training, ealth and psychological preparation ıd debriefing.

The holding facility is defined as "training and medical maintenance nter" for the space crewman. To its job—completely preparing the tronaut for his mission—the facility eally would be located close to the ınch site; provide quarters for all sup- ırt personnel; and be equipped to odify life support gear, simulate near- ace conditions, and carry out final reening and selection.

The holding facilities would give omedical personnel maximum oppor- nity to control and observe the as- onauts' environment and behavior be- re and after a mission.

It was estimated that for four to weeks prior to launch the astronaut ould be isolated from his family and ıdergo an intensive training period in nulators, centrifuges, and other de- ces. The holding facility now being ınned for the *Mercury* program at ıpe Canaveral will be able to simu- le every parameter of the mission cept weightlessness.

Biomedical experts at the meeting ld varying opinions of the holding cility. Some felt that the four to 12- eek period was absolutely mandatory. hers, including Toby Freedman of AA, felt that the holding facility with s isolation concept would be fine for one-shot mission, but that if the aim continuing space flight for long pe- ıds of time, it should be made as n-special" as possible, while still aintaining the requirements necessary r successful completion of the mis- on. The amount of special treatment r astronauts was the main point of ntention.

• **Lamps for wives?**—Freedman's per conceded that it is worth every ort to keep the astronaut free from ease. But he questioned the wisdom an absolute quarantine. ("In short, ould our space pilot sleep with his ultraviolet lamp on his wife?")

"On the other hand," maintained Lt. Bruce W. Pinc of AF Ballistic Missile Division, "We can't have this highly-trained man abort a mission simply because he has a middle-ear block from a cold which he picked up from his wife six days ago and didn't detect until the morning of launch."

• **Propulsion**—In the realm of propulsion, the meeting heard a profusion of highly-technical papers on all types of systems and problems.

Ramjet engines were viewed as an excellent answer to hypersonic flight, even though many obstacles must be overcome in their development. Better ramjet performance was predicted as Mach numbers go up.

The principal problem, that of temperature, was graphically stated when Richard J. Weber of NASA pointed out that the stagnation temperature at Mach 8 is 4500°F, or nearly half the surface temperature of the sun. Neither stainless steel nor such other currently available materials as molybdenum or ceramics can retain adequate strength at such temperatures.

Design techniques can, however, limit the structural temperatures to values that can be withstood by currently-available materials. Both regeneratively cooled ramjets and thermal-radiating ramjets have been considered for the dissipation of heat. The difficulty with the former is the larger amount of surface that must be regeneratively cooled, and the principal problem with the latter system is design of engine components, nacelles, etc.

The solid-propellant ducted rocket, basically a solid-propellant gas generator exhausting a fuel-rich gas into the combustion chamber of a ramjet, where it is further burned and exhausted, is also in search of heat-resistant materials. But it is considered profitably usable on a great many vehicles operating within the atmosphere.

The principal advantage would be the ability to achieve greater burning times than pure rockets, with low cost. In addition, high total impulse to gross weight makes the system attractive as a large ballistic missile booster. Also cited were its simplicity, reliability and high performance.

• **Ion outlook**—Tests of first-generation ion engines have shown that a number of engineering and scientific problems must be solved before these high-performance, low-thrust devices can be extensively used in space flight. According to Rocketdyne engineers, analysis has demonstrated that improvements in both the power-source-conversion and ion-source-accelerator systems must await development of scientific data not now available.

The accelerations produced by these first-generation ion engines will likely be less than 10^{-4} g, but they are advanced as useful engines for long missions, and some not-so-long missions. The coasting time of a chemical rocket to the nearest planet is about one year, and the low-thrust but lon[g] duration ion rocket could make t[he] trip in the same time.

However, a paper presented by e[n]gineers at Electro-Optical Systems Inc cited problems—electrode destructio[n] ionizing-surface poisoning, insulati[on] failure and loss of electrical power d[ue] to electron feedback—that must [be] solved before ion propulsion com[es] into its own.

Some of the difficulties encounter[ed] in ion propulsion have been circum[-] vented by extracting ions from the i[on] source at high voltage, then decelera[t]ing them to the desired lower voltag[e] according to ABMA scientists writi[ng] on the subject. This method wou[ld] avoid increasing weight, volume a[nd] complexity.

Materials problems were the prin[cipal] item of interest at most propulsi[on] discussions, mostly involving the te[m]perature and structure-strength cha[r]acteristics of currently available a[nd] newer materials now under develo[p]ment and study.

• **APU picture**—Auxiliary pow[er] systems for space vehicles were most[ly] considered as eventually evolving in[to] two types, solar and nuclear. Includ[ed] in a survey of feasible APU system[s] were: silicon photovoltic cells ("stan[d]ard power system in 10 W-500 [W] range"); solar thermo-electric ("pro[m]ising"); solar thermionic-diode ("ve[ry] promising"); solar fuel cell ("promis[ing] high efficiency, much development r[e]quired"), and solar turbo alternato[r] ("very attractive about 3 KW. Need [to] prove 6000-hour bearing life").

Nuclear power sources number[ed] four in the survey by JPL's Rob[ert] C. Hamilton: radioisotope therm[o-] electric or thermionic diode ("a[t]tractive in 10 W-100 W range. Mo[re] costly than solar power. Hazards."[)]; reactor thermo-electric ("promisi[ng] above 3 KW. Depends on materi[al] research"); reactor thermionic-dio[de] ("very promising. Cesium plasma r[e]search promising. Multiple staging [bet]ter"); reactor turbo-alternator ("ve[ry] attractive above 3 KW. Need to achie[ve] 6000-hour bearing life.")

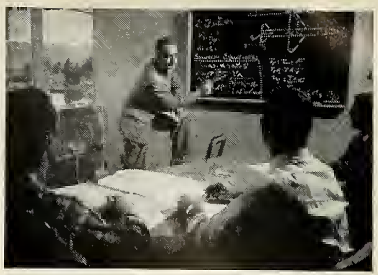
Other sessions of great interest i[n]cluded guidance systems, high-ener[gy] liquid rockets, high-performance p[ro]pellants and vehicle program repor[ts]. These, however, were classified.

Tours arranged for members [at]tending the meeting included visits [to] the *Polaris* underwater jury rig firi[ng] Convair-Astronautics, and a trip on [a] missile ship with firings at sea.

Almost 60 exhibitors set up boot[hs] at the meeting, and a glance at t[he] list showed a sizable majority of We[st]ern representation, but a relatively hi[gh] percentage of firms from the E[ast] Coast.

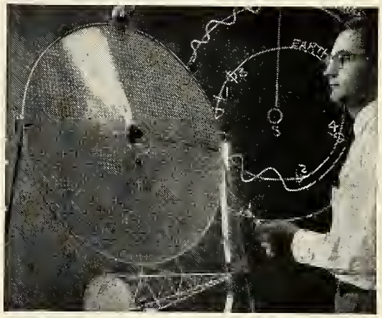
The Reliable *Mace*

USAF TM-76 Martin *Mace* is launched from "simulated shelter" in recent New Mexico test. The bird has been termed the "most reliable" and "least complex" in the U.S. inventory by Maj. Gen. Daniel W. Jenkins of the Air Force's Tactical Air Command.



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

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



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

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Prospects for Thermoelectricity

Heavy investment in research gives hope for long-lived power units for space application

by Hal Gettings

WASHINGTON—Widely hailed as the t evidence that practical power gen- tion could be achieved by thermo- ctricity, the SNAP III generator nonstrated before President Eisen- ver in January was indeed a signifi- t development. Developed under the C's SNAP (Systems for Nuclear xiliary Power) program, this first t offers hope that small electrical rces can operate in space for long iods with no maintenance or re- ling.

The need for such units is obvious. nsidered only in the light of mili- y application, thermoelectric genera- n fills many desirable requirements:

1) Units with greater efficiency n present powerplants for shipboard l base production of electrical power.

2) Units free from the noise of ving engine parts.

3) Small power units with high ciency and small maintenance re- rements.

4) Small power units for satellites l spacecraft capable of using nuclear rgy and solar radiation.

5) Power units adapted to use non- ventional sources of energy such nuclear energy, solar radiation, and te sources of all types.

• **Operating principles**—The basic nciple of the thermoelectric genera- is deceptively simple: if the junc- s of two dissimilar metals in a ed circuit are at different tempera- s, a current will be generated in circuit.

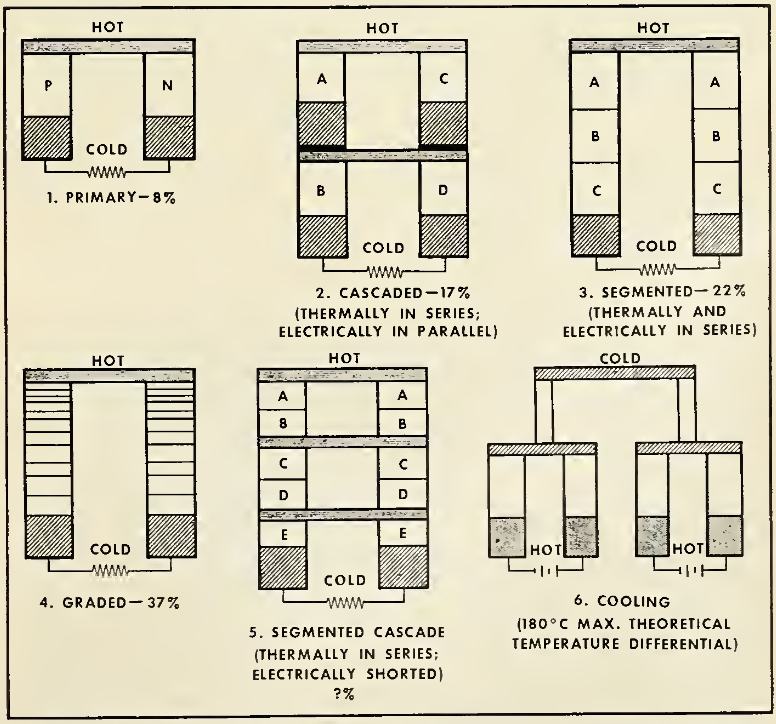
This principle was first stated by mas J. Seebeck, a German physi- , over 125 years ago. In 1834, Jean ier restated it in reverse: a current ugh the junction of two dissimilar als causes heat to be absorbed or n off. This is the "Peltier effect" he basis of electronic refrigeration.

Neither Seebeck nor Peltier really erstood what he had found, how- r, and except for Lord Kelvin's of by the principles of thermo- amic theory, nothing much was e for almost 100 years.

The diagram shows a basic thermoelectric circuit. To understand the principle even more clearly, one could imagine a box partially and uniformly filled with electrons. If one end of the box is heated and the other kept cool, the electrons at the warm end move around more and push toward the cold end. So long as new electrons are added (from the other member of the junction) and an electrical load draws off the excess that tends to pile up at the cold end, the current continues to flow. Heat is "pushing" the electricity. (By considering that the electrons carry some of this heat, a picture of Peltier heating and cooling can also be developed.)

• **Commercial application**—The Russians have been given much credit for their early application of the Seebeck principle. They developed a kerosene-powered generator for home radios, which received much publicity, and have also successfully applied Peltier cooling.

The first commercial application of thermoelectric power generation in this country was in the early 1950's and resulted from the experiments of Dr. S. Karrer, then director of research of the Baltimore Gas and Electric Co. Dr.



BASIC CONFIGURATIONS of thermoelectric generators. First three types in working and experimental stages. Graded (Type 4) requires development of technique to produce semimetal with linearally varying amount of impurities (from .0001 to .01%, for example) throughout length of material. Relative maximum efficiency figures based on given temperature differential.

Karrer later organized a research department at Baso Inc. and this group developed a doped lead-telluride junction that was capable of generating 10 times more power than the bimetal thermocouples. This binary compound exhibited the high thermoelectric power, low electrical resistivity, and low thermal conductivity requisite for an efficient conversion.

This device was successfully incorporated in heat-powered control valves for gas heating systems. Power generated by the thermocouple in the gas pilot flame electrically held open the main gas valve and provided fail-safe operation. (If the pilot went out the main valve closed and would not answer thermostat control.) The Baso valve is used today in practically every gas furnace and hot water heater.

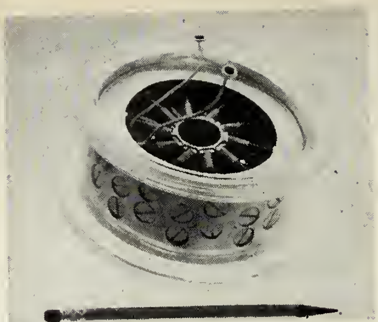
The Baso research team, under Dr. R. W. Fritts, later moved to Minnesota Mining and Manufacturing Co. Here they applied the same basic device to the SNAP III generator; except now they used the natural decay heat of radioisotopes as a heat source instead of a gas flame.

When Martin, the prime contractor, ordered the thermoelectric generator for SNAP III from 3M—on a purchase order; not a research and development contract—it was practically an off-the-shelf item based on the previous eight years of development. Every issued or pending patent pertaining to the design and construction of the thermopile is today in the name of 3M.

Many companies—at last count, 837—are presently involved in thermoelectric research. All work for the armed forces is coordinated by the Navy's Bureau of Ships, a strangely reticent group which apparently makes a concerted effort to keep its name out of the public press. Whether BuShips is merely modest or is intent on developing their own in-house capability is not known. They have, however, a large and responsible part in thermoelectric progress and certainly deserve considerable credit for their work. They oversee today some $3 million in research and development contracts. Budget for FY 1960 is reported to be around $6 million with increasing amounts in following years.

• **Nuclear power application**—The SNAP III unit—two of which have been built—uses 1700 curies (0.38 gram) of polonium-210 to deliver 3.3 watts of electricity. The four-pound unit has an efficiency figure of 5.5% and can deliver about 10 kilowatt-hours over a period of 280 days.

Although this efficiency figure was considered fantastically high a short time ago, efficiencies of 18% are now reported possible within the present state of the art. Unless available money



MODEL OF the SNAP III device, the heart of which is a thermoelectric generator designed and built for the Atomic Energy Commission by the Minnesota Mining & Manufacturing Company.

is wisely used in development, however, it may be several years before a working application with this efficiency is realized. According to Dr. Clarence Zener of Westinghouse, figures as high as 35% may be attained in the foreseeable future. Only two years ago no one had exceeded 1%.

• **Materials development**—Although the doped lead-telluride thermocouple was developed many years ago and has proved itself capable of efficient application, a large percentage of BuShips research and development money is going into materials research. The number of possible binary (and ternary) semi-metal combinations is practically unlimited, and a program to investigate every combination could assume fantastic proportions. Present methods require about a week per sample to merely screen each material. Thorough evaluation, which must come later, will require many weeks for each sample.

Presently, money is allocated roughly on the following basis:

Materials, 50%; devices, 40%; generators and radiators, 7%; servo controls, 2%; and services, 1%.

The attention given thermoelectric materials is, of course, demanded by their importance. Other aspects of the problems must also be considered, however, in designing a workable system.

Since the possible compounds that might be explored are almost limitless, there is a pressing need for criteria to predict the more promising materials.

In evaluating a thermoelectric material, three properties are of particular concern: Seebeck coefficient, electrical resistivity, and thermal conductivity. The relative importance of these properties varies with the application.

Of the various parameters involved in materials evaluation, thermal conductivity gets the most attention since it is least susceptible to modification. For this reason it serves as a valid basis for screening in a materials survey. A major problem here, however, i: that measurements of thermal conductivity are extremely difficult to make

The basic properties have been expressed in a relationship to provide : "figure of merit" (Z) for use as : yardstick in preliminary evaluation:

$$Z = \frac{S^2 p}{K}$$

S = Seebeck coefficient
p = specific electrical conductivity
K = specific thermal conductivity

The figure of merit thus provides basis for relative comparisons of th materials under study. To the presen a figure slightly in excess of $2.5 \times 10^{-}$ per degree Centigrade is the best th: has been obtained for a single materi: in commercial quantities.

Some of the best representative ma terial combinations developed to dat and their figures of merit, are bismutl telluride (2.8×10^{-3}), lead tellunc (1.8×10^{-3}), and germanium-telluric (1.1×10^{-3}). Near-future goals a for figures of 4×10^{-3}. It is general felt that figures of above 4 will l necessary for commercial application

• **Government-sponsored research**— Westinghouse is the largest contract to the Navy under the current prograr It currently holds contracts totaling excess of $2,000,000, mostly for m terials development. They have h: and are continuing a company-su ported research program larger th: that for the Government. Much Westinghouse's materials developme started from the work of Dr. Zen (of Zener-diode frame). It was the fi to obtain efficiencies of more than 4%

Government-supported work f the Air Force and Army on generatc and radiator systems is being carri on by General Electric's Engineeri Lab. A company-underwritten progra is in progress at the Knolls Aton Power Lab. Total GE contracts amou to more than $200,000.

Servomechanisms Inc. is doing cl: sified materials research work whi grew out of previous company proje dealing with high-temperature el tronic components. At present, S Navy contracts total about $100,0(

Naval Research Laboratory p vides service for the entire defense p gram, including a measurements fa ity just nearing completion. NRL a is involved in what is described as "minor" materials effort.

A study of thermoelectricity l been in progress at Battelle Memo Institute for several years and has cluded a number of semi-conduc materials. Institute contracts are excess of $100,000.

At least 12 other contractors implementing the Department of l fense program. Several small contra ve recently been let. These are relaely small, mostly around $100,000, d concern materials development ly.

The entire SNAP program is under e Atomic Energy Commission and ly a part relates to the thermoelectric velopment. The only other project blicized to date is the development a "plasma thermocouple" which uses sium gas as one of the metallic ermo elements. This unit produced 3 volts for almost 12 hours before it as shut down. Heat was provided by riched radium.

The AEC provides substantial sup-rt on fundamental work on material d devices. They recently began oper-ons at a new $2.2 million fission oducts plant at Oak Ridge to sepa-te isotopes from reactor fuel wastes. ne of the important uses of these covered isotopes will be as heat urces for thermoelectric generators. ne of the isotopes, cerium-144, is of rticular interest for the SNAP proj-t. Even strontium-90 is being used.

•Industry-sponsored programs—ompany-supported work in thermo-ectricity is about equal to the present overnment program. It includes sev-al major efforts as well as numerous nall projects.

One of the major research efforts in aterials is carried on by Merck and ., which has a pilot plant operation th a capability of about 50 kg of smuth telluride per month. Merck s under development processes for ge-scale production of lead telluride, d selenide, alloys of these two com-unds and ternary alloys of bismuth luride. Fundamental research is be-g done on new compositions to hieve substantial improvement in the ure of merit. They reportedly are orking on an unspecified material hich it is hoped may reach a figure of erit of 4 or better.

As mentioned earlier, Minnesota ining and Mfg. Co. has been active thermoelectric material development nce 1950. 3M's work covers a wide nge of research from theoretical treat-ent of thermoelectric phenomena to e design of working, commercially plicable generators.

Both RCA and Whirlpool are work-g on Peltier refrigeration materials. CA was the first to produce a full-size ermoelectric refrigerator.

Other companies active in the field clude Nortronics, Texas Instruments, urtiss-Wright, Franklin Institute, Gen-al Atomic and National Carbon.

•Future research—The future pro-am includes five main areas of re-arch. The first of these is materials d includes high-temperature materi-, liquids, and films.

The second deals with the behavior of materials under severe environments —radiation, thermal and mechanical shock, and chemical atmospheres.

The third area has to do with design and fabrication principles of hardware: contact problems, cascading, structures optimimization, heat transfer, encapsulation and loading.

The fourth and fifth areas concern performance characteristics and physical-chemical phenomena.

Westinghouse has just completed a 100-watt generator for ARDC, called the TAP-100 (Terrestrial Auxiliary Power). This unit uses gas for fuel and is claimed to have an efficiency of about 8%. The thermoelectric material is a combination of semiconductors in cascade, also developed by Westinghouse. An advanced version being built will use a nuclear isotope source for heat.

Two contracts have recently been let for oil-fired 5 kw generators. The guaranteed efficiencies of these units, however, should be no more than 6.4%, a figure well below the present state of the art which would allow efficiencies up to about 18%. Requirements for 500kw generators are now in preparation.

The Atomic Energy Commission is continuing with work on both isotope and reactor-heated generators.

Considering these facts, it seems logical to say that the potentialities of thermoelectric power generation (and refrigeration) are just beginning to be explored. The first giant steps have already been taken with practical versions of small generators and cooling units. Larger units can be foreseen in the near future.

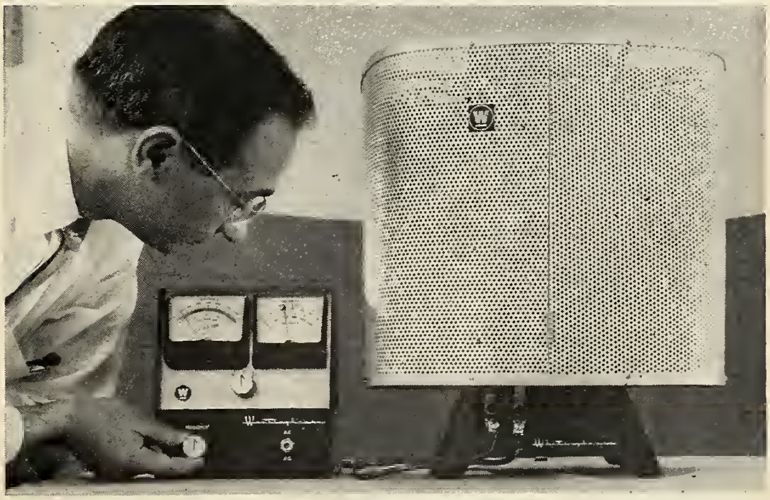
With purposeful direction and adequate financing, the next year or two could certainly yield significant advancements to make possible early practical nuclear-powered thermoelectric generators for space vehicles and more mundane applications. Conceivably, a generator sufficient to power the plasma propulsion engine for interplanetary travel (M/R June 8) could be built within the next few years.

Thermoelectrics face severe competition, however, from several other exotic power sources which have come to the fore very recently. Solar cells are being continually improved and show promise for many space applications. Solar energy may, of course, be directly converted to electrical power through solar cells or used to furnish heat to a thermoelectric generator.

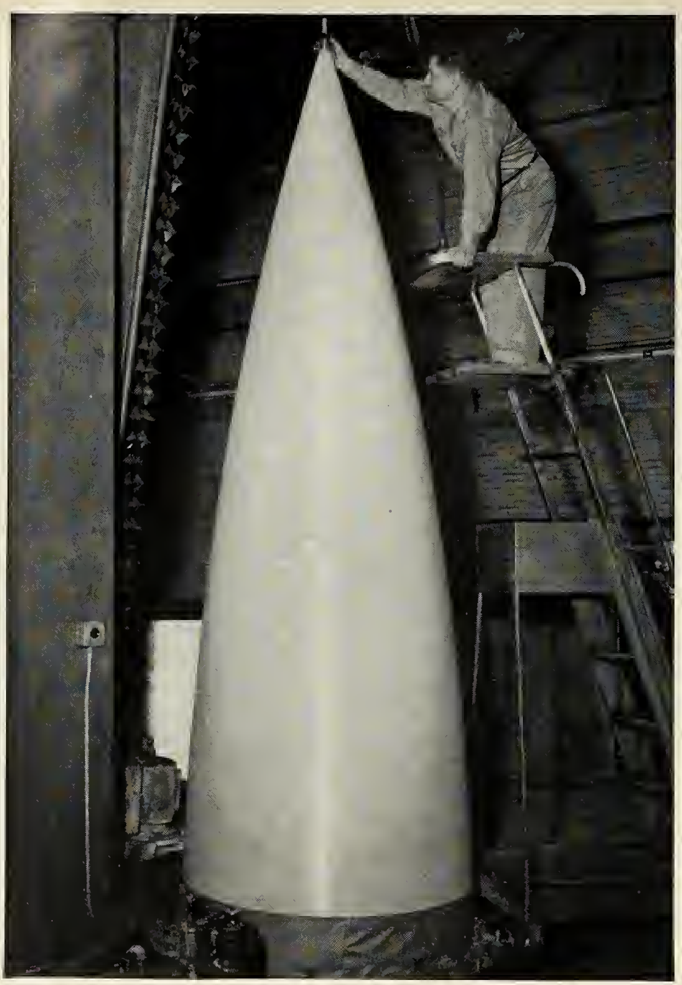
Electrostatic generation, although 300 years old, has been proposed as an efficient source for high-power applications in the vacuum and weightlessness of outer space.

Fuel cells which produce electricity directly from hydrogen and oxygen, such as the one recently announced by General Electric (M/R, June 8) are predicted to have a very bright future. Yale and Towne has announced plans for a cell within one or two years capable of powering a lift truck. A proposed sodium-mercury fuel cell would reportedly have fantastic potential.

It is impossible to say which of these possibilities, or even as-yet-unknown ones, will emerge as the most universal of tomorrow's power sources. It is fairly certain, though, that we may expect revolutionary progress in the near future. With the impetus of space program requirements and the broad interest of industry in the problem, the next few years may yield tremendous advancement.



TAP-100 built by Westinghouse is ten times larger than any similar thermoelectric device to date, and produces 100 watts.



NEW—the world's biggest filament-wound fiberglass radome!

Here it is — twelve feet high, four feet in diameter — the largest filament-wound fiberglass radome ever made. This huge form was produced by a special winding process—product of Kidde engineering knowledge and research — which results in an extremely high strength-to-weight ratio, plus a maximum in physical and electrical uniformity. Furthermore, this Kidde continuous-winding process, plastic reinforced by fiberglass, permits the construction of fiberglass shapes and forms which were either difficult or impossible to fabricate by previous methods.

Walter Kidde & Company has available complete facilities and personnel for the development, testing and production of fiberglass forms. If you have a problem in this area — write Kidde today. We've solved some pretty tough ones in the last thirty years!

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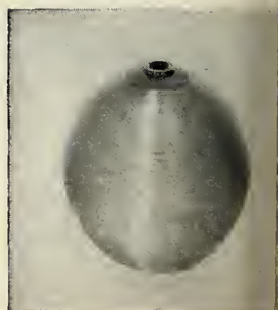
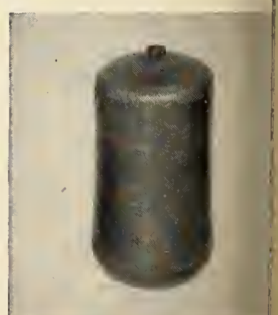
FIBERGLASS FORMS ARE A KIDDE SPECIALTY!

Thanks to Kidde's continuou winding process, a new field fiberglass forms is now open aviation engineers. Structur tubing, pressure vessels can no be made stronger than steel wi half its weight!



For the engineer interested the field of pneumatics, filamen wound fiberglass spheres off the solution to many problem Available in capacities of fro 50 to 2500 cubic inches the spheres can withstand pre sures up to 5000 psi.



Missile rocket motor cases, t pedo bodies and missile radom are but a few of the forms whi Kidde can fabricate from hig strength, low-weight fibergla capable of withstanding te peratures as high as 1000°F. f short periods of time.

Successful AME Is Unveiled

Page Communications' gear tested in North Atlantic is expected to find more use on ionoscatter circuits and offers potential for increased channel capacity

by Charles D. LaFond

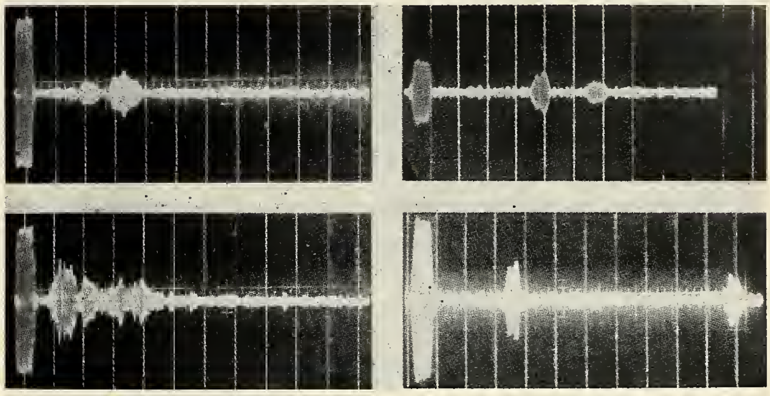
WASHINGTON—Three years in de-elopment, a new and highly success-l anti-multipath equipment (AME) roviding a significant increase in tele-mmunications reliability has been re-ealed here by Page Communications ngineers, Inc., a subsidiary of the orthrop Corporation.

The equipment essentially employs frequency translation technique at th the transmitting and receiving ds. Following long tests on northern erational ionospheric-scatter commu-cation circuits of the U.S. Air Force, rcuit outage resulting from ground-atter multipath has been reduced om a recorded high of 27% to a aximum of 2½% of total operating ne.

The North Atlantic Ionospheric-atter System in which AME has been nployed is the first operational sys-n built for the Air Force to use this opagational mode. A part of the obal defense communication system, stretches from Wachusett, Mass., to oose Bay, Labrador; Sondrestrom and ule, Greenland; Iceland, and Eng-nd.

With a few changes in stations, the stem has been in operation (includ-g its initial test period) since 1954. liability has been very high and, sed on this successful operation, many ousands of miles of additional de-nse scatter circuits have been or will constructed. It is expected, that AME ll be employed in the near future on her similar ionoscatter circuits.

• **History**—When the early VHF oscatter circuits were placed in op-ation, there existed a period of de-ning solar activity. Long-delay multi-th as a result of ground scatter, opagated by the F-layer during day-ht hours, was low. That multipath uld increase with high solar activity s recognized, but its effect on reliability was underestimated. By November, 1955, solar activity had increased, the resulting sun-spot numbers had almost trebled, and multipath seriously affected operational performance.



Frequently Observed — Rarely Observed

PHOTOGRAPHIC examples of ground-scatter multipath propagated by the F-Layer back-scatter multipath. To determine delays, a 6.6-millisecond pulse was transmitted with 10-millisecond timing markers.

It was at this time that the occurrence of long-delay multipath was observed on the North Atlantic ionoscatter circuits. Delays of the order of 50 milliseconds (msec) were encountered during daylight hours, severely impairing radio teleprinter operations and, at times, making operation impossible. To reduce this performance degradation, Page conceived a practical program for an experimental anti-multipath equipment and began its long development.

By the spring of 1957, prototype models built by Rixon Electronics, Inc., of Silver Spring, Md., were ready and installed in a few of the northern scatter stations. Tests were continued through the fall of 1957 and subsequently modified equipment (by then installed in five stations) provided substantial reduction in circuit outages due to ground-scatter multipath.

A considerable amount of data was gathered during these preliminary tests. Delay data were obtained on these circuits while operating on a frequency of the order of 35 mc/s, with a transmitted pulse of approximately 6.7 msec. Ten msec markers were employed to determine the delays.

The ground-scatter multipath propagated by the F-layer was characterized by relatively long delays. Multiple echoes occurred in many instances—the majority arriving with delays in the range of from 10 to 50 msec. Occasional delays as long as 100 msec were observed. With the insertion of AME in the system, multipath interference was all but eliminated.

It was determined that an anti-multipath equipment providing protection for delays ranging from approximately 10 to 50 msec would be expected to give satisfactory performance.

• **Design criteria**—The character of multipath is such that to use frequency translation, the rate must be chosen so as to effect the first translation before the arrival of shorter delay multipath. Also, the first translation frequency cannot be reused until the more serious multipath echoes have subsided.

This implies that for longer bit widths such as 5 to 10 msec, the translation had to occur once for every bit. For shorter bits the translation could be made to occur for any whole number of bits, as long as the sum of the widths does not exceed approximately 10 to 50 msec.

Multipath discrimination is a function of the magnitude of the frequency shift and skirt selectivity of the associated FSK (frequency shift) receiver. The receiver type in use on the systems under consideration, is a dual filter type and is known as the FSK-2. The skirt selectivity of the receiver is such that when using a frequency shift of 800 cps the discrimination against an echo arriving with a delay of 6.66 to 46.6 msec is from 12 to 60 db.

• **Description of AME**—AME as installed on the North Atlantic scatter system avoids receiving delayed multipath signals by means of a sequence of frequency translations. Immediately after the reception of each information bit, the transmitter and receiver are shifted synchronously from one frequency to the next. With the receiver lagging the transmitter by a time interval equal to the sum of the propagational and certain inherent equipment delays, the equipment operates in such a manner that the receiver and transmitter are not returned to any previously used frequency until approximately 46 msec have elapsed.

By this means, multipath signals arriving with delays longer than the time required for one frequency translation cycle, or arriving at a time less than the total time period required for one complete sequence of frequencies, will be off-frequency with respect to the receiver and will be attenuated in accordance with the receiver selectivity characteristics.

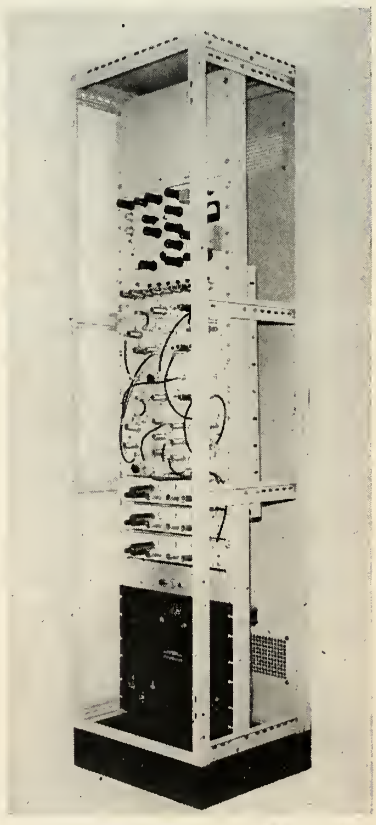
The equipment satisfactorily attenuates multipath components by shifting in 800-cps increments and employing seven different frequencies for mark and space. Beginning at the normal operating frequency, a shift of 800-cps is made, followed by successive shifts to 1600 and 2400 cps above the operating frequency. At this point a negative translation is made to 2400 cps below normal operating frequency, followed by successive shifts upward to 1600 and 800 cps below the normal operating frequency.

When used in a typical ionoscatter system, the transmitting AME is inserted between the output of the frequency multiplier and the input of the exciter combiner.

The signal input to the transmitting AME is the normal FSK-2 signal, while the output is translated over seven frequencies for mark and seven frequencies for space. Thus the output signal may appear on any of 14 frequencies, but only one frequency is transmitted at any one time.

The receiving AME is inserted between the output of the FSK-2 r-f amplifier and the input to the converter panel. The receiving translation is accomplished in a manner such that the signal applied to the converter now approximates the original FSK signal with the multipath echoes appearing off-frequency. The F-layer propagated multipath is attenuated by the selectivity of the mark-space filters of the FSK-2 receiver.

The rate at which the frequency translation occurs is determined by t timing of the multiplex equipme (When operating with the AN/FGC multiplex, the frequency translati occurs once for each transmitted and is coincident with the mark-spa transition.) Since the FSK-2 receiv normally is operated in dual space versity, it is necessary to provide AM with an additional set of mixers a an i-f amplifier.



PROTOTYPE model of Page's rack-mounted experimental Anti-Multipath Equipment Built by Rixon Electronics, Inc.

• **Cryptographic compatibility**—T experimental AME will operate w encrypting systems compatible with t multiplex equipment now in use on t scatter circuits. The equipment install in the North Atlantic area has be handling routine encrypted traffic w satisfactory performance. The equ ment also will handle synchrono cryptographic systems having a mai space output and a discrete modu tion rate not exceeding 600 bits/s and with a minimum mark-space tran ition rate of approximately 30 bits/s

• **Transmission security**—Page a has indicated that AME has a degi of inherent transmission security. Sir additional operations are performed modulation at the transmitting en these operations must be demodulat at the receiving end. For secure tra mission, the number of frequency ste can be increased in the translation p gram in a random manner but w a known key.

Attempts to jam such a syst would require an increased bandwic with the resulting increase in power the jamming transmitter. An impro ment in transmission security wou thus be obtained, but additional f quency spectra would be required.

• **Performance**—During Janua 1958, traffic averages on the northe circuits due to ground-scatter multipa ranged from about 15% to as high 27% of the total operating time w almost all averages occurring duri the daylight hours. During Februa and March 1958 operation, followi the installation of the experimen AME, circuit averages ranged fr 0.1% to a max of 2.5% of the to time. This improved performance a includes time for multipath recogniti and time to place the equipment operation. An appreciable portion this outage time was due to interf ence. (Improved FSK-2 channel filt and additional personnel are expec to produce a further reduction in o age time.) Loss in signal detectabi when using AME was measured a found to be approximately 1db.

• **Meteoric and auroral multipatl** The instrumentation required for measurement of ground-scatter mu path delays also permitted observat of meteoric multipath. A 400-μ pulse was transmitted and a total

536 meteoric-multipath observations vas made during April, 1958. The ma- ɔrity of meteoric multipath delays anged from 100 to 300 μsec with the elays occurring up to approximately 00 μsec.

During the above tests, a brief eriod of auroral disturbance was en- ountered, and limited data were ob- ained. This type of multipath is char- cterized by an exponential decay over relatively long period. From the dis- ibution of the observed auroral multi- ath, the predominent delays were less ian approximately 1 msec, but con- nuous echoes ranging from possibly 00 msec to over 4 msec in length were bserved.

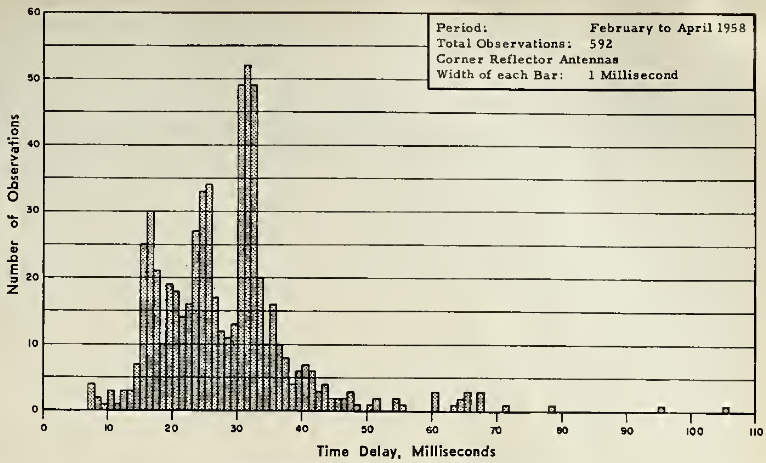
• **High-speed operation**—The con- antly increasing volume of commer- al and military traffic is requiring a ntinual increase in the number of affic channels. If additional teleprinter annels are to be provided by time- vision multiplex equipment, the bit ngth becomes progressively smaller.

With newer 16-channel multiplex erating at 100 words per minute, the t length is 1 msec. Such high-speed nsmission would be expected to re- t in a moderately high error liability e to meteoric and auroral multipath. om the limited data obtained, it ap- ars that satisfactory high-speed op- tion of AME may be possible by viding a minimum delay protection ual to the delay of a single bit and maximum delay protection approxi- ting 5 msec.

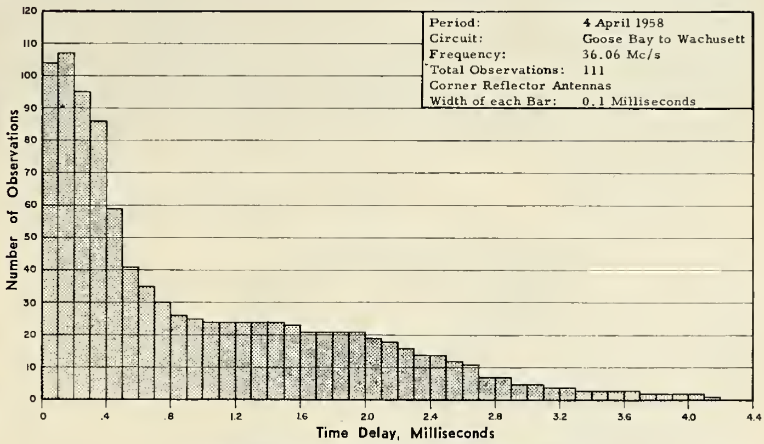
Synchronous transmission at high eds with low error rates on iono- eric scatter has been limited in the t by problems of decision ambigu- i, filtering, diversity combination, tipath and timing errors. Experi- nts recently conducted using im- ved diversity and decision techni- s together with the AME appeared rovide at least partial solutions for except the timing problem.

The development of AME together w advances in diversity and decision te niques offers the potential for in- cr sing channel capacity of present sc er circuits.

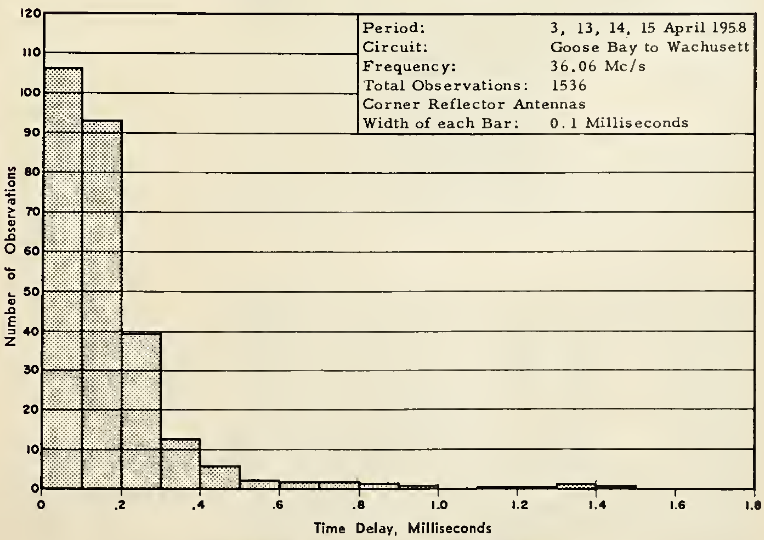
• **High frequency tests**—In June, 19, under contract with National Bu au of Standards, Boulder, Colo., a tes program was initiated to de- ter ine the effects of an experimental A for reducing teleprinter errors fro multipath propagation on an ex- isti high-frequency radio circuit. A was shown to provide an appre- ia e reduction in multipath errors. Te results were similar to those ob- ai d on ionoscatter circuits. A 2-10 ol reduction in errors were consis- en observed, while the average re- uc on in error rate was approximately 1



Distribution of F_2 Multipath Delays.



Distribution of Auroral Multipath Echoes.



Distribution of Meteoric Multipath Echoes.

lew 4000° Range or Pyrometers

WASHINGTON—Many of the quesions arising in high-temperature standrdization, calibration, use, and manuacture of optical pyrometers were disussed at the recent National Bureau f Standards symposium on high-temerature pyrometry. Principal subject t the meeting was the possible use of e temperature scale beyond 4000°K.

In the last few years, the interest high-temperature measurements has reated a demand for optical pyromers capable of greater precision and ccuracy. Recent studies, principally at e National Bureau of Standards and rgonne National Laboratory, the symosium sponsor, have shed new light some of these problems.

Trends in the NBS work on optical yrometry were outlined at the beginng of the conference by Dr. C. M. erzfeld, chief of the bureau's Heat ivision. He pointed out the necessity improving methods of temperature easurement in the range 800°C to 00°C under ideal conditions. Here, said, accuracy, precision, and connience of operation need further imovement.

An extension of methods for mearing temperatures under ideal or apoximately ideal conditions in the nge 4000°C to 10,000°C is also reired. And improvements in temperare measurement under non-ideal conions, such as in flames and complited systems, are needed along with ore basic research for new and better ys of measuring temperature.

• **Setting scale**—The procedure used Argonne to establish the temperature le in the range of 1000°C to 00°C was discussed by R. J. Thorn d G. H. Winslow. The starting point s the freezing point of copper, which been determined as 1083°C on the 48 International Temperature Scale. ove the freezing point of copper a ck body constructed of tungsten, tained in a vacuum and heated inctively, was employed as a light rce.

The National Bureau of Standards Argonne National Laboratory opl pyrometer temperature scales ee within 1°C at the gold point, but er by 4°C above 1600°C. It was gested that the most likely source the difference lies in the effective e lengths.

• **Limits**—Basic limitations on accuy of optical pyrometry were dised by D. R. Lovejoy of the Naal Research Council of Canada. An

estimate of the errors arising in p mary standard pyrometer calibratio and in secondary standard strip lan calibrations agreed with the results a recent intercomparison of seconda strip lamps. An evaluation of a carb arc, accepted as a useful seconda standard at 3514°C, showed that this region the effect of the unc tainty in eeffctive wave length excee all other sources of error combined.

Even though very precise wo was involved in determining the pla num point at 1769°C, metal freezi points seem to offer little advanta over the strip lamp as secondary stan ards. It was determined that go commercial pyrometers can be ca brated with a precision comparable that of primary standard pyrometers the lamp current is calibrated direc rather than through the internal p tentiometer and scale.

R. D. Lee of the Bureau discuss the procedures used in calibrating op cal pyrometers and tungsten ribb filament lamps submitted to the B reau. Temperature comparisons made with the NBS standard pyron ter from 800°C to 3800°C. In ca brating optical pyrometers, a tungst ribbon filament lamp is used as a te perature source up to a brightness te perature of about 2400°C, and a z conium arc and carbon arc to te peratures of 2800°C and 3800°C, spectively. Since the brightness te perature of a non-black body is det mined in part by the red filter glass a pyrometer, corrections are made test pyrometers with different tra mission characteristics.

The estimated uncertainty of calibration below 2800°C is based experience with a number of inst ments rather than on the specific d of a given instrument. The stand deviation, with respect to the Inter tional Temperature Scale, of pyrome and strip lamp calibrations is ab ±1° from 800°C to 1500°C, ±2° fr 1500°C to 2000°C and increases about ±6° at 2800°C.

• **Photoelectric**—A summary NBS work on photoelectric pyro ters was given by C. P. Johnson D. Erminy. The first model of the N photoelectric pyrometer has a se tivity of 0.1°C at the gold point a spectral band width of only 100 These features together with its jective character make it an attrac instrument. However, the measurem of brightness temperatures to a p cision of 0.1°C introduces many d cult problems involving lens abe tion, scattered light diffraction, and stability of light sources. These n be investigated in great detail before photoelectric pyrometer can be c sidered a reliable accurate instrum

McElroy Hit for Failure To Halt Missile Rivalry

A bitingly critical statement by the U.S. Chamber of Commerce accuses Defense Secretary McElroy of ignoring his power to stop "unhealthy and intolerable" service rivalry over missiles. The Chamber told the Senate Defense Appropriations Subcommittee Congress should force full and prompt use of McElroy's power "to curtail multiple development . . . and to eliminate unnecessary overlapping and duplication in a dozen or more support-type activities."

Without referring to specific cases, the Chamber urged the subcommittee to go along with House cuts in President Eisenhower's budget. Added the business group: "Congress has barely scratched the surface insofar as savings opportunities are concerned."

President Eisenhower has signed a bill increasing the authorization for an AEC "weapons diagnostic" plant at Los Alamos from $2.2 million to $3.5 million.

Nike-Hercules missiles have been integrated into the air defense system of U.S. military installations in West Germany.

Snark alert test at Northrop Field, Calif., was well past the half-way mark in a 400-hour continuous 24-hour standby operation last week. Total run will require 17 days.

Scientists Protest Secrecy; Harming Basic Research

Consensus of opinion of 17 Nobel Prize-winning scientists is that secrecy in basic research is senseless and harmful, and in many cases causes unnecessary duplication of effort. The views were expressed in letters sent to the Senate Constitutional Rights Subcommittee in repsonse to queries from Chairman Thomas C. Hennings, Jr. (D-Mo.). Other points raised by the scientists—physicists, chemists and medical doctors—included:

—the government's "need to know" contract restrictions hinders scientific progress because it is often impossible to prove NTK until it is known "what the other man is doing";

—blanket security classifications often cover areas of a project which in no way touch on the sensitive;

—because many good scientists steer clear of classified projects under the present set-up, secrecy could become a cloak for mediocrity—morale is lowered when a scientist is denied the recognition that comes with publication of a discovery.

Hourglass Rocket Chamber

For NASA Solar Aircraft has developed brazed stainless steel rocket thrust chamber, shaped like hourglass. Chamber is cooled regeneratively and is being used to test new propellant combinations at Lewis Research Center, Cleveland. Chamber is formed of 120 U-shaped AM-350 channels .008 inches thick, assembled around a stainless steel mandrel with about 100,000 spot welds and wrapped tightly with .008 inch stainless steel ribbon, which is brazed with copper.

A prototype device to measure amount and temperature of gas in the upper atmosphere has been developed by **Lockheed Aircraft.** The unit, mounted in a satellite, contains a small hole which allows a beam of gas molecules to enter. This beam is chopped by whirling blades and hits a microphone where it produces a tone directly proportional to the density of the gas. In addition, the beam fans out, or spreads, a measurable amount proportional to the temperature of the entering gas. The same technique could, according to Lockheed, be used to provide an input to stabilize the satellite.

Renegotiate Act Extension Approved by Senate Unit

The Senate Finance Committee approved a 30-month extension of the current Renegotiation Act.

The committee's move had the effect of rejecting a House-passed four-year extension of the law. Critics attacked the House bill as a boon to big missile and aircraft manufacturers.

The Democratic Advisory Committee called for spending an extra $30 billion over the next four years to expand U.S. defenses.

The committee charged U.S. defenses are in disastrous shape compared to Russian military might.

It said one of the first steps needed to improve U.S. defenses is "a crash effort to bridge the missile gap." It called for doubling the production of **Martin** *Titans* and **Convair** *Atlases*.

NASA established a committee to study the possibilities of establishing an equatorial launching site for satellites. Dr. John P. Hagen, NASA assistant director, is chairman. (M/R May 18)

French IRBM?

France is trying to develop its own IRBM. A special society called SEREB has been established to do the job in cooperation with French industry.

The Air Research & Development Command announced a twin-rail rocket sled reached a speed of 2,075 miles an hour last month in a test at Edwards AFB, Calif.

ARDC said it believed the speed was a record.

NASA awarded a contract to **Grumman Aircraft Engineering Corp.** to conduct studies for search and recovery operations for Project *Mercury*.

Consideration will be given to recovery by ships, helicopters, airplanes and airships.

March of Progress

Electronic Communications, Inc. has acquired Advanced Technology Corp. of Santa Barbara in exchange for 1,000 shares of ECI common stock. ATC which was formed by a group of research scientists formerly with Aerophysics Development Corp. and Avco will be operated as a wholly owned subsidiary of ECI . . . J. H. Pomeroy & Co., Inc., engineering and construction firm, has been cited for outstanding support of the Navy's ballistic missile program . . . Aerospace Industries Association (formerly Aircraft Industries Association) has raised the status of its Guided Missile Committee to Guided Missile Council—expanding its functions to include "all types of management interests relating to guided missile manufacture." . . . Aerojet-General Corp. has set up a Space Technology Division which will concentrate on research and development in electrical and other advanced propulsion and space systems. Facilities purchased by the company last month at Downey and Riverside, Calif., will be used to continue product development and to expand its powerplant and systems programs . . . Recent groundbreakings for new computer production facilities were begun by Philco in Montgomery County, Pa., and by Librascope, Inc., at Sonora, Calif. Philco's multi-million dollar plant, just west of Willow Grove, is scheduled for occupancy in November and will house production facilities for the Transac S-2000 electronic data processing system. Librascope, subsidiary of General Precision Equipment Corp. supplies weapon control systems and computers for anti-submarine warfare.

—moscow briefs—

by Dr. Albert Parry

The building of their first electron computers is reported by the scientis and engineers of Poland and Rumani Aid given by Soviet experts is praise The first Polish computer was made f that country's Hydro-Meteorological I stitute. The first Rumanian machin built under the leadership of the sta of the Timisoara (Temesvar) Polytec nic Institute, can make more tha 15,000 operations per second in add tion and subtraction.

Under the title "Materials of Sovi Rockets," a brief article in Prague monthly magazine *The SNTL Tec nical Digest* states that "the who world" is asking these questions: Wh are the most stressed parts of Sovi rockets made from? What materials a used in the fuel pump nozzles and com bustion chambers of the huge engin stressed by temperatures of many tho sand degrees and enormous force What materials are used for the k details of the 300,000 component par combined into one single interplaneta rocket? The Czechoslovak magazi then proceeds to give this answer:

"No material produced by metallu gical processes hitherto known prov to be satisfactory. In the USSR the pr duction of these materials has been d veloped on the basis of ultrasonics a plied during casting and solidificatio The crystallization of a freezing met begins with the formation of fir-tr shaped skeletons, the so-called dendrite

"The distribution of the solidifi metal around the dendrite axes dete mines the homogeneity of the structu and thus the quality of the final pro uct. In a melt exposed to vertical ult sonic vibration and to a horizontal v bration with frequencies 10 tim higher, up to 200,000 c/s, the dendri axes are continuously breaking off, t solidified material acquires a super-fi ordered structure, and a material remarkable properties is obtained. T solution of the riddle is: while vib tional casting is solved in the USSR the stage of shop operation, it is n yet solved in the USA."

• **Several movies** devoted to Sov advances in rocketry have recently be produced and issued by the Mosc Studio of Scientific Popular Film Among them is "Four-Legged Ast nauts" on the role of dogs in Russi rocket flights. A 20-minute docume tary, it includes material not alone the training of such canines as Lai of *Sputnik II* but also on Soviet expe ments with birds and rabbits which p ceded the work with dogs. This film ısed on a scenario by P. Isakov and rected by N. Tikohonov, with assistıce from A. Genin and A. Seriapin, 70 of Russia's space-medicine experts. nother latest Soviet film is "Automats Cosmos," dealing with automatic luipment installed on Russian rockets nt aloft for purposes of research.

This film is notable for a detailed monstration of the equipment sent in *Sputnik III*. Yet another recent oscow film is "Mankind's Great Vicry," dedicated to the launching of the nar rocket *Mechta* or, as it is called ıtside the USSR, *Lunik*.

olaris Data Gathered y Leach Cylinder

COMPTON, CALIF.—A rugged inument cylinder has been developed the Leach Corp. for use in gatherg launching data on the *Polaris*.

Mounted in the nose of a dummy ssile test-launched from submarines ship simulators, the 176-lb. cylinder rries 15 pounds of encapsulated inuments in a ½" steel shell. It can thstand complete submersion for two ys or more and resists water pressure 75 psi.

Instrumentation, claimed to have thstood more than 1000 g's in the ckage, includes a 14-channel rerder, battery power pack, three acelerometers, two rate gyros, transisized amplifiers, control and calibran circuits, a static inverter providing 0-cycle power to the gyros, and a modulator package.

According to Leach engineers, en the *Polaris* dummy was test-fired to a bed of concrete the package svived the shock with all instrunts functioning perfectly, although t missile itself was damaged.

ilors Study *Polaris* ıb's Auto-navigator

DOWNEY, CALIF.—Selected U.S. vy men have begun a 12-week ining course in installation, check, maintenance and operation of the rtial auto-navigator being produced North American Aviation's Autoics Division for *Polaris*-equipped marines.

Training specialists of the division's litary Logistics and Service Departnt are instructing the Navy students a specially-designed laboratory containg the first auto-navigator producn model—including gyro-stabilized tform, separate navigation console d digital computer.

missile business . . .

By DONALD E. PERRY

What's best when you want to pick up . . .

more defense business? Acquire a new company—and take a lot of bad features along with the good capabilities you want, or go after competent personnel and build from within your existing organization? There's a lot of merit in the latter approach, and one company that is going all-out for it is the Crosley Division of Avco Corp., which is attempting to up its military business from a present $80 million annually to $125 million.

Avco-Crosley has a good position in the areas . . .

it went into earlier: some 75 to 80% of the business in command receivers, good prospects in fuzing and arming—*Titan* work now and a new NOL contract for *Polaris*—and a healthy outlook for honeycomb structures both in aircraft and missiles.

An old-timer in *Falcon* structures . . .

and complete radar systems (both looking good), Avco-Crosley under President F. C. Reith months ago started broadening. "We determined," Reith said, "to get competent technical and professional people in new areas which we had not been in before." Targets: sonar, electronic checkout equipment, human engineering, infrared (surveillance, ICBM detection, mapping).

But how to approach it . . .

was another thing. Reith decided almost entirely on going out and getting the personnel. "Not that we have anything against acquisition; we haven't. We're still looking in the infrared field but we are being selective," he says.

Crosley's personnel build-up is reflected . . .

by nearly a 30% increase in its professional staff, giving the company what Reith considers a strong capability for new business. In key spots are many newcomers brought in from other concerns usually for one reason: a broad background in particular areas where Crosley wants to expand its business scope.

To cite just a few . . .

Dr. E. A. Steinhoff (formerly with Aerophysics Development Corp.), and former member of von Braun's Peenemunde team, heads up a new missiles department. He is considered one of the world's foremost authorities on missile system guidance and control. Marine Electronics has Dr. H. W. Marsh (formerly with Westinghouse in missile ground-handling equipment), who has a broad background in the quantitative nature of environment and signal processing for sonar systems.

Still another former Westinghouse specialist in electronic and electromechanical systems R&D—Dr. F. E. Lowance—serves as Crosley's vice president of engineering. Dr. John W. Odle, director of Crosley's Advanced Development Department, came from the University of Michigan with a varied background in mathematics and systems and analytical studies.

Brought in from Control Instrument Co. where he was Controller and director of Purchasing was R. B. Marston, Crosley's engineering controller.

Dr. Frank B. Brown, Crosley's Reliability Director, came from Melpar, where he directed a study program for integration of SAGE into Air Traffic Control. Coming from Martin's *Titan* program was J. C. Elms, now Crosley Electronics Engineering vice-president, directing Crosley's weapon systems R&D.

So you can take your choice . . .

Buy up companies and perhaps get too much deadwood, or be selective and pick your own. Avco-Crosley thinks it has the best approach.

iokol Plans Clarified

the Editor:

We are afraid that the West Coast ustry column in the May 18 issue of ssiles and Rockets may create con- rable misunderstanding among our tomers regarding our intentions to- d systems contracting.

Thiokol Chemical Corporation has no ntion of becoming a prime systems tractor based upon the fact that our tomers are such contractors and it is eved that they would not look favor- y on purchasing engines from a com- tor.

The history of engine development and duction activities in this country has nonstrated the validity of separating n activities from airframe development production. We believe that the valid- of this principle applies equally to tbe raft and air-breathing engine field and field of rocket engine development production for missiles. The cost of development and production of a ket power plant is normally a small tion of the cost of a missile system. single missile system sbould have to port the cost of a strong technological n engaged in engine development.

We believe tbat the current tendency combine a wide range of technologies into a single organization can only serve to weaken the technological strength of many of the groups engaged in sub-system development. The current tendency to integrate rocket development technology with prime systems capability could bave a very debilitating effect upon tbe whole industry.

It will remain the policy of Thiokol Chemical Corporation to serve as an engine development and production contractor. We hope to be able to serve many prime systems contractors in such a role. We have no intention whatsoever of scaring off our customers by going into competition with them.

H. W. Ritchey
Vice-President
Thiokol Chemical Corp.
Huntsville, Ala.

Trolley Breakdown?

To the Editor:

Regarding the "Moon Trolley" letter in the June 8 issue of M/R.

The two fellows from Picatinny Arsenal could have saved themselves a lot of embarrassment by a few simple calculations.

The strongest materials today would be torn by their own weigbt if made into a cylindrical cable only 20 miles in length. Even at an altitude of 4000 miles, the longest cable that could be hung would be 80 miles; at 12,000 miles: 320 miles long. A *tapered* cable could be made approximately 1000 miles long at the 12,000-mile altitude. However, the 1000-mile cable would be of little value toward spanning the 239,000 miles to tbe moon.

Sorry fellows, but the "moon trolley" must be given up as well as that strong brand of coffee you have been drinking.

R. S. Ronay
Aero. Engineer
Douglas Aircraft Co.
Cocoa Beach, Fla.

Our Pleasure

To the Editor:

The U.S. Army Ordnance Guided Missile School Library wishes to thank the Editors of Missiles and Rockets for tbeir most gracious gift of the bound sets of Missiles and Rockets, volumes 1-4, presented 7 May 1959.

These volumes are an invaluable reference addition to our new library. They form a nucleus for researcb in tbe field of guided missiles and are much appreciated and used by staff, faculty, and students of the school.

H. M. Thomas, Jr.
Major, Ord Corps.
US Army
Ordnance Guided Missile School
Redstone Arsenal, Ala.

STRENGTH OF CERAMICS AT HIGH TEMPERATURES, U.S. Department of Commerce, National Bureau of Standards, Summary Technical Report.

The strength of aluminum oxide single crystals has recently been studied at the National Bureau of Standards as a function of temperature. Modulus-of-rupture measurements were related to factors affecting crystal strength at temperatures up to 1000°C.

Certain crystal orientation significantly affects crystal strength by giving rise to plastic deformation at stress concentrations. As these stresses are relieved, crystal strength increases.

AN ANALYSIS OF ELECTRON BEAM INTERACTION WITH EMPHASIS ON THE CROSSED FIELD PROBLEM, J. W. Kluver, University of California for WADC, USAF, 86 pp., $2.25, available from OTS, U.S. Department of Commerce, Washington 25, D.C.

A general method of approach for the approximate solution of the small-signal perturbation of a bounded electron stream surrounded by a periodic structure was developed. With the requirement that energy be conserved, the electron stream is described on the basis of the Maxwell-Boltzmann equations.

The perturbation of dynamic equations is carried out and its effect on a defined boundary of the electron stream discussed. Beginning with the Lorentz reciprocity theorem in its complex form, the approximate boundary conditions for the rf electric field at an equivalent surface of the periodic structure are derived.

Characteristic waves are found by employing the discontinuity conditions at the beam boundary. A power theorem describing the conversion of rf kinetic energy into electromagnetic energy is also given.

GROWTH OF METAL SINGLE CRYSTALS, U.S. Department of Commerce, National Bureau of Standards, Summary Technical Report.

Equipment has been developed to grow preferentially oriented metal monocrystals in practically any cross-sectional shape. These crystals, having an ordered atomic arrangement, are particularly useful in studying the influence of crystal structure on corrosion.

A pre-selected crystallographic orientation is obtained with a technique known as "seeding," and the desired cross-sectional shape is produced by growing the crystals in a vertical furnace.

MECHANICAL DEGRADATION OF POLYMERS, U.S. Department of Commerce, National Bureau of Standards, Summary Technical Report.

To obtain basic information on mechanical degradation of polymers, the tional Bureau of Standards has beei vestigating the effect of mechanical sl ing on various concentrated polyr solutions. By studying mechanical deg tion, the use of polymers which deg excessively under severe conditions be avoided and special polymers w will remain intact under such condi can be developed.

SURVEY OF THE FIELD OF MECHAN TRANSLATION OF LANGUAGES, G Reitwiesner and M. H. Weik, Ballistic search Laboratories, U.S. Army, 65 pp., available from OTS, U.S. Department of merce.

Developments and problems in field of mechanical translation of guages by means of high-speed elect computers are analyzed in this Arm port.

The information, gleaned from a ature survey and from interviews workers in the field, covers the mecha translation activities of government, mercial, and educational institution the United States as well as contribu made in Britain and Russia. Includ a bibliography of 175 references.

The subject is described in term the two major aspects of machine t lation, methodology and equipment. methodology, the problems of g matical rules, syntactical analysis, tionaries, flow charts, and program are discussed. Information on equip deals with character sensing equip information storage devices, pri methods, and arithmetic or proce organs.

A number of general purpose tronic computing systems are disc along with the special purpose comp of the University of Washington an Air Force's Mechanical Translator 1. Predictions are made concerning f developments and the time necessar fore working programs in the ma translation field can be expected.

EXPERIMENTAL ALTITUDE PERFORMA OF JP-4 FUEL AND LIQUID-OXY ROCKET ENGINE WITH AN AREA R OF 48, Anthony Fortini, Charles D. He and Vearl N. Huff, May, 1959, 27 pp. (N MEMORANDUM 5-14-59E).

The performance of a rocket e having a nozzle area ratio of 48 wa perimentally measured at four alti and corrected to vacuum condition comparison of experimental perform with that of a sea-level engine havir area ratio of 5.5 was made.

The propellant combination JP-4 and liquid oxygen was used for bot gines. The chamber pressure was cor at 600 lb./sq. in. abs. Altitudes wer tained by an ejector system utilizin rocket exhaust gas as the pumping

Results indicate the large-area engine gives a specific impulse of lb.-sec./lb. at vacuum conditions. A level, the large-area-ratio engine countered flow separation within nozzle and the specific impulse was lb.-sec./lb. The results also include ured heat-transfer rates and heat loa the engine.

propulsion engineering

Basic studies on plastics . . .
at Brooklyn Polytechnic Institute will give propulsion engineers more data on solid propellants. Brooklyn Poly will study cracking in rigid plastic materials under a $28,325 Wright Air Development Center contract. Far from being "library research" on a theoretical level, the project is primarily concerned with cracking under actual environmental stresses. Although the materials to be studied first are not fuels or binders, the information they yield will be applicable to polysulphide rubber and polyurethane. Brooklyn poly researchers will first look at nylon, polystyrene and irradiated polyethylene.

Propellant grains may change radically . . .
if the study yields new information about cracking, and many chemists and engineers expect it will come up with new findings, since very little has been done along this line. Grain sizes, configurations, storage requirements and applications are controlled by cracking characteristics of plastic material fuels and binders.

You can learn solid state chemistry . . .
or at least the rudiments of the solid state chemistry you have to have in your work, in a quick, easy way—thanks to a new Department of Commerce ten-year study of Navy activity in the field. Commerce's Office of Technical Services reviews 75 Office of Naval Research Reports in solid-state work in "Solid State Chemistry: Final Report on the Activity During the Period of This Contract 1948-1957," Technical Report No. 76, $1.00. W. A. Weyl and E. C. Marboe break down a discussion of the properties of matter into five easy-to-follow subheadings, and then cover six classical areas.

The ortho-para hydrogen conversion . . .
which has been discussed in this column several times as a factor moving liquid hydrogen closer to practical consideration as a missile fuel, is used as a brief example of quantum mechanics in the study. Weyl and Marboe discuss the K. Fajans concept of chemical binding forces at length: "Quantum mechanics deviates from the classical approaches to chemistry by not using atoms or ions as the ultimate building units, but by referring to the interaction of nuclei and electrons . . ."

For missilemen the major points . . .
outlined in the report are:

(1) Building unit properties change with their environment; concept of a "constant chemical bond" can be misleading.

(2) Any disturbance of a crystal lattice creates a "depth action" on the chemical binding forces.

(3) The first principle is establishment of electro-neutrality in the smallest volume possible; the second is the need of screening of positive cores, which accounts for most elements being solids at room temperatures.

(4) The rate of many chemical reactions is determined by penetration of a proton into a polarizable anion; anion polarizability varies with thermal vibrations of surrounding ions.

Properties of oxide surfaces . . .
is one study covered by the final report. Others in the list of 76 papers which contribute to the review include:

Catalytic activity of gases on decomposition of hydrogen peroxide; decomposition of hydrogen peroxide by lead fluoride; catalytic activity of semiconductors; effect of foreign atoms on electronic properties of crystals; change of a P-type semiconductor into a N-type semiconductor by vapor treatment; mechanism of recrystallization and sintering; differential thermal analysis of metal hydroxides; application of the polarization theory to ceramic problems; kinetics of reactions between oxides in the solid state; structure of the high-temperature modification of lithium sulphate.

John H. Rubel, 39, on leave from the Hughes Aircraft Co., where he was director of airborne systems laboratories, has been named assistant director for strategic weapons in the DOD office of research and engineering headed by Dr. Herbert F. York.


RUBEL

An electrical en-eering graduate of California Institute Technology, Rubel has 16 years' ex-ience in the electronics industry. In 46, he joined the Hughes company, ere he contributed to work on auto-tic celestial navigation, the *Falcon* ies of air-to-air guided missiles and airborne armament control systems d in Air Force all-weather jet inter-tors.

Dr. F. Kenneth Brasted, president of University of Dallas since 1955, has ned Texas Instruments Inc. as ad-nistrative director of the Central Re-rch Laboratory. Dr. Brasted holds a helor of arts degree from the Univer- of Florida, an M.A. degree from lumbia University, and a Ph.D. from w York University. Before coming to llas, he served seven years as a mem- of the coordinating committee and ector of the educational department, tional Association of Manufacturers.

Space Technology Laboratories, Inc., appointed **Walter B. Brewer** manager its airborne systems and test depart-nt, *Atlas* Program Office. Brewer had n associate manager of the airborne ems and test department since joining in March of this year.

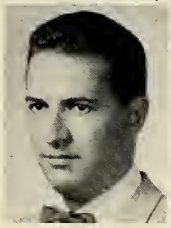
A new hypersonic tunnel department Cornell Aeronautical Laboratory, Buf-, will be headed by **King D. Bird,** merly head of the transonic tunnel de-tment. **James F. Martin** has been ned assistant head of the new depart-nt.

John P. Andes has been named head the transonic tunnel department and **W. Cotter,** assistant department head. les was formerly assistant department d of transonic tunnel.

Rocket Power, Inc., a subsidiary of the Gabriel Co., has named **A. Lincoln Pittinger** vice president for planning and marketing. Pittinger, closely linked with the rocket and missile industry sinee 1943, was commander of the first Navy rocket plant at China Lake. As civilian of product and production engineer- at NOTS through 1951, he helped place into production the Navy 2.75-inch *Mighty Mouse* aircraft rocket and many other advanced weapons. Called to Europe in 1952 by the NATO countries, he set up rocket facilities in Belgium and Greece to support the free world arsenal. Pittinger also has served as director of R&D for the Cooper Development Corp., and was responsible for major advances in upper-atmosphere sounding rockets. He resumed private practice in late 1957, and had been very active in the development of high-altitude meteorological sounding rockets prior to joining Rocket Power, Inc.


PITTINGER

Rocket Power, Inc., also has appointed **John K. Elder** vice president of its applied research and testing laboratories. Following graduation from the California Institute of Technology, Elder was employed by the Aerojet-General Corp. where he engaged in solid propellant research and development activities for four years. He joined Grand Central Rocket in 1955.


ELDER

William H. Clark is the new general superintendent of Allen B. Du Mont Laboratories, Inc. Clark will be responsible for the company's plant and office facilities in Clifton, Passaic, and East Paterson, N.J. He succeeds **Walter H. Husselrath,** who died on May 25.

At the Norden Division, United Aircraft Corp., **Samuel B. Sherwin** has been appointed manager of the Ketay department in Commack, L.I., and **Wladimir Reichel** engineering manager. A native New Yorker, Sherwin has been manager of the overhaul and repair department of UA's Hamilton Standard Division at Windsor Locks, Conn. Reichel is Norden's basic design chief and a pioneer in instrument miniaturization. Born in St. Petersburg, Russia, he has been in the United States since 1923 and holds numerous patents on servo components, gyro and navigational instruments. He directed important work on inertial navigational system development.


SHERWIN

Dr. Robert W. Perry has been named head of Republic Aviation's re-entry simulation laboratory in the company's new $14 million Astronautical Center. **Dr. Samuel Korman** will head the Materials Development Laboratory to create new alloys and synthetics capable of withstanding the rigors of outer space. Associated with Dr. Korman are **Dr. Robert P. Bastian** and **Dr. Stanley Zirinsky,** who have been appointed chief chemist and chief metallurgist, respectively. Perry was formerly manager of the research branch, gas dynamics facility, at the Arnold Engineering Development Center, and is a member of NASA's Advisory Committee on Fluid Dynamics. Korman was formerly a consultant to the Atomic Energy Commission, the Air Force and several American industrial firms. Before joining Republic, Bastian was associated with Sylvania Electric Products, where he was an engineering specialist in analytical and inorganic chemistry, and Zirinsky was previously staff consultant to the Missiles and Space Vehicles Division of the General Electric Co.

Woodman Perine, president of Vitro Engineering Co., has been named vice president of Vitro Corp. of America. **James C. Tourek,** chief project manager, was named acting general manager of Vitro Engineering, replacing Perine. In his new position, Perine will direct the activities of Vitro's Technical Services and Products Group which includes Vitro Engineering; the Refinery Engineering Co., Tulsa, Okla.; Nems-Clarke Co., Silver Spring, Md.; Thieblot Aircraft Company, Martinsburg, W.Va., and Vitro Laboratories, Silver Spring, Md.

Dr. A. W. Wortham, manager of the Quality Assurance Department, Semiconductor-Components division of Texas Instruments Incorporated, has been elected executive director of the American Society for Quality Control. Dr. Wortham has jurisdiction over District 14 of the ASQC, including Texas, Oklahoma, New Mexico, Louisiana and Mexico.

Shareholders of Lear, Inc. recently elected six new directors and re-elected eight to the board. The new directors are: **James L. Anast,** who became president on April 9, 1959; **Roy J. Benecchi,** group vice president; **Barney M. Giles,** assistant to the president; **Philip E. Golde,** senior vice president, secretary and general counsel; **K. Robert Hahn,** executive vice president, and **Andrew F. Haiduck,** group vice president.

Re-elected were **William P. Lear,** chairman of the board, and **Richard M. Mock,** chairman of the executive committee; and the following non-employee directors: **Harold R. Boyer** of General Motors Corp., **A. G. Handschumacher** of Rheem Manufacturing Co., **Kenneth MacGrath** of High Standard Manufacturing Corp., **Richard W. Millar** of William R. Staats & Co., **Clarence J. Reese** of Continental Motors Corp. and **Russell A. Stevenson,** University of Michigan.

Jay W. Schnackel has been appointed vice president of Remington Rand Division of Sperry Rand Corp. in an overall staff position in the company's Univac-Tabulating Division. Schnackel has been vice president for manufacturing services of International Business Machines Corp. since 1956.

ARPA

$600,000—**RCA**, for studying the feasibility of tracking and intercepting enemy space satellites.

MISCELLANEOUS

$193,000—**Avion Div. of ACF Industries, Inc.**, Paramus, N.J., for production of radar beacons used in test firings to extend the precision of tracking range of ground radar. (Contract awarded by the United Kingdom Treasury and Supply Delegation in the U.S.)

NASA

Grumman Aircraft Engineering Corp., has been awarded a contract to conduct studies concerning the search and recovery operations of Project *Mercury*. (Amount not disclosed.)

$100,000—**Applied Science Corp. of Princeton**, for airborne statistical telemetering equipment for Project *Mercury*. (Subcontract from **McDonnell Aircraft Corp.**).

NAVY

Stavid Engineering, Inc., Plainfield, N.J., for initiation of a new, advanced, lightweight shipboard radar, designated AN/SPS-40. (Amount not disclosed.)

$3,750,000—**Collins Radio Co.**, Cedar Rapids, Iowa, for production of electronic counter-measures receivers to be installed on both surface and undersea craft.

$140,050—**Cooper Development Corp.**, Monrovia, Calif., for development and fabrication of flight instrumentation assemblies.

$128,000—**Ralph T. Viola**, Oxnard, Calif., for site preparation for Cotar acquisition system at Point Mugu, Calif.

$100,000—**Magnetic Research Corp.**, Hawthorne, Calif., for production of 28 volt, 60 cps ground power supplies for use on the *Talos* missile.

$92,000—**Les Kelley**, Belmont, Calif., for instrumentation site, Point Pillar, Princeton, Calif., for naval missile center, Point Mugu, Calif.

$87,000—**NRC Equipment Corp.**, Newton Highlands, Mass., for design, development and production of ultra-high-vacuum gauges for satellite instrumentation.

$49,929—**Raymond Engineering Laboratory, Inc.**, Middletown, Conn., for design, manufacture and evaluation of rocketborne ionosphere antennas, housing units and antenna opening mechanisms.

$34,800—**General Dynamics Corp., Liquid Carbonic Div.**, Los Angeles, for liquid bulk oxygen.

$32,688—**Broderick & Bascom Rope Co.**, St. Louis, for wire rope, 6x19, preformed, high-strength, uncoated for aircraft launching and arresting.

$26,390—**Century Tool Co.**, Palmyra, N.Y., for organizational maintenance and assembly tool kit for the *Nike*.

AIR FORCE

Hermes Electronics Co., Cambridge, Mass., has been awarded a contract of more than $1,000,000 dollars for timing equipment for the IBM Bombing-Navigation Missile Guidance System to be used in the B-70 (subcontract from **International Business Machines Corp.**).

Westinghouse Electric Corp., Air Arm Div., Baltimore, has been awarded a "multi-million" dollar contract for development and building of a defensive system for the B-70 (subcontract from **North American Aviation**).

$47,000,000—**Sperry Gyroscope Co.**, **Great Neck**, N.Y., for development and production of high-powered air search radar systems.

$3,900,000—**Ryan Aeronautical Co.**, for *Firebee* jet targets to be used to simulate "enemy" attacks at Tyndall AFB, Fla.

$3,600,000—**Lear, Inc., Instrument Div.**, Grand Rapids, Mich., for coordinate converter systems for the early version of the Boeing *Bomarc IM-99*. (Total program now exceeds $20,000,000.)

$2,712,132—**Convair Div. of General Dynamics Corp.**, for B-58 mobile training units.

$2,300,000—**International Telephone & Telegraph Corp.**, San Fernando, for 36 multiple voltage supply systems for the B-58 (subcontract from **Convair Div. of General Dynamics**).

$1,843,944—**General Precision Laboratory, Inc.**, for navigation equipment components.

$1,706,469—**Convair Div. of General Dynamics Corp.**, San Diego, for installation of new Azusa Mark II missile tracking equipment at Cape Canaveral.

$1,500,000—**Electronic Associates, Inc.**, Long Branch, N.J., for range instrumentation equipment for the Eglin Gulf Test Range (subcontract from **IT&T**).

$951,374—**Convair Astronautics Div. of General Dynamics Corp.**, San Diego, for design, development and fabrication of a cosine rate system for the Azusa Mk II and other related items.

$819,400—**Diversified Builders**, Cocoa, Fla., for construction of a blockhouse for the *Saturn* missile at Cape Canaveral.

$194,692—**Conoga Div. of Underwood Corp.**, Ft. Walton Beach, Fla., for seven airborne timing systems to be used in telemetry aircraft of the AFMTC's 6550th Operations Squadron.

$182,500—**Raytheon Mfg. Co., Missile Systems Div.**, Waltham, Mass., for 13 Rayspan spectum analyzers.

$153,000—**Model Engineering & Mfg., Inc.**, Huntington, Ind., for signal generators to support various aircraft and missiles.

$100,000—**Ratigan Electronics, Inc.**, Glendale, Calif., for components to be used in the *Falcon* (subcontract from **Hughes Aircraft Co., Tucson Div.**).

$86,971—**Graflex, Inc.**, Rochester, N.Y. for 231 speed graphic camera sets.

$54,717—**Motorola, Inc.**, Phoenix, Ariz., for sub-miniature frequency modulated UHF radio receiver set used to receive and decode range safety command signals during missile flight operations.

$43,930—**Cooper Development Corp.**, Monrovia, Calif., for *Aspan* rocket vehicles, less *Nike* booster and *Nike* fins, engineering field service and firing circuit test set.

$37,955—**University of Illinois**, for laboratory investigation of SAGE operator performance factors contributing to operator fatigue.

$36,000—**Minneapolis-Honeywell Regulator Co., Aeronautical Div.**, Minneapolis, for liquid oxygen amplifiers for various aircraft.

$35,000—**Consolidated Avionics Corp.**, Westbury, N.Y., for a strain gage data reduction system (subcontract from **Hamilton Standard Div., United Aircraft Corp.**).

ARMY

BJ Electronics, Borg-Warner Corp., Santa Ana, Calif., for GMD-1 transportable ground tracking and data recording equipment (substantial addition to a $500,000 initial contract).

$3,172,929—**Douglas Aircraft Co. Inc.**, Santa Monica, for launching area items.

$2,798,219—**Blount Brothers Construction Co.**, Montgomery, Ala., for construction of *Bomarc* facilities.

$2,390,567—**Jet Propulsion Laboratory, Calif. Institute of Technology**, for continued research and development of the *Sergeant*.

$981,000—**Sperry Utah Engineering Laboratory**, Salt Lake City, for *Sergeant* missile repair parts.

$900,000—**The Firestone Tire & Rubber Co.**, Los Angeles, for the *Corporal* missile.

$390,000—**Rheem Manufacturing Co.**, Downey, Calif., for research and development.

$363,961—**Westwood Construction Co.**, Denver, for construction of liquid oxygen facility at F. E. Warren AFB, Cheyenne, Wyo.

$260,483—**Gilfillan Brothers, Inc.**, Los Angeles, for engineering services.

$150,879—**Douglas Aircraft Co., Inc.**, Santa Monica, for *Honest John* program.

$140,000—**The Rust Engineering Co.**, Pittsburgh, Pa., for architect-engineer services in connection with design of Third Increment Missilemaster facilities.

$122,599—**Murray Construction Co.**, Battle Creek, Mich., for building rehabilitation for SAGE support facility at Fort Custer AFB.

$100,000—**Paul Monroe Co.**, Bell Gard Calif., for construction of specialized draulic equipment for actuating the d of "half-hard" *Atlas* sites at Fairc AFB.

$85,000—**Pennsylvania State University**, versity Park, Pa., for research and velopment on the determination of tron densities of the ionosphere.

$84,240—**Motordyne, Inc.**, Monrovia, C for motor generators.

$75,000—**Ryan Aeronautical Co.**, San D for miscellaneous support items.

$70,000—**California Institute of Technol** Pasadena, for research and developm

$68,577—**Gilfillan Brothers, Inc.**, Los A les, for *Corporal* missile repair parts.

$64,481—**The Andy Electric Company** Andalusia, Ala., for the installatior 500 KW engine generators at Cape Blas, Fla.

$60,000—**University of Florida**, Gaines for basic research.

$57,527—**Aircraft Armaments Inc.**, Coc ville, Md., for design, fabrication and livery of a rocket sled.

$56,279—**Telemetering Corp. of Ame** Sepulveda, for technical services.

$54,161—**Nortronics Div., Northrop C** Anaheim, Calif., for research and dev ment.

$50,359—**Douglas Aircraft Co.**, Charl N.C. for *Nike* spare parts and compon

$49,850—**Spectralab Instruments**, Monr Calif., for telemetry systems.

$39,800—**Servomechanisms, Inc.**, Hawth Calif., for computer systems.

$35,000—**North American Aviation, Ro dyne Div.**, for design and developme

$34,042—**Interstate Electronics Corp.**, heim, Calif., for supplies.

$34,000—**Murice H. Connel & Associates**, Miami, Fla., for architect-engine services for design of *Saturn* missile ice structure at Patrick AFB, Fla.

$31,911—**Motorola, Inc.**, Phoenix, for tel try sets.

$30,800—**Thiokol Chemical Corp.**, El Md., for motor, recruit and solid pr lants.

$25,686—**Ryan Aeronautical Co.**, San I for target missile flight service pro

$16,636—**Western Electric Co., Inc.**, York, for *Nike* spare parts and co nents.

BIDS

The following bids were made publ

Ogden Air Materiel Area, Hill AFB, Att: Directorate of Procurement and duction.—Removal and installation c tenna supporting structures at Site adjacent to McChord Air Force Wash.—Job—IFB 42-600-59-336B—Bid ing 22 June '59. If reply necessary for OOPPCS-2.

U.S. Army Engineer District, Sacra Corps of Engineers, Wright Bldg., mento, Calif.—Radar tower, FPS-7 pah AF Station, Tonopah, Nev.— IFB Eng. 04 167 59 67B. Bid openi June '59.

Procurement Office, Patrick Air Force Fla.—Installation of fire protectior emergency shower facilities for laur pads 5, 6 and 26A & B, Cape Can Missile Test Annex, Fla.—Job—IF 606-259B. Bid opening 29 June '59.

U.S. Army Engineer District, Los A Corps of Engineers, 751 So. Figuer Los Angeles 17, Calif. Construction final increment of a technical bu complete, including appurtenant u and site improvements at Army Elec Proving Ground, Ft. Huachuca, Ariz IFB Eng 04-353-59-95. Bid openi June '59.

Purchasing and Contracting Branch, ing T-5333, Fort George G. Mead Alterations and improvements to and drainage at *Nike* site 25, 26, 30, 43.—Job—IFB 18-102-59-98. Bid o 24 June '59.

U.S. Naval Air Station, Oceana, V Beach, Va., Air condition guided support bldg. No. 920 at Naval A tion, Oceana, Va.—Job—IFB NBY Bid opening 25 June '59.

212 L EXPEDITE

ENGINEERS • SCIENTISTS

General Electric's Heavy Military Electronics Dept.

AWARDED CONTRACT FOR

Systems Integration, Engineering, and Management of...

AIR WEAPONS CONTROL SYSTEM 212L

A universal electronic control system to meet the vast problem of Air Defense outside of the Continental United States

Systems-oriented engineers and scientists will appreciate the broadband technical challenge of the Air Weapons Control System 212L. There are important openings for men who are experienced in: WEAPONS SYSTEMS ANALYSIS • MATHEMATICAL ANALYSIS OF ENGINEERING PROBLEMS • COMPUTER PROGRAMMING • MILITARY COMMUNICATION SYSTEMS • RADAR SYSTEMS • WEAPONS CONTROL SYSTEMS • ELECTRONIC CIRCUITRY • INDUSTRIAL & MILITARY PSYCHOLOGY.

Working in close cooperation with the USAF, it is Heavy Military's responsibility to integrate all subsystems—data acquisition, communications, data processing and display—plus various defensive weapons into a well coordinated and efficient operating system.

VERSATILE AIR CONTROL APPLICATIONS The revolutionary 212L can be used to defend a single airfield, or, by linking control sites together, it could be used in a limited action to provide air control for an area the size of Alaska. Similarly, by linking the capabilities of countries together, a system could be provided for the air control of an entire continent. Designed for *both* fixed and mobile applications, the 212L will be used primarily outside the U. S. since the SAGE system is used for the defense of this country.

HMED IS ALSO DESIGNING THE "HEART" OF THE SYSTEM
In addition to its prime mission of providing systems management, HMED will design, develop and produce the data processing and display subsystem which is the "heart" of the 212L. Capable of rapidly and automatically detecting and tracking air targets, the subsystem operates without human assistance, except under unusual circumstances.

OTHER FAR-RANGING PROGRAMS AT HEAVY MILITARY

At the present time additional far-ranging programs are being pursued in diverse and important areas at HMED:

- Fixed & Mobile Radar
- Shipborne Radar
- Underwater Detection Systems
- Missile Guidance
- Data Handling Systems
- Communications

Individuals with experience in systems analysis or specific equipment design in the areas listed above are invited to forward their resume in complete confidence to Mr. George Callender, Div. 73-WY.

HEAVY MILITARY ELECTRONICS DEPARTMENT

GENERAL ELECTRIC

COURT STREET SYRACUSE, N. Y.

JUNE

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

Nuclear Industry Division, Instrument Society of America, Second National Symposium, Idaho Falls, Idaho, June 24-26.

Institute of Radio Engineers' Professional Group on Military Electronics, Third National Convention on Military Electronics, Sheraton Park Hotel, Washington, D.C., June 29-July 1.

Pennsylvania State University, Summer Seminar on Plastics—Its Mechanical Properties, Design and Applications, University Park, Pa., June 29-July 3.

JULY

Tenth Annual Basic Statistical Quality Institute, University of Connecticut, Storrs, July 12-24.

Radio Technical Commission for Aeronautics and Los Angeles Section of the Institute of Radio Engineers, Third Biennial Joint Meeting, Ambassador Hotel, Los Angeles, July 16-17.

Scond Annual Institute on Missile Technology, Chief of Research and Development, U.S. Army, University of Connecticut, Storrs, July 26-Aug. 7.

The Denver Research Institute of the University of Denver, 6th Annual Symposium on Computers and Data Processing, Stanley Hotel, Estes Park, Colo., July 30-31.

AUGUST

Institution of Investigation of Biological Sciences, sponsored by Air Force Office of Scientific Research—Aeromedical Div., World Health Organization and United Nations Educational Scientific and Cultural Organization, Montevideo, Uruguay, Aug. 2-7.

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

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

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

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

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.

Air Force Association and Panorama; send reservations to AFA Housing Bureau, P. O. Box 1511, Miami Beach, Sept. 3-6.

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

Instrument Society of America, Conference and Exhibit, Chicago, Sept. 21-25.

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

American Rocket Society, Solid Propellants Conference, Princeton University, Princeton, N.J., Sept. 24-25.

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

OCTOBER

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

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

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

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

Institute of Aeronautical Sciences, Annual Midwestern Meeting, Lassen Hotel, Wichita, Kan., Nov. 3-4.

Mid-American Electronics Conference, Kansas City, (Mo.) Municipal Auditorium and Hotel Muehlebach, Nov 3-5.

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

The Institute of Radio Engineers, 1959 Northeast Electronics Research and Engineering Meeting, Boston Commonwealth Armory, Boston, Nov. 17-19.

Advertisers' Index

SHARPEST new "eye" for flight is the Ryan C-W Doppler navigator. Based on the advanced development of continuous-wave radar, this system of electronics "intelligence" has been pioneered by Ryan and the U.S. Navy for navigation at all speeds. It tells pilots how to fly to any spot on the globe, with speed and precision, and lets them know exactly where they are at all times.

With the Ryan navigator, military aircraft and jetliners can fly a new "electronic skyway" which provides precise separation between planes and conserves time and fuel. And, because RYANAV systems work right down to ground and sea levels, these advantages accrue at take-off, climb-out, descent and landings, as well as enroute.

The Navy has selected RYANAV for installation in six major types of naval aircraft. They are already in squadron use in the Navy's first all-weather anti-submarine helicopters and are being installed in Army aircraft and helicopters, for low-level "nap of the earth" operations.

Reasons for such wide and versatile use are found in the unique features of RYANAV systems: They are the lightest, simplest, most reliable, most compact of their type. They are setting new standards of accuracy, freedom from adjustment, and ease of maintenance . . . opening new areas of navigational, guidance, and orientation applications. Ryan electronics engineering assistance is available upon request, to those who wish to explore these areas.

Ryan's rapid growth in electronics is creating new opportunities for engineers and technicians

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