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missiles and rockets

Magazine of World Astronautics

October, 1957 Volume II, No. 10

Subscription Rates:

Domestic		Foreign	
1 year	$ 8.00	1 year	$ 9.00
2 years	$12.00	2 years	$14.00

Single copies $ .75

Subscription Service: All subscription orders, correspondence, and change of address should be sent to:

Geneva C. Kinnaird
Circulation Fulfillment Manager
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Changes of Address: Send old address exactly as imprinted on mailing label of your magazine copy, and new address with zone number if any, to above address and allow two weeks for change-over.

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Publishing Information: Published every month by American Aviation Publications, Inc., Washington, D.C. Printed at The Telegraph Press, Harrisburg, Pa. Second Class mail privileges authorized at Washington, D. C., with additional entry at Harrisburg, Pennsylvania.

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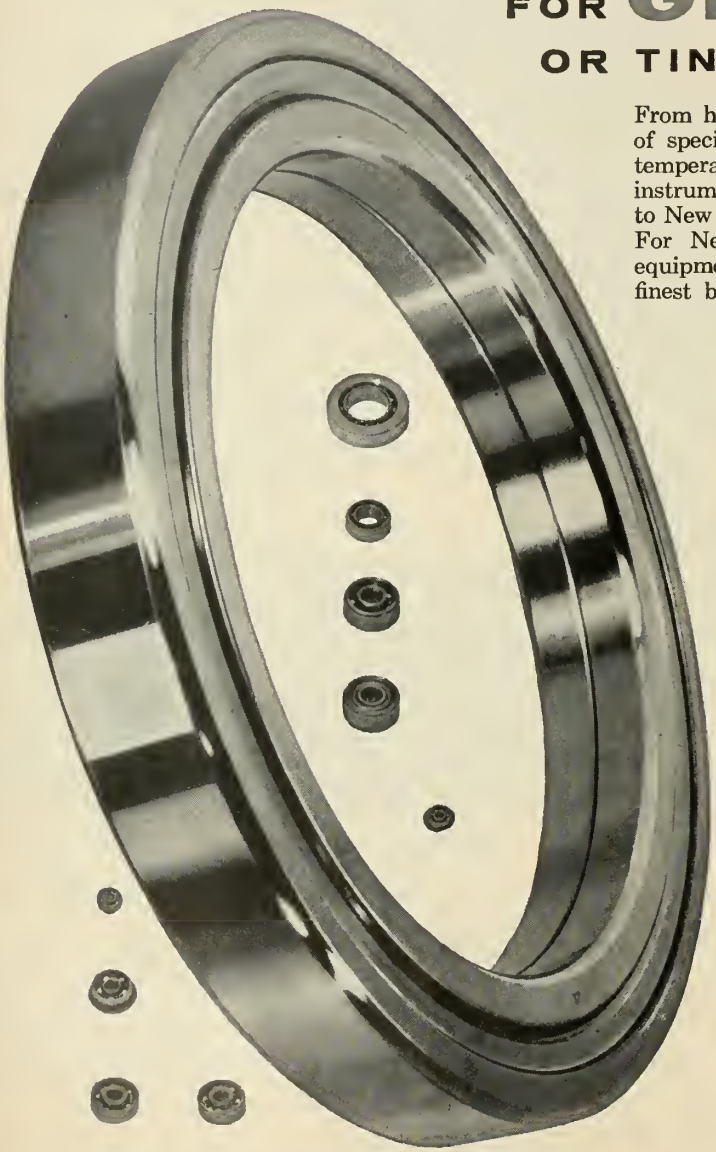

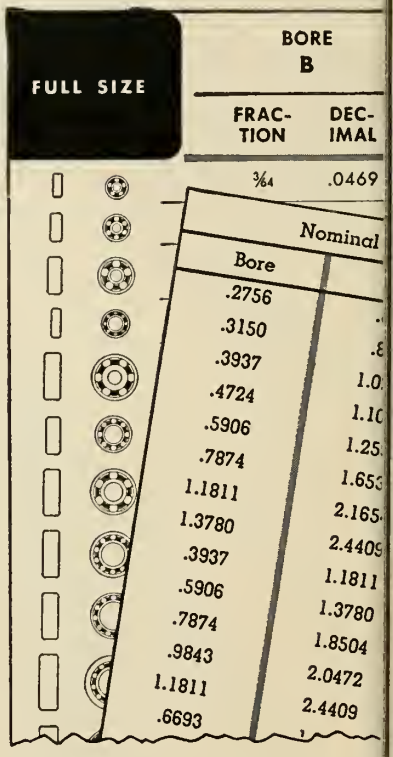

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NOTHING ROLLS LIKE A BALL

news and trends

special features

missile production

industry spotlight

missile electronics 157

next issue: Human Factors in Space Flight

cover picture:

Oerlikon's type 54 SAM, over 19 feet long, is regarded as one of the world's best antiaircraft missiles. The type 54 is a beam-rider and utilizes a liquid propellant engine burning white fuming nitric acid and kerosene. The beam-transmitter of the type 54 system is shown on the cover of missile electronics *(following page 156) and has both coarse-beam and fine-beam guidance.*

columns

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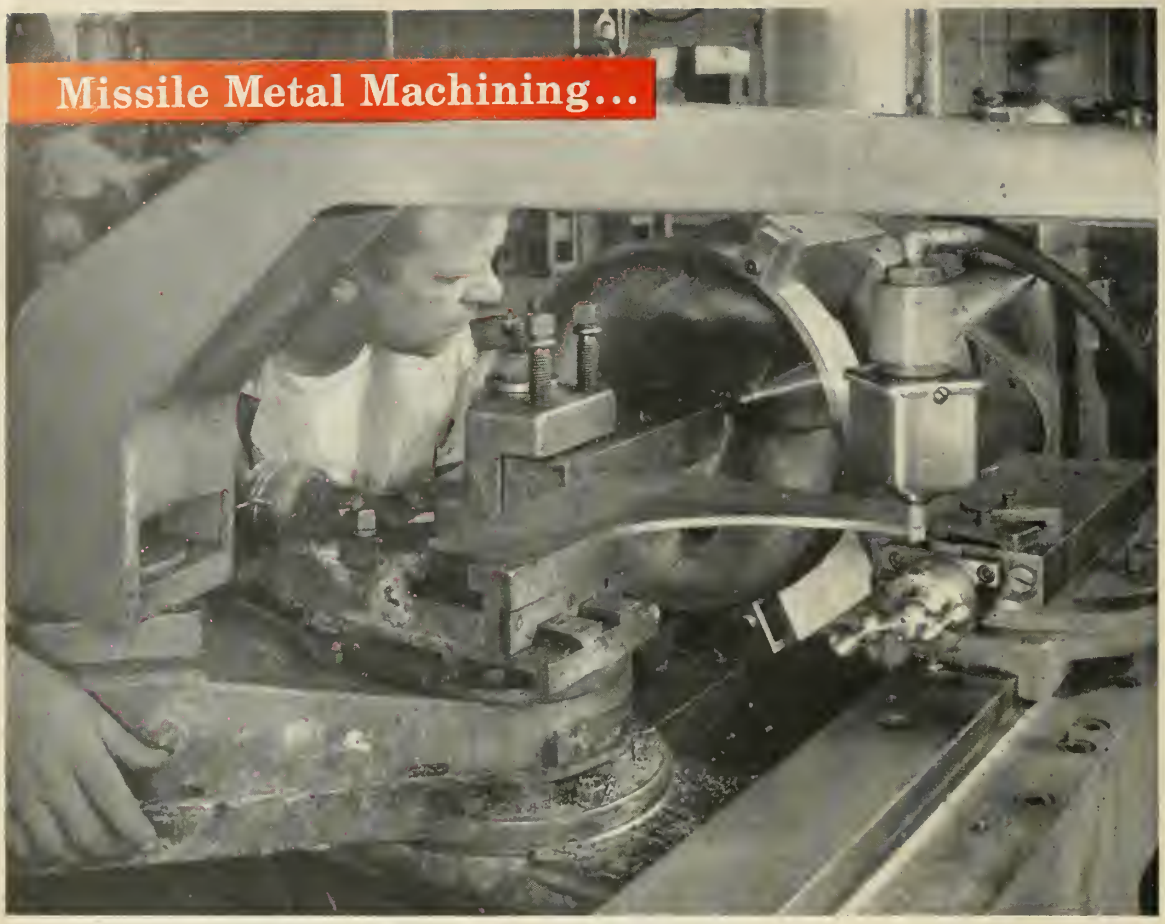

FROM BLANKS TO BULKHEADS!

The Diversey craftsmen above is machining the inner diameter of a Forward Bulkhead of the Hawk missile to a fine 63 microinch finish. Notice the precision curved template in the center of the picture with the follower at the right end transferring the contour to the interior of the bulkhead. Another good example of the famous air gage tracer lathe technique that has brought the missile hardware field to such an advanced state.

Diversey starts with blank forgings. Using their remarkable ability to integrate hydrospinning and contour turning techniques Diversey craftsmen are able to produce the finest and most precise missile and rocket hardware components.

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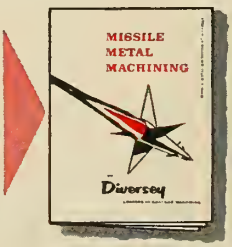

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missiles and rockets

Magazine of World Astronautics

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From Air Force to Space Force

Washington defense planners and Air Force officials were jolted recently by a brilliantly written article in LOOK magazine. With the cover headline "The Coming Death of the Flying Air Force," LOOK introduced to the man in the street one of today's most thought-provoking topics. This inevitable article expressed the views that Air Force people themselves have been too frightened to mention in the open. This is in spite of the fact that AF experts such as General Nathan Twining have warned that the AF must encounter considerable cuts in terms of manned planes and that missiles are on the way in.

The LOOK article meticulously detailed the increased use of missiles in place of aircraft—a view that we have shared and expressed in our columns since our very first issue. Nevertheless, the LOOK article built chronologically to the "coming death of the flying Air Force," implying that with the ascendancy of the missile in current military concept there would be no need for a separate air force.

We disagree with this view. You don't need to be an expert to foresee that the Air Force will continue to be our most important arm of retaliation for immediate action against any Russian blow against the Free World. But the Air Force gradually will become a Space Force—with clipped wings, with rocket ships instead of airplanes. By-and-by our Air Force will have to build up a space force system. Today's fighter squadrons will become space reconnaissance squadrons tomorrow. Goodbye to the pilot? No, tomorrow's rocketcraft will be manned. They will be manned by a new breed of pilot. Col. John P. Stapp, Maj. David Simons and a few others are paving the way for these pilots of tomorrow. And our space force will pave the way for the new defense system in general.

The question remains, however, whether our Air Force planners fully comprehend all this. Do they have the vision to understand that now is the time for transition from planes to missiles and spacecraft?

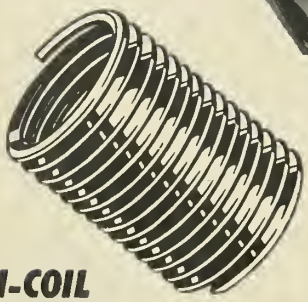
The Air Force will never become a Space Force by capriciously cutting Air Force Office of Scientific Research's expenditure rate. It will never become a Space Force if it continues to allow routine personnel action to put out to pasture such pioneering scientific genius as that of Col. William O. Davis, Deputy Commander, Operations, AFOSR.

AFOSR has one of the smallest budgets in the country. Yet, for the future of America's military security, for man's advance into space, there is no office or agency that is more important. Nor in the experience of this country's rocket men is any one more capable of aiding and abetting this advance than Col. Davis. The murmur of protest at the AFOSR budget cut has swelled into a rumble, and top Pentagon planners had second thoughts. The money has been reinstated. There are no such reports however that minds will also be changed about Bill Davis' impending transfer to conventional duties in Dayton.

The fact that AF would cut its exploratory research budget and shuffle off one of its most practical and imaginative researchers is bad enough in itself. What is more fundamental, however, is the existence of thinking in high places that would permit such actions to occur. It is the thinking of men chained by links with the past and blinded by the brilliance of the future, of men who think tomorrow will be just like today. It is the kind of thinking that will, in fact, make the LOOK article a forecast of things to come; that will in fact assure the "Coming Death of the Flying Air Force."

ERIK BERGAUST

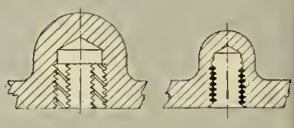
Here's Use



HELI-COIL Stainless Steel Screw-THREAD Insert

This is the insert that permanently protects threads against wear, stripping, corrosion, galling, seizing, vibration and shock. Made of (18-8) stainless steel wire, cold-rolled into a diamond shaped cross-section, this ***Heli-Coil*** Insert is work hardened to a tensile strength of approximately 200,000 psi . . . conforms to military standards MS 122076 through 122275 (ASG) and MS 124651 through 124850 (ASG) . . . conforms to standard commercial and industrial thread forms, including coarse, fine, pipe-thread and MM sizes . . . permits use of standard boss configurations.

Here Are



Save Space, Weight and Costs

Substantiol savings in materials, weight, space ond casts are possible, as ogoinst solid bushings, becouse smoller (or standard) bosses, flanges and threoded fasteners can be used.

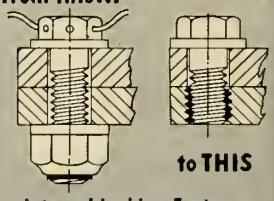
New HELI-COIL Stainless Steel Screw-LOCK Insert

Pat. Pending.

Conforming to military specifications for locking torque and vibration, this notable new ***Heli-Coil*** Screw-LOCK *one-piece* insert provides all the thread protection of the Screw-THREAD Insert, **PLUS** an exclusive internal locking feature that eliminates the need for clumsy protruding lock nuts, lock wiring and other supplementary locking devices . . . saves cost, space and weight . . . permits simplified streamlined design. The Insert is a permanently integrated part of the component—permits repeated service repair disassembly and reassembly, *with locking action remaining unimpaired.* Available in sizes from 4-40 up.

Here Are

from this...



to THIS

Internal Locking Feature

Insures positive internal locking action—eliminates lock nuts, lock wiring and other protruding locking devices—saves space, weight, cost. Yet screw may be easily disassembled with no loss of locking torque.

➡ ***Heli-Coil*** **Field Engineers are at your service for**

CUSTOM LOCK NUTS

The ***Heli-Coil*** Screw-LOCK Insert is adaptable to special-shaped lock nuts, shells, spacers and fasteners and can be engineered to meet your torque or performance requirements. ***Heli-Coil Corporation*** is fully equipped to manufacture these special lock nuts to your specifications.

Note: Custom nuts, with Screw-LOCK Inserts, meet military specifications for lock nuts.

How Design Engineers HELI-COIL* INSERTS to

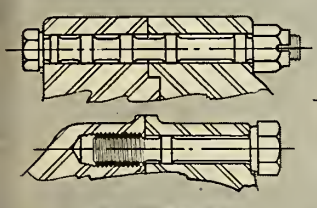
SAVE: SPACE—WEIGHT—COSTS

PERMANENTLY PROTECT THREADS AGAINST

ABUSE • WEAR • CORROSION • STRIPPING • GALLING • SEIZING • VIBRATION

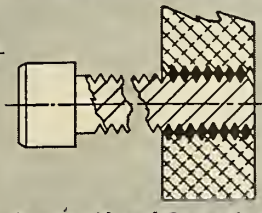
Eliminate Lock Nuts — Lock Wiring — Lock Washers

Some Typical *Heli-Coil* Screw-THREAD Applications



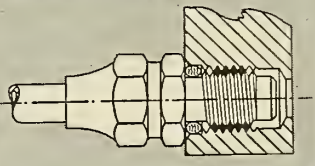
Compact Design

Improves design features by elimination of nuts, washers and extra-length bolts.



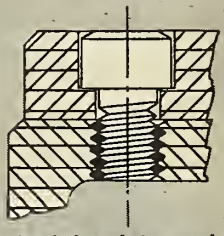
Stronger Thread Connections

Under excessive tension, torsion and impact loads in standard proportion bosses, the screw will break but the *Heli-Coil* Screw-THREAD Insert will remain undamaged . . . even in light alloy metal.



Leak-Proof Connections

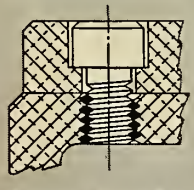
In lightweight, high pressure hydraulic equipment, stainless steel inserts, regular and pipe thread, protect threaded pump and valve ports sealed with "O" rings.



Steel Threads in Wood, Plastics and Fiberglas

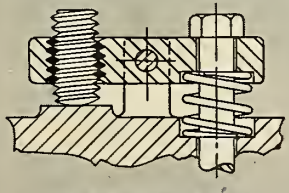
Provides permanent, strong, corrosion-resistant and wearproof threads in soft materials. Especially valuable where frequent assembly and disassembly is necessary.

Some Typical *Heli-Coil* Screw-LOCK Applications



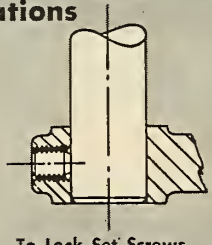
Flush Nut Assemblies

Permits a securely locked, flush assembly, because its internal locking feature eliminates need for drilled head bolts and other protruding locking devices.



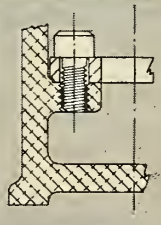
Lock Adjustment Screws

This simple design allows permanent, positive adjustment of screws in any position; secure against vibration or impact.



To Lock Set Screws

Positively locks assembly against loosening at desired adjustment — protects threads against stripping under high torque—permits use of light housing materials.



Inaccessible or Miniaturized Assemblies

Heli-Coil Screw-LOCK Insert permits installation of the locking feature from front or top. No blind fumbling for assembly of locking devices inside or behind.

design consultation — without obligation.

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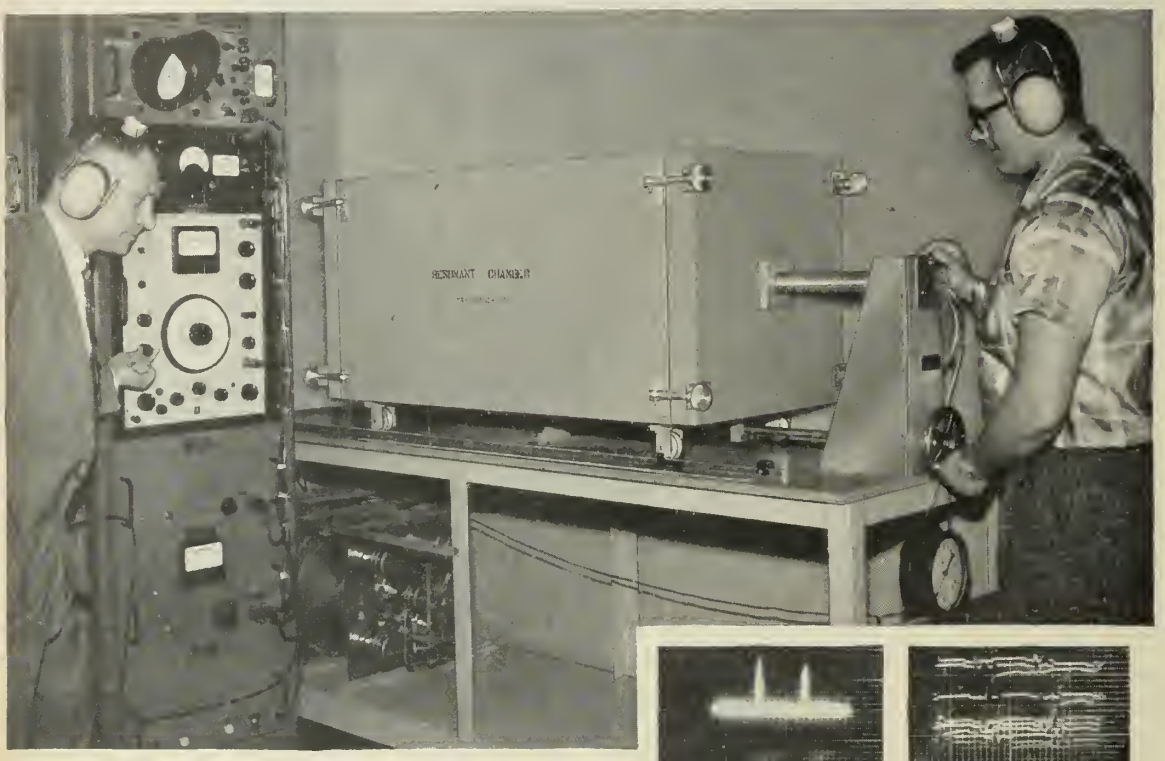
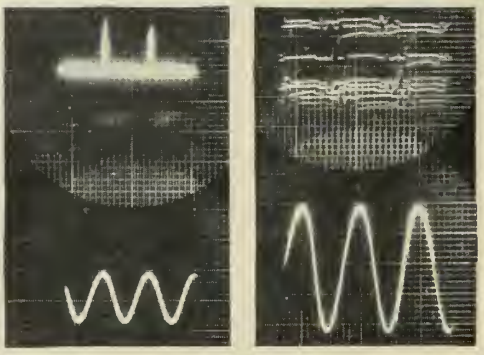


L to R: Dr. Fricke, Engineer-in-charge Acoustics Laboratory, and Mr. Kuzara Acoustics Engineer, evaluating a component in a high intensity acoustic environment. RIGHT: Malfunction of a relay at high-intensity sound as disclosed in a sound chamber.



Contact resistance at 140 d b sound-pressure level.

Contact chatter of same relay at 150 d b sound-pressure level.

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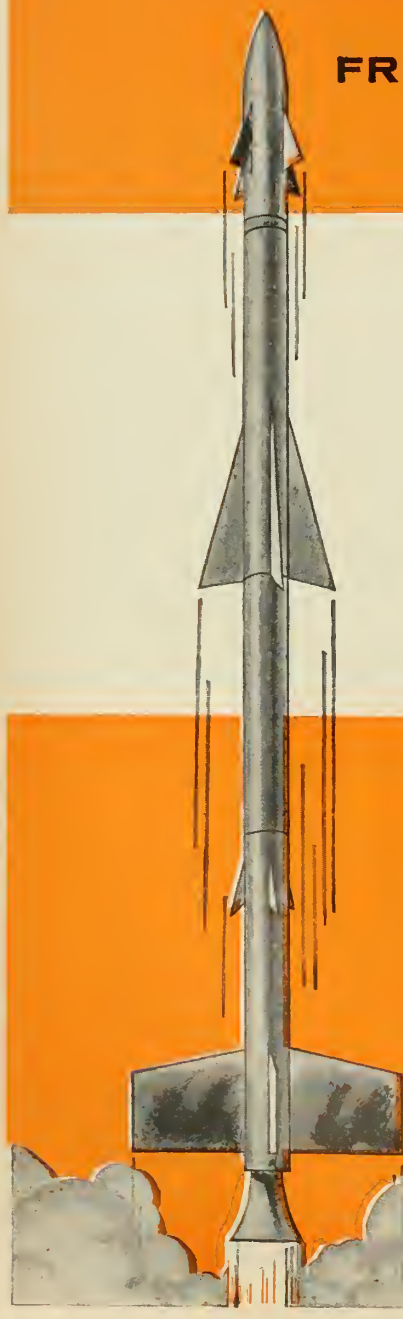

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2) Checks individual thermocouples "on the bench" before placement in parallel harness.

3) Checks thermocouples within the harness for continuity.

4) Checks thermocouples *and* paralleling harness for accuracy.

5) Checks resistance of the Exhaust Gas Temperature system.

6) Checks insulation of the EGT circuit for shorts to ground and for shorts between leads.

7) Checks EGT Indicators (in or out of the aircraft).

8) Checks EGT system with engine removed from aircraft (in production line or overhaul shop).

9) Reads jet engine speed while the engine is running with a guaranteed accuracy of ±0.1% in the range of 0-110% RPM. Additionally, the TAKCAL circuit can be used to trouble shoot and isolate errors in the aircraft tachometer system.

10) JETCAL Analyzer enables engine adjustment to proper relationship between engine temperature and engine RPM for maximum thrust and efficiency during engine run (Tabbing or Micing).

ALSO *functionally* checks aircraft Over-Heat Detectors and Wing Anti-Ice Systems (thermal switch and continuous wire) by using TEMPCAL Probes.. Rapid heat rise . . . 3 minutes to 800°F! Fast cycling time of thermal switches . . . 4 to 5 complete cycles per minute for bench checking in production.

Tests EGT System Accuracy to ±4°C at Test Temperature

(functionally, without running the engine)

Tests RPM Accuracy to 10 RPM in 10,000 RPM (±0.1%)

The JETCAL is in worldwide use . . . by the U. S. Navy and Air Force as well as by major aircraft and engine manufacturers. Write, wire or phone for complete information.

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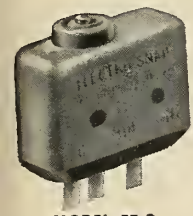
Circle No. 14 on Subscriber Service Card.

FOUR PROVEN ANSWERS TO SWITCHING PROBLEMS

Subminiature sealed switch is environment-free; mounts interchangeably with MS25085

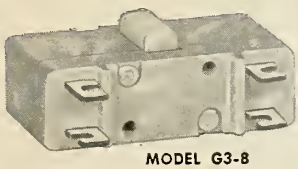


MODEL EF-3

gle Pole, Double Throw
re. Differential, .004 Max.
rtravel, .003 Min.
er. Force, 5 to 17 oz.
ease Force, 60 grom
. Life Ratings:
50,000 ops. @ 125/250 V. A.C., 2.5 AMP.
00,000 ops. @ 125/250 V. A.C., 5.0 AMP.
50,000 ops. @ 30 V. D.C., (2.5 AMP., IND.; 4.0 AMP., RES.)
p. Temp., −65° to +180° F.

Sealed in a corrosion-resistant, treated aluminum enclosure, this tiny switch is environment-free; highly vibration and shock resistant. It carries 5 amps. at 125/250 V.A.C. with an electrical life rating of 100,000 operations. Low operating force and small movement differential make it ideal for bi-metal temperature, diaphragm operated and other "feather-touch" devices, while small size permits mounting singly or ganged in restricted space. Rugged and dependable, it has positive snap action.

ny 40 amp. basic switch has high pacity, longer life and constant ability of tolerances



MODEL G3-8

asuring only 1¾" x 43/64" 5/64", the Electro-Snap G3-8 ic Switch handles current rat- up to 40 amps. A new hod of combining Electro- p's double-break action with eavy-duty switching element ires electrical and mechanical of 100,000 cycles at large acities; also provides constant stability of tolerances and accurate eatability. New plastic compound case gives the switch an am- nt temperature rating of —100° to +300° F. with extreme shock stance. Small size makes it ideal for motor controls and compact omation set-ups. A wide range of actuators is available.

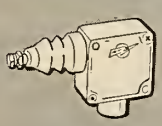
OPERATING CHARACTERISTICS

Single Pole, Double Throw
40 AMPS @ 125/250 V. A.C.
@ 30 V. D.C. Res.
Oper. Force, 45 oz. Approx.
Overtravel, .015" Min.
Move. Differ., .055 ± .010

ELECTRO SNAP

PRECISION SWITCHES

BASIC SWITCHES

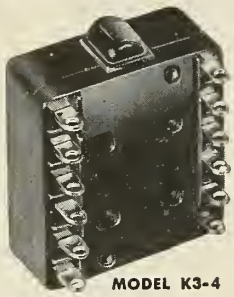


DIECAST ENCLOSED SWITCHES

HERMETICALLY SEALED LIMIT SWITCHES

CONFORM TO MIL & AN SPECIFICATIONS

Simultaneous triple-pole switch interrupts 3-phase ac. circuits; 6-circuit control in a small package



MODEL K3-4

Triple-Pole, Double Throw
15 AMP., 125/250 V. A.C.
30 V., D.C. Res.
10 AMP., 30 V., D.C., Ind.
Overtravel, .015 Min.
Move. Diff., .028 ± .007
Mech. Life, 1,000,000 ops.
Elec. Life, 500,000 ops.

This Electro-Snap triple-pole switch simultaneously reverses current flow through three windings of a 3-phase motor up to 1 H.P. and interrupts other types of multi-switching installations. Instantaneous "make" and "break" snap-action of the three poles is independent of the speed of actuation—even extremely slow moving cams can be used.

The K3-4 Series offers designers a wide variety of 3-phase circuit hookups for servo-controls, to limit movement of machine members and as a start-and-stop switch which formerly were possible only with complicated relays or a number of separate switches. A large selection of standard actuators is available.

Small basic switch is low cost; directly interchangeable with AN3234 Specs

F2 SERIES

These Electro-Snap F2 Series snap action switches are extra-compact with extremely high electrical capacity for their size. Mechanical and electrical life at 1/32" overtravel is 150,000 operations, minimum, with accurate repeatability and constant stability of tolerances. Self-aligning springs provide contact wiping action rare in a switch of this size.

Durable case of special plastic gives the switch an ambient temperature rating of −100° to +275° F. or +375° F. Available, *at low cost*, in three basic models with a wide selection of actuators.

SERIES F2 BASIC SWITCH: F2-3: Single Pole, Double Throw
F2-2: Single Pole, Normally Open; F2-1: Single Pole, Normally Closed

OPERATING CHARACTERISTICS

Electrical Rating: 10 AMP. 125/250 V. A.C. 60 cycles
30 V. D.C. inductive and resistive (6 AMP, 30 V. D.C. for Airborne Application)
Operating Force, 7 to 12 oz.
Reset Force, 4 oz. Min.
Pretravel, 3/64 Max.
Movement Differential, .011 ± .005
Overtravel, 1/32 Min.

SEND COUPON FOR MORE DATA

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4252 W. Lake St., Chicago 24, Ill.

Please send data sheets on switch checked:

- ☐ EF-3 — subminiature sealed
- ☐ G3 — 40 Amp. basic
- ☐ K3 — Triple-pole
- ☐ F2 — Extra-small basic

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Avco makes things better for America...

Avco

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letters

Adland Revisited

To the Editor:

It may come as a surprise to some of your readers that space is for sale and that a professional group of "space salesmen" exists. I don't, of course, refer to the kind of space that rockets are designed to overcome. I'm talking about the kind of space you were good enough to lend Mr. A. Swoboda last month for an auroral display of ignorance about advertising and the people who write it. Space salesmen of any publication will fail to confirm his assertions.

It's hard to be sensitive about stuff like his bit about "advertising writers suddenly becoming experts and dispensing hogwash," but I'll do my best. First of all, it would seem worse than futile to try to misinform technical men. And then, an advertisement is an important business investment. The people who invest in space, words and art in order to sell their products or services rarely care to see their money float away in hogwash.

Advertising men are not born very differently from other members of the human race, nor are they swaddled in grey flannel. Those I know are very hard working, unpretentious and competent people, with not even a sincere tie to distinguish them. While they may not be experts, they try to know all they can about the products they sell.

For myself, I have always had a soft spot for the guided missile, ever since I engaged in a years-long project for the evaluation of all missiles work done by Germany. It was my privilege and pleasure to translate a large chunk of the work on this subject done by the Russians. The fact that I now write advertising copy for a basic material which is indispensable in both guidance and plumbing systems may be entirely accidental. It would pain me to believe that similar accidents are not to be met with among advertising writers. Thanks for the space.

Andrew Certner
New York City, N.Y.

Coming Up

To the Editor:

As a British subscriber to m/r, may I congratulate you on a fine magazine. I wonder if we can look forward to an issue on missile control systems (hydraulic/pneumatic actuated etc.), sometime.

D. A. Parrish
18 Arundel Road
Hollywood
Worcestershire, England

We are planning an issue on missile components and subsystems to be published in May 1958.—Ed.

Historical Correction

To the Editor:

We were pleased to note your excellent summary of the *Dart* missile (m/r, July 1957, p. 128), for which the H. A. Wagner Co. has designed and developed the guidance system. However, one historical point should be corrected.

Your article indicates that although the Germans had made a few test firings of a wire-guided missile, "they did not have much luck." Actually, the wire command link was fully developed for speeds up to Mach .85. For use with two missiles, the HS-293 and the *Fritz X*, a large number of sets were supplied to the front should the Allies start to interfere with the radio link. Since the Germans never detected such interference, the wire link did not come into use.

Dr. H. A. Wagner, President
H. A. Wagner Co.
14707 Keswick St.
Van Nuys, Calif.

Repeat on Reprints

To the Editor:

I truly believe you have established your magazine as a leader in the field. I look forward to every issue.

You started something that you may not be able to stop in granting copies of m/r cover reprints. I want a color reprint of the July cover of the Be X-IE. I would also like a reprint of th very excellent First Annual Guided Mis sile Encyclopedia to give my supervisor There is nothing like it. I too want t echo another letter to the editor reques ing a coverage of *research* missiles in th encyclopedia. I have enjoyed so man articles in the magazine that I would no dare try to list them, but I do want t make special mention of Dr. Wernhe von Braun's article, "Space Travel and Ou Technological Revolution."

Horace S. Solliday
Douglas Aircraft Co.
2717 Carnegie La.
Redondo Beach, Calif.

Thank you. A color reprint is bein prepared for you. Also, reprints of vo

Braun's excellent article will be mailed to you as soon as we get them from the printer. (We had to go to a second printing.) Reprints of the encyclopedia are in the mail.—Ed.

Wants Second Helping

To the Editor:

Several weeks ago you were good enough to send me 12 copies of the Guided Missile Encyclopedia, reprinted from the July 1957 issue of m/r.

At the time I requested these I was aware that it was an excellent and very informative compilation. However, I must admit that I completely underestimated the degree of interest that it evoked among our people here. I find now that I need about a dozen additional copies to satisfy the requests from our sales and management staff.

I wonder if you can help me with another twelve reprints?

Murray Heyert

Avien, Inc.
58-15 Northern Blvd.
Woodside 77, New York

In the mail—Ed.

Rocket & Research Societies Invite Queries

To the Editor:

In response to Mr. L. F. Megow of the Rocket Research and Development Society of Houston, who requested information on launching facilities, the Pacific Rocket Society and Reaction Research Society have a firing range in the Mojave Desert about 130 miles northeast of Los Angeles. Our facilities include a concrete block house, several launching towers, a 2000 pound static test cell, and two tracking stations. It would be a pleasure to answer any inquiries by serious amateurs regarding our facilities or the activities in which the societies are engaged.

Robert A. Citron
Pacific Rocket Society
Northrop Aeronautical Institute Branch

1155 West Arbor Vitae St.
Inglewood 1, Calif.

Plaudits for Dr. von Braun

To the Editor:

We wholeheartedly agree that Dr. von Braun's "Space Travel and Our Technological Revolution," published in your July issue, is extremely well done.

I wonder if you could give us some idea of what 200 reprints would cost. The writer is chairman of Immanuel Lutheran Parent-Teachers' Society here in Kansas City and it is our idea to send a copy of this to each parent.

Fred C. Stebbins
Aviation Sales Manager
Puritan Compressed Gas Corp.

Kansas City, Mo.

The response to Dr. von Braun's article has been overwhelming. Unfortunately our supply of reprints has been exhausted. The second printing is in the works and your copies will be in the mails as soon as they are available.—Ed.

Amateur Missileer Stymied

To the Editor:

Received my first issue of m/r and was much pleased with its extended coverage in the rocket field. However, I understand from other subscribers that you have available an introductory issue composed of various subjects taken from past issues. This I would very much like to receive.

The question "Why doesn't American Rocket Society set up a missile launching base for amateur missileers," in Missile Miscellany, is one the undersigned and a lot of other people would like to have an answer to. I can name a hundred missileers who would give a month's pay to have a place to test their hardware.

Just in our small group on Project *Vanguard* we have home-built projects using anything from black powder to UDMH and from six inches to 16 feet. The big question is not EST etc., but where can we test and fire these jobs? We can't find the answer. Can you? We have a rocket ready to fire now employing as much range safety and tracking gear as *Vanguard* itself, but that doesn't give us permission to run the countdown. If you can give us any assistance toward a launch site, please do.

Harry R. Sampsey

31-48 78th St.
Jackson Heights, N.Y.

Try a local university. Also, consult Prof. S. Fred Singer, Physics Department, University of Maryland, College Park, Md. See Mr. Citron's letter, this page.—Ed.

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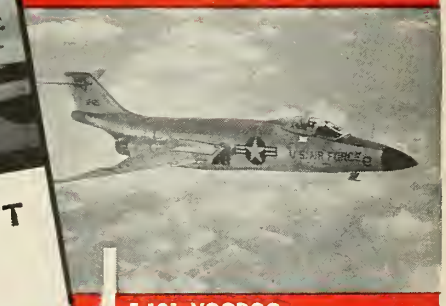

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*As of 30 June 1957

To: Raymond F. Kaletta, Tech. Placement Supvr.
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St. Louis 3, Missouri

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Address

College attended

Type engineering degree and year received

Type assignment in which interested

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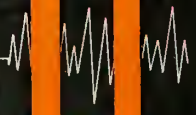

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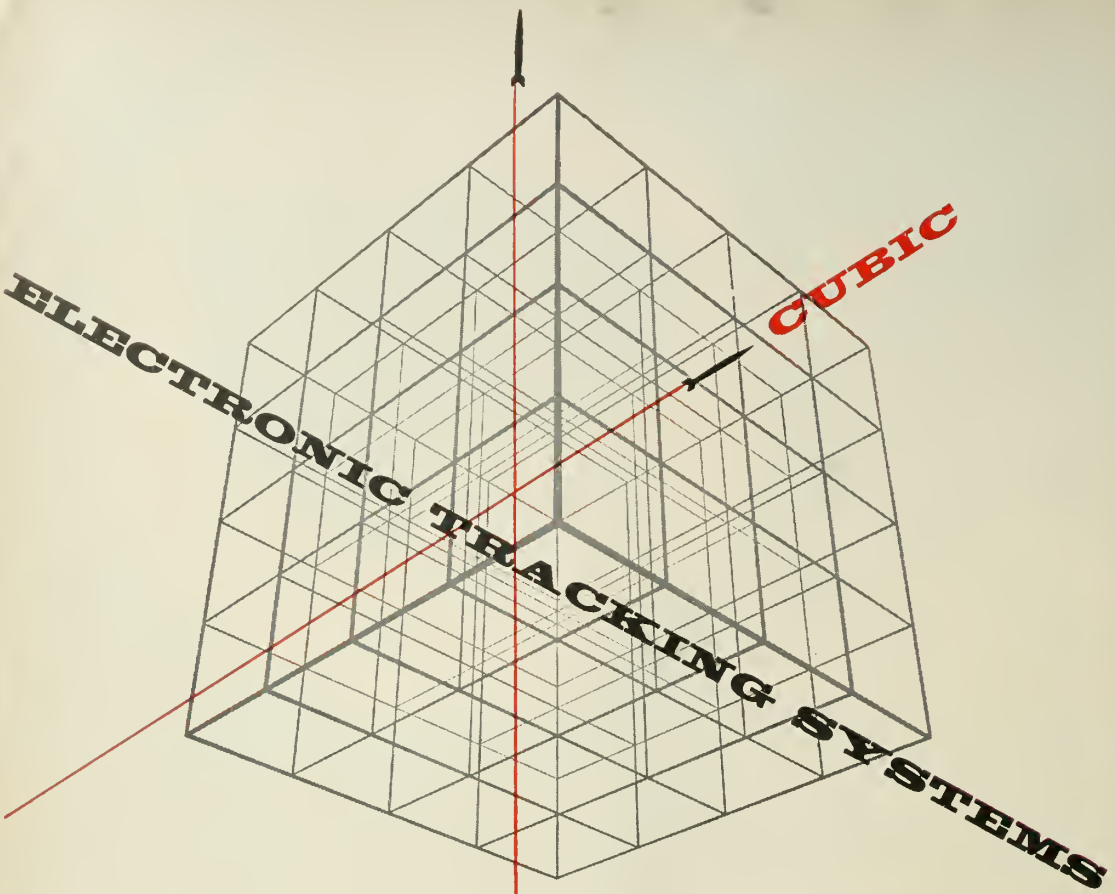

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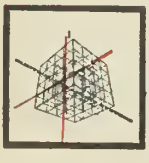

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Office of the Associate Director of Engineering

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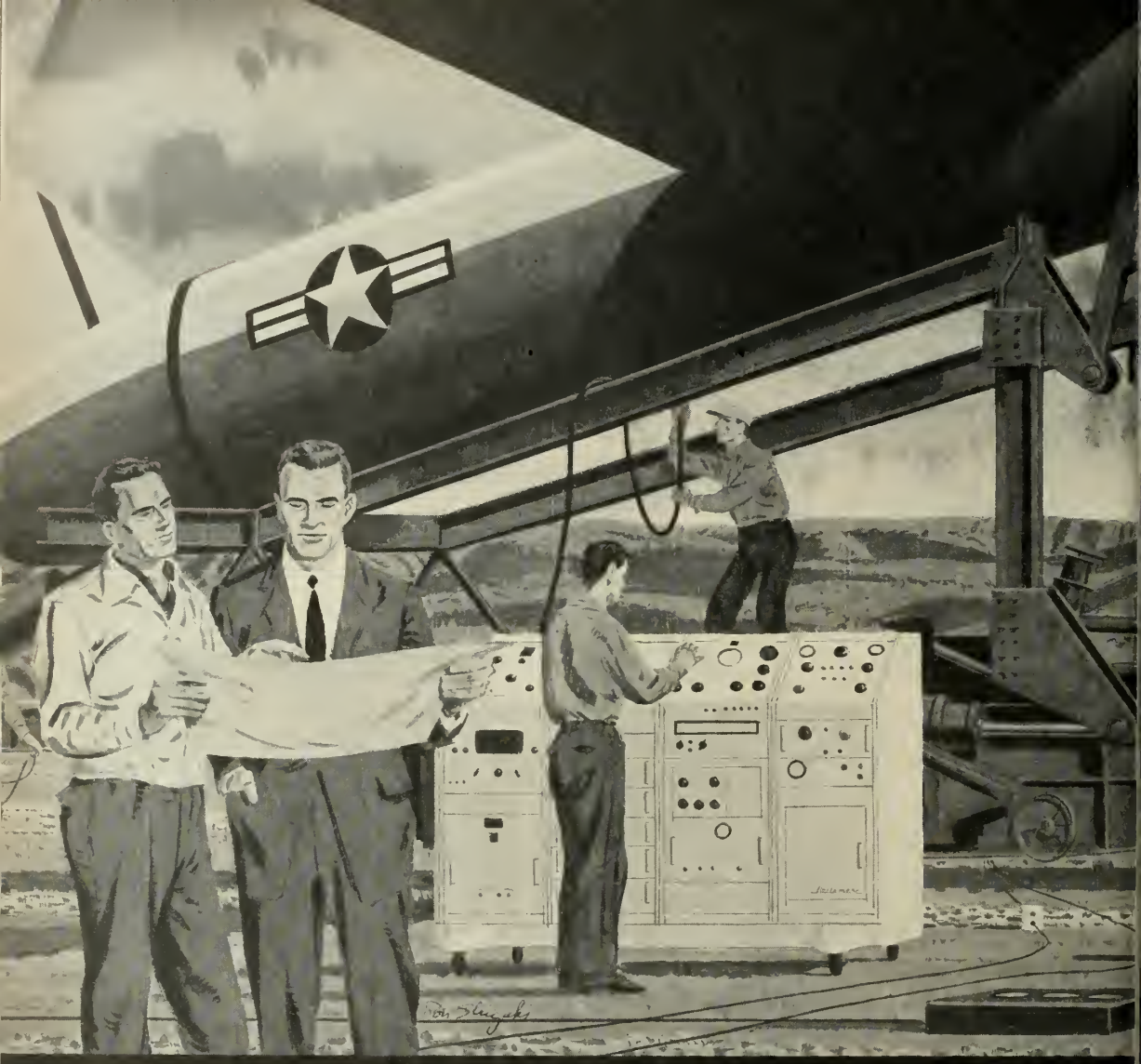

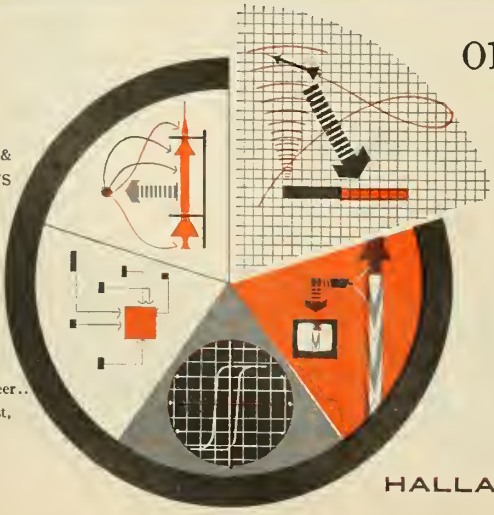

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It fits lightly into the hand; it can be carried in a pocket; it weighs about a pound; it will go places too small for ordinary cameras, too dangerous for man; it will observe without being conspicuous; it may be mounted on a tripod, fastened to wall or bulkhead, hand-held by a pistol grip. Size: 1⅞" x 2⅜" x 4¾".

By means of a transistorized circuit and the new RCA half-inch Vidicon, the "Telemite" actually surpasses standard Vidicon-type industrial TV cameras in sensitivity. It produces clear, contrasty pictures with a scene illumination of 10-foot candles or less.

The "Telemite" operates with up to 200 feet of cable between it and the control monitor, and this distance can be further extended by using a repeater amplifier. This is the first TV camera to employ photoelectric sensitivity control, which provides automatic adaptation to widely varying scene illumination.

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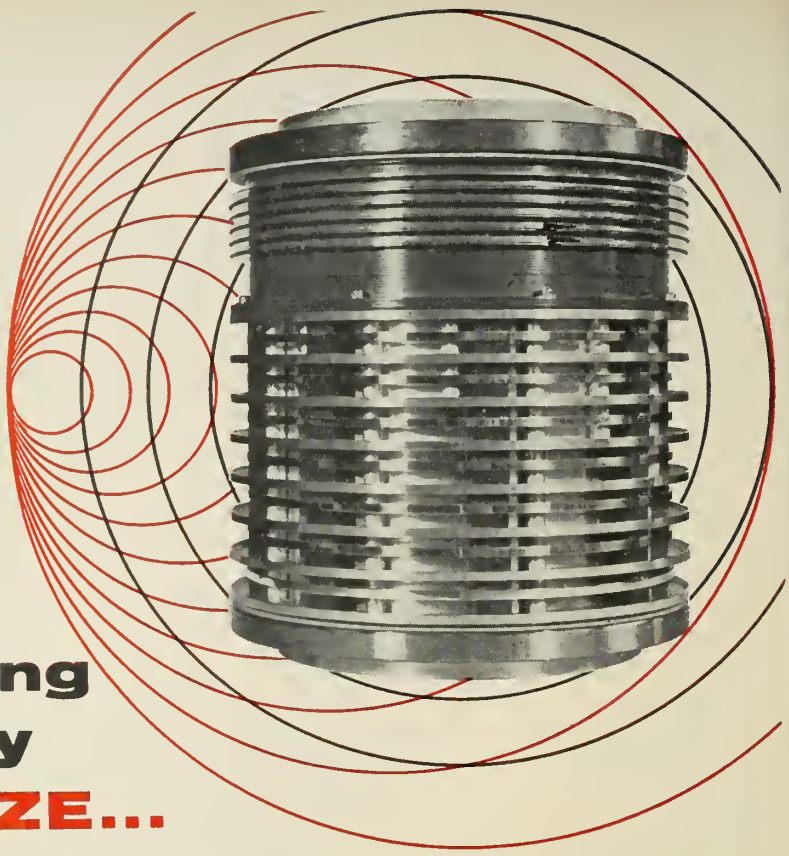

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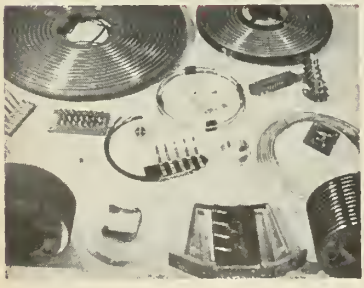

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OCTOBER

ASME-ASLE, Joint Conference, Hotel Royal York, Toronto, Canada, Oct. 7-9.

NACA Lewis Propulsion Lab. Triennial Inspection, Cleveland, Ohio, Oct. 7-10.

International Astronantical Federation, 8th Annual Conference, Barcelona, Spain, Oct. 7-12.

ARDO Fifth Annual Science Symposinm, Interdepartmental Auditorium (across street from AFOSR hdqrs), Host Center: AFOSR, Washington, D. C., Oct. 8-9.

Society for Experimental Stress Analysis Nat'l Fall Convention, El Cortez Hotel, San Diego, Calif., Oct. 9-11.

National Noise Abatement Symposium, Sherman Hotel, Chicago, Ill., Oct. 10-11.

ASME Fuels Div. and AIHE, Joint Conf., Chateau Frontenac Hotel, Quebec, Canada, Oct. 10-12.

National Society of Professional Engineers, Fall Mtg., Grand Pacific Hotel, Bismark, N. D., Oct. 17-19.

ASME Conference on New Developments in the Field of Power, Americus Hotel, Allentown, Pa., Oct. 21-23.

Canadian Aeronautical Institute/IAS Mtg., Montreal, Canada, Oct. 21-22.

Computer Applications Symposium, sponsored by Armour Res. Foundation, Morrison Hotel, Chicago, Ill., Oct. 24-25.

Association of the U.S. Third Army Annual Mtg., Sheraton-Park Hotel, Washington, D. C., Oct. 28-30.

IRE, Engineering Writing and Speech, First National Symposium, Sheraton-McAlpin Hotel, New York, N. Y., Oct. 21-22.

American Nuclear Society, Henry Hudson Hotel, New York, N. Y., Oct. 28-31.

National Industrial Packing and Handling Exposition, Convention Hall, Atlantic City, N. J., Oct. 28-31.

IRE, East Coast Aeronautic and Navigation Conference, Baltimore, Md., Oct. 28-29.

IRE, Annual Technical Meeting, Electron Devices Group, Washington, D. C., Oct. 30-31.

NOVEMBER

Joint Military-Industry Guided Missile Reliability Symposium (security clearance required), Naval Air Missile Test Center, Pt. Mugu, Calif., Nov. 5-7.

IAS Weapons System Management mtg., Statler-Hilton Hotel, Dallas, Tex., Nov. 7-8.

IRE, Instrumentation Conference and Exhibit, Atlanta, Ga., Nov. 11-13.

Vickers Aircraft Hydraulics Conference, Park Shelton Hotel, Detroit, Mich., Nov. 12-13.

National Plastics 8th Exposition, International Amphitheatre, Chicago, Ill., Nov. 17-21.

DECEMBER

ASME Annual Mtg., Hotel Statler, New York, N. Y., Dec. 1-6.

American Rocket Society Annual Mtg., Hotel Statler, New York, N. Y., Dec. 2-6.

ARS 1957 Eastern Regional Student Conf., sponsored by the Polytechnic Institute of Brooklyn Chapter, Hotel Statler, New York, N. Y., Dec. 6-7.

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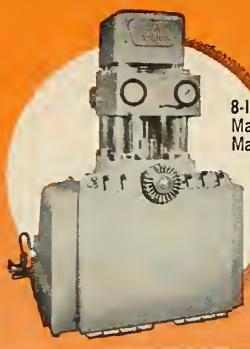

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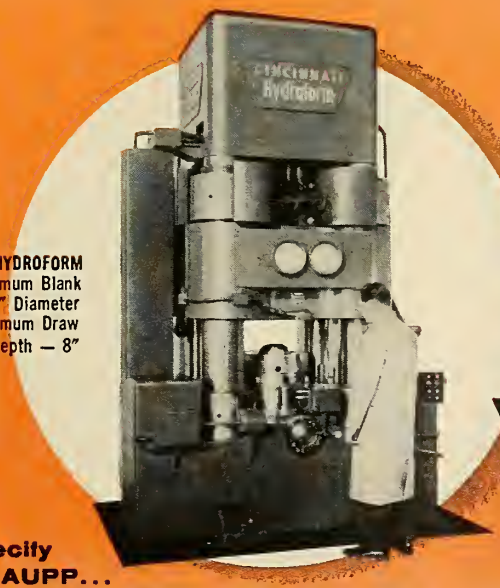

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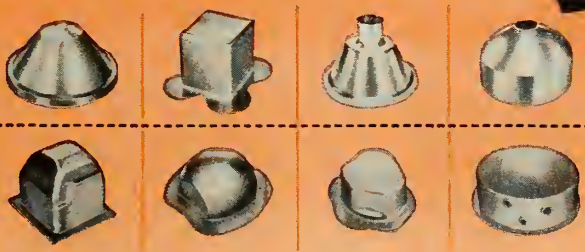

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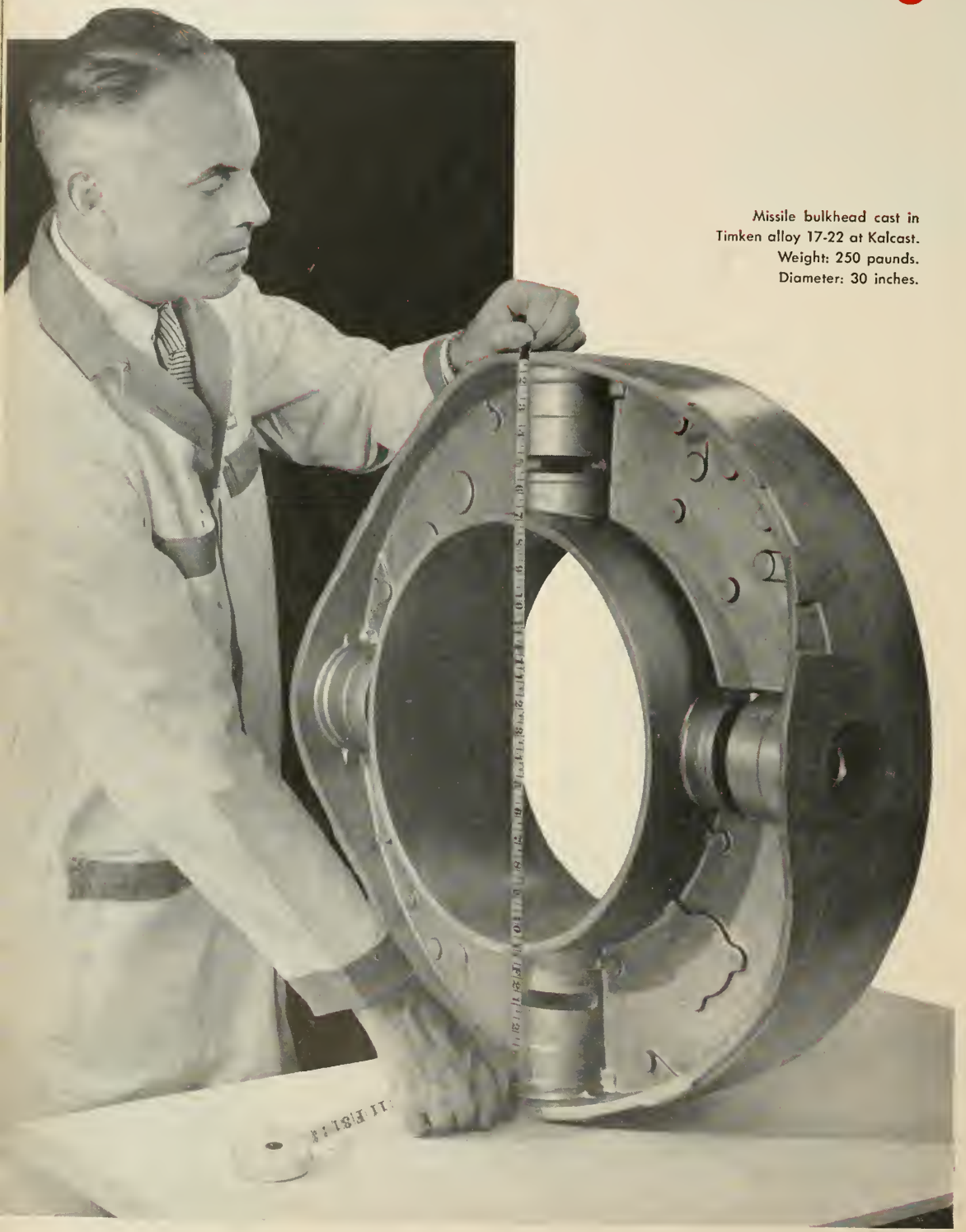

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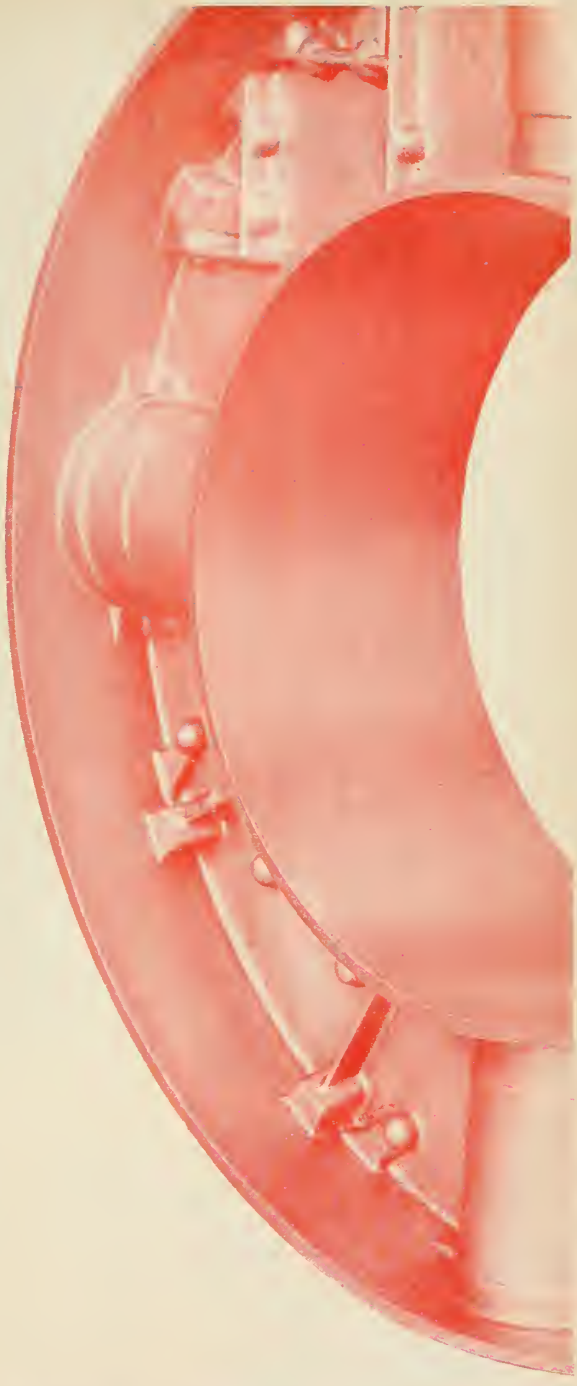

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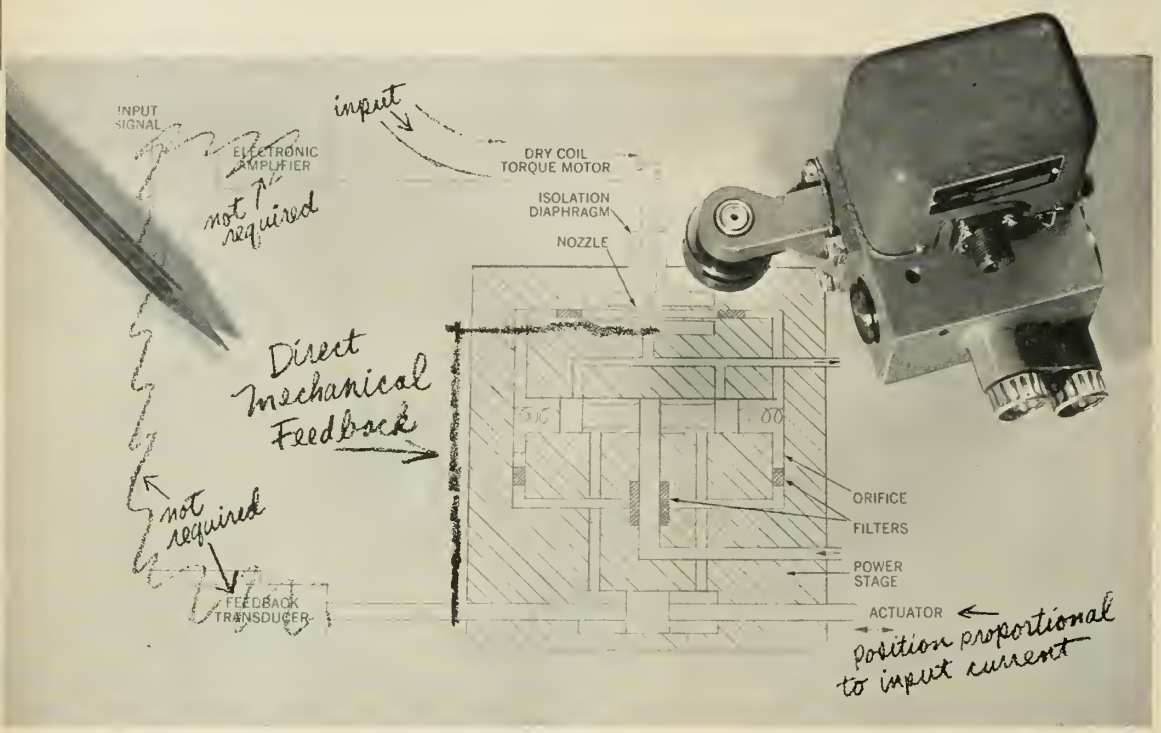
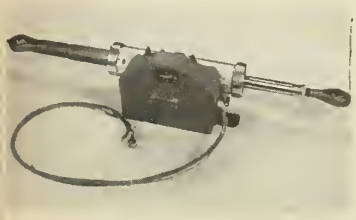


Hydraulic Research's new integrated electro-hydraulic servo valve – actuator combination eliminates amplifier and electrical feedback by the addition of a mechanical feedback spring and increased servo valve gains.
This mechanical spring feedback loop provides a considerably lower time constant, and essentially infinite resolution. Also, greater reliability and lower costs result.

The unit illustrated above has a ¼" stroke with .16 watt electrical error input. It is in production. The design may be modified to any desired stroke, with inputs of .06 watts and lower. Hydraulic Research's new servo system design utilizes a basic dry coil torque motor servo valve. It is compact, lightweight, and adaptable to any application where precise positioning is required.



Developers and manufacturers of the "Hydamat"—compact multiple input servo package.

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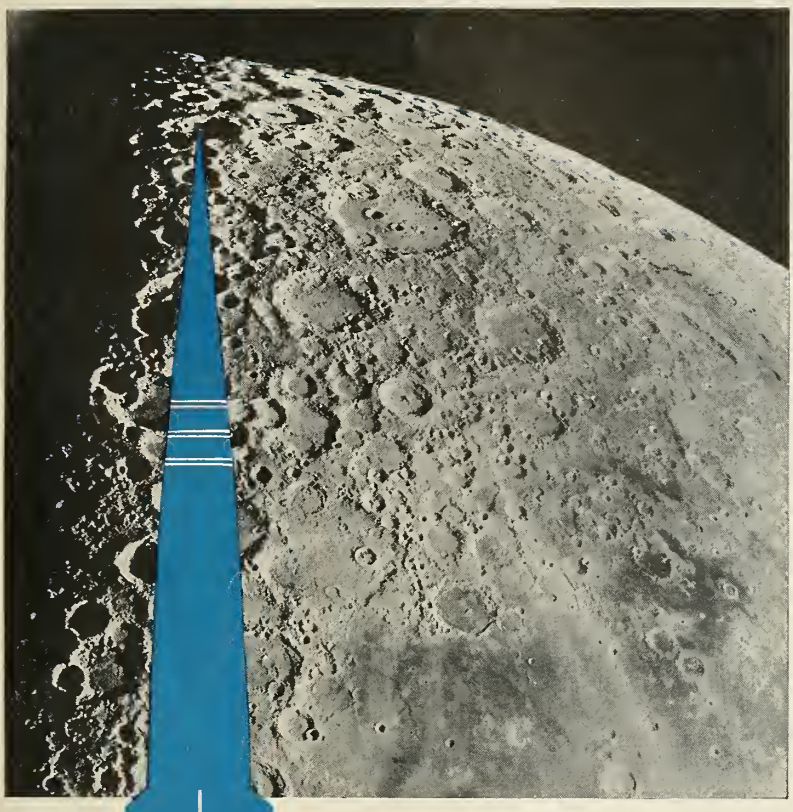

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Inter-Planetary Ballistic Missiles

IPBMs May Mean Safe H-bomb Tests

Build Inter-Planetary Ballistic Missiles and use the moon as a safe, profitable test site for H-bombs—this suggestion from Maryland University's Dr. S. Fred Singer at the Eighth Congress of the International Astronautical Federation in Barcelona, Spain, October 7-12. Dr. Singer is one of the original proposers of the *Far Side* space exploration rocket project now underway at Eniwetok.

As m/r goes to press, leading rocket, missile and space flight scientists, engineers, lawyers and editors from all over the Free and Communist worlds are meeting to read papers and discuss the latest state of the space-flight art—including everything from space law and moon rockets to IPBMs.

Dr. Singer, in a detailed technical paper, demonstrates the feasibility of testing missile-launched H-bombs on the moon. He insists that not only will this free the earth of any danger from radioactive fall out, but it will provide valuable scientific data as well. Some of the debris kicked up from blasting craters on the moon may result in dust particles and even boulders bombarding the earth. The latter would be large enough to be recovered pretty much intact. Study of these "moon samples" would provide valuable data on the history and current state of the solar system. Significantly, Dr. Singer suggests that nuclear bombs will soon become too big for safe testing on earth. "It is difficult to predict what will happen when we 'progress' to the point where a truly cosmic bomb can be produced, but since such a development is inevitable, we might as well face it."

Astrophysicist Singer argues that sending an IPBM to the moon 240,000 miles away will be no more of a technical problem than launching an ICBM 5000 miles. He points out that there will be a great weight-saving since it will need neither a heavy reentry nose cone nor such highly refined guidance as does the ICBM. The moon is an easier target than a city. He also notes that development of IPBMs is inevitable.

Advantages of this proposal include: "A good record of the power of the H-bomb for all to see;" lack of the need for expensive, space-consuming test ranges; less dependence on weather conditions for test shots; and new craters which will provide "unique opportunities for perpetuating the names of presidents, prime ministers and party secretaries." In addition, of course, there are numerous scientific benefits to be derived including the theories of meteor craters; study of meteoric-dust effects on the earth's weather; study of the motion of interplanetary gas with respect to the earth, study of magnetic and electrical phenomena, etc.

The moon missile's peak velocity would have to be 35,000 fps to escape the earth's gravitational field and fall into that of the moon. This is 40 per cent higher than satellite velocity. The point of light from an H-bomb flash on the sun would be twenty times as bright as a similar point of light on the moon. A 100-megaton bomb would blast a crater on the moon's surface 12,500 feet in diameter and 1800 feet deep. A 1000-megaton bomb would dig a hole 25,000 by 3000 feet. This compares to Clavius, the largest natural moon crater, which is 146 miles across and 16,100 feet deep.

Other papers at the Barcelona Congress include a treatise on space law by Andrew G. Haley who has been nominated as the next president of the IAF; and another by Darrell Romick on *Meteor Junior*—"A Preliminary Design Investigation of a Minimum-Sized Ferry Rocket Vehicle of the Meteor Concept."

Space lawyer Haley points out that even as space vehicles will bear little resemblance to their airborne, earth-bound cousins, so must whole new legal concepts be developed when "up" become "out" and when, eventually, living beings are found on other planets. Haley refers to his legal theories as metalaw.

Haley cites the self-evident fact that there is a difference between non-military, scientific satellites passing over some one else's sovereign territory—as will be the case with the IGY satellites—and a larger vehicle with direct military potential. He points out that we are on the verge of having to begin to think about the answers to these questions that will soon be critical in international, and interplanetary law. He also suggests next steps.

Rocketeer Romick presents in engineering detail a proposal for landing men on the moon's surface and getting them back again for a total cost of $30 million. Co-authors with Romick were Richard E. Knight and Samuel Black. All are with the Goodyear Aircraft Corp.

Navy *Polaris* Test Vehicle Fired

The first flight of the Navy's *Polaris* FBM was made from Cape Canaveral during the third week of September, and was described in an unconfirmed report as a "highly successful" flight.

Designated a test vehicle, it is believed to have been a two-stage configuration. Thiokol Chemical Corp. under contract with Army Ordnance is supplying full scale test missiles. Lockheed is prime contractor. Thiokol has a contract for at least six *Polaris* test vehicles.

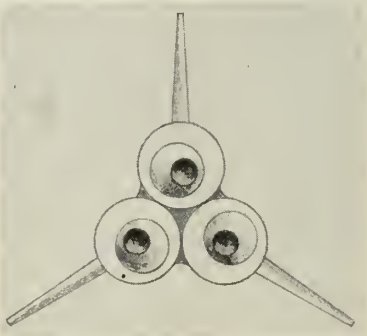
The first stage consisted of two or more solid-propellant motors reported to be modified *Sergeant* surface-to-surface powerplants. The second stage, utilizing the latest principles in solid propellant development, was a single unit.

The new techniques employed in the second-stage motor of the *Polaris* test vehicle are considered a major breakthrough in the field of solid propellants. The motor exhausts into a high-pressure plenum chamber, which then directs the gas through four small nozzles. Four additional nozzles, spaced between the other four and turned to exhaust in the direction of missile travel, serve as pitch, yaw and nose-cone-separation control.

The ability to gimbal a solid-propellant motor has not been reported a state of the art. This leaves only two methods of control known to solid-propellant engineers—fins and venting. Fins are functional only when operating in the atmosphere. A *Polaris* FBM traveling 800-1500 miles would, during the later phase of its powered flight,

be operating at extreme altitudes above appreciable atmosphere. Therefore, a vented rocket system appears to be the only answer at this time.

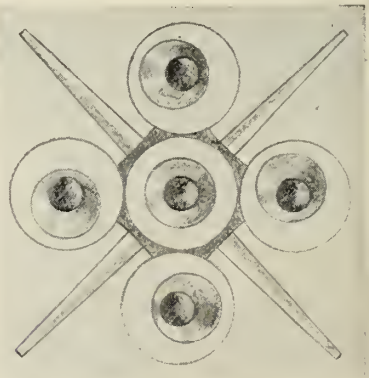
Another major problem with solid-propellant rockets has been the decay of specific impulse and the inability to control precisely the velocity at burnout. This is a critical problem in ballistic missiles because the velocity at burnout determines the point of impact. Nozzles exhausting against the direction of travel will insure clean separation of the nose cone at the instant it is needed. Details of how such a missile



Aft view of possible arrangement of an 800-mile POLARIS test vehicle. Three solid-propellant rocket motors with canted nozzles arranged to impart spin during boost.

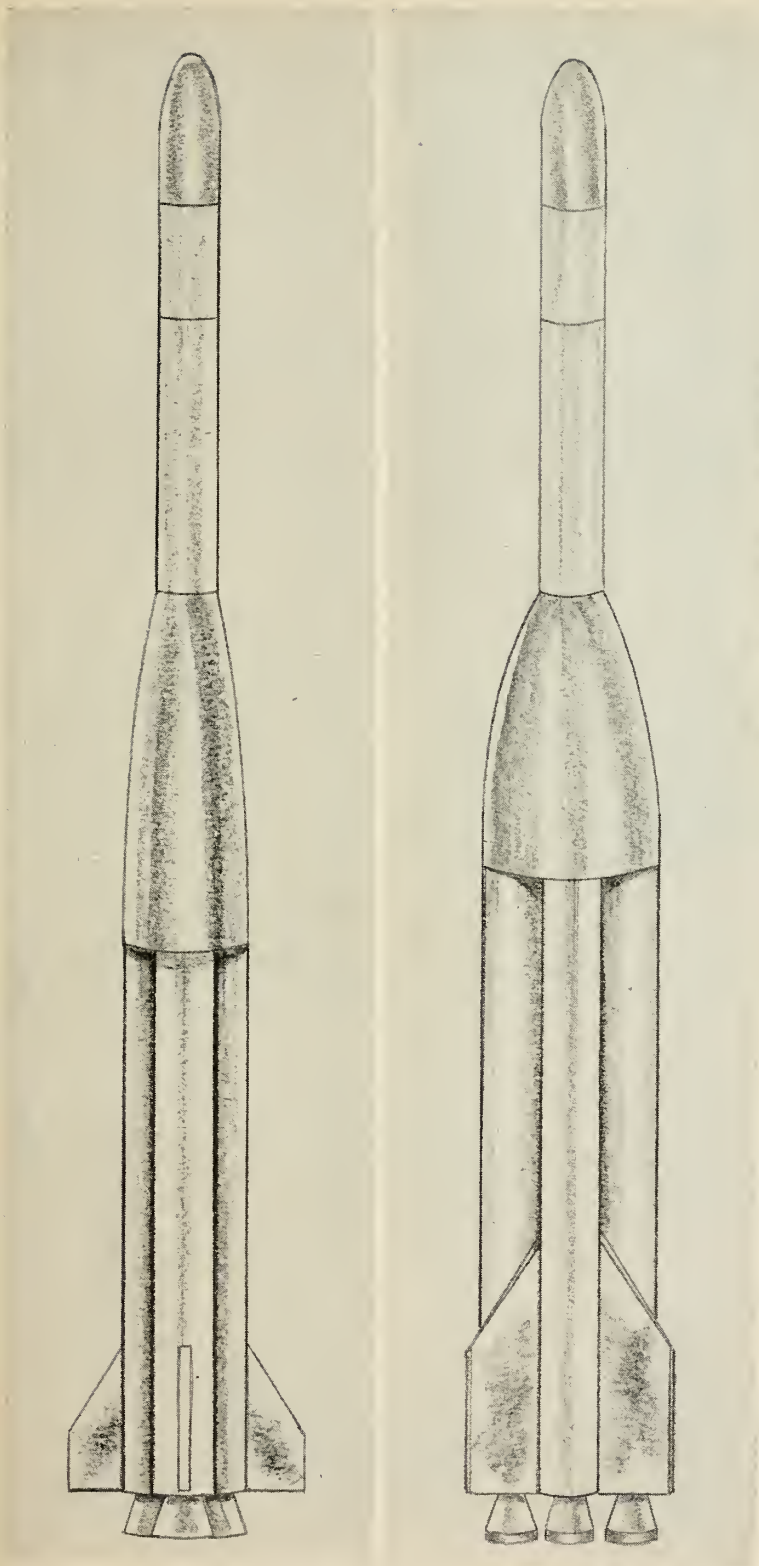
will be controlled in roll and the pitch and yaw plane of references is not known.

The *Polaris,* designed to be fired from submarines and surface ships, will necessarily have to use zero-length launch pads. For this reason the first stage will probably be fin- and spin-stabilized similar to the X-17. The



Aft view of the booster section of a possible arrangement for a 1500-mile POLARIS test missile. Center rocket could either be second stage of three-stage configuration or fifth booster rocket of possible two-stage model.

Polaris test vehicles are estimated to be four to six feet in diameter and 50 feet in length. Lockheed is currently using the X-17 on a separate *Polaris* test program.



Shown in an artist's conception are possible staging arrangements for the POLARIS test vehicles. Shown are an 800-mile test vehicle (left) and a 1500-mile version (right).

Snark Missile Squadron To Be Activated

Air Force has announced that the first *Snark* guided missile squadron will be activated late this year.

This will be the first intercontinental guided missile to come in to operational use. An aerodynamic cruise missile, it will travel at subsonic velocities.

The squadron, to be assigned to the Strategic Air Command, will be equipped with the high-altitude, jet-propelled missile, which is capable of delivering a nuclear warhead.

The *Snark* SM-62, manufactured at the Northrop Division of Northrop Aircraft, Inc., at Hawthorne, Calif., is the first intercontinental missile to go into production for the Air Force.

Commander of the squadron will be Lt. Col. Richard W. Beck. Currently assigned to SAC's directorate of operations, Col. Beck formerly commanded a B-47 bombardment squadron at Lockbourne AFB, Ohio.

The exact site for the new missile unit has not been named at this time. SAC officials emphasized that missile units will be so positioned as to reduce problems of noise and to insure that missiles, if ever fired, will not pass over heavily populated regions.

Plans call for no missiles to be launched from operational sites except in case of war. For training purposes, missile crews will practice actual firing at an established range such as Patrick Air Force Base, Fla.

The missile squadron will be manned by some 500 officers and men. Personnel are now undergoing special training in the operation and maintenance of the *Snark* at Northrop's plant in Hawthorne.

Nike-Zeus On the Way

The U.S. Army Ordnance Corps is pushing hard on development of the *Nike-Zeus* system as a logical improvement of the up-and-coming *Nike-Hercules*. The *N-Z* would have a slant range of over 100 miles, be able to carry a nuclear warhead, and is to counter targets in the Mach 2, 50-75-thousand-foot altitude class.

Zeus would put the Army close on the heels of the Air Force *Bomarc* cruise missile. Thus, Ordnance Corps wants to progenerate the AAC by introducing a competing missile in the ground-to-air defense spectrum. In addition, there have been hints that *N-Z* could evolve into an anti-missile to counter the Soviet ballistic missiles.

Various designs for *N-Z* have

been leaving the drawing board at a fast rate while systems development is being carried out at Redestone Arsenal and other facilities. Indeed, some components are well beyond the drawing board and are entering the test phase.

Thiokol Has Tried Large Solid Rocket

Thiokol at Huntsville is said to have static-fired a large solid-propellant motor which may be the *Zeus*. The Army is known to favor an all-solid-propellant powerplant—possibly an ammonium nitrate-polysulfide formulation. The reason for this may be the rapidity with which Thiokol turned the *Hercules* design into production. It is felt that as soon as test firings and engineering analysis have been completed, the Army will push for adoption of this new weapon, claiming better reliability and lower cost than *Bomarc* and more versatility than *Hercules*.

Specification Breakdown

Speculators hint that *Zeus* may have the following makeup:

- Short-fat design to minimize center of gravity changes. This design would also facilitate handling and allow present equipment and storage facilities to be utilized with little modification. The large-diameter configuration would also allow the use of high-yield nuclear warheads for anti-missile use. An alternate design suggested uses the telephone-pole configuration.
- Single-stage, high-thrust motor, possibly with built-in program of high-thrust boost and lower-thrust level for cruise. Total burning time would be 30-60 seconds using an uncooled motor.
- Extensive use of lightweight alloys. Case bonded, internal-burning grain to permit high mass ratios. Protective insulation (burnaway liners, phenolic glass inserts, and Rokide-coated nozzle).
- Canted nozzles for spin-stabilization.
- Plenum chamber and combustion gas bleed to provide for auxiliary jet altitude control.
- Combustion cut-off achieved via cartridge-actuated vents to drop pressure and, hence, snuff out burning.
- Total loaded motor weight of two to four tons with motor volume of *Hermes* RV-A-10 proportions.

Since solid-propellant operation is expected, the system could probably be completed and ready for evaluation within a year. At this time, therefore, the Army can be expected to push hard for budgetary favors in getting *Nike-Zeus* into operation.

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Moon Cities Planned By Red Civil Defense Chief

N. A. Varvarov, chairman of the astronautical section of Russia's civil defense organization, has revealed plans for future Soviet cities which, he says, the government of the Soviet Union will build on the moon by early next century.

According to Comrade Varvarov, the future Red lunar city will have an artificial atmospheric pressure enabling humans from the earth to survive and even thrive on the moon. It will be a pressure one-third less than now present on the earth at sea level, but it will contain more oxygen so that man will be "able to breathe without any unpleasantness for his health."

The Red city will be built in one of the lunar craters, under a tremendous dome of glass and supplied with aluminum doors or "air-locks." Inside, at every half-mile or so, the city will be partitioned by glass walls with double doors. These will minimize the damage that may result from falling meteorites or other accidents.

"We will find it too expensive to carry food from the earth to the moon," says Varvarov. "A loaf of bread on being transported to the moon will be worth its weight in gold. Therefore, our future lunar settlements will have to be self-sufficient insofar as food is concerned."

Because of the difference in gravity, all plants will grow fantastically when transplanted to the moon: "A radish will be as tall as a date palm on earth; onions will send forth sprouts 33-feet long."

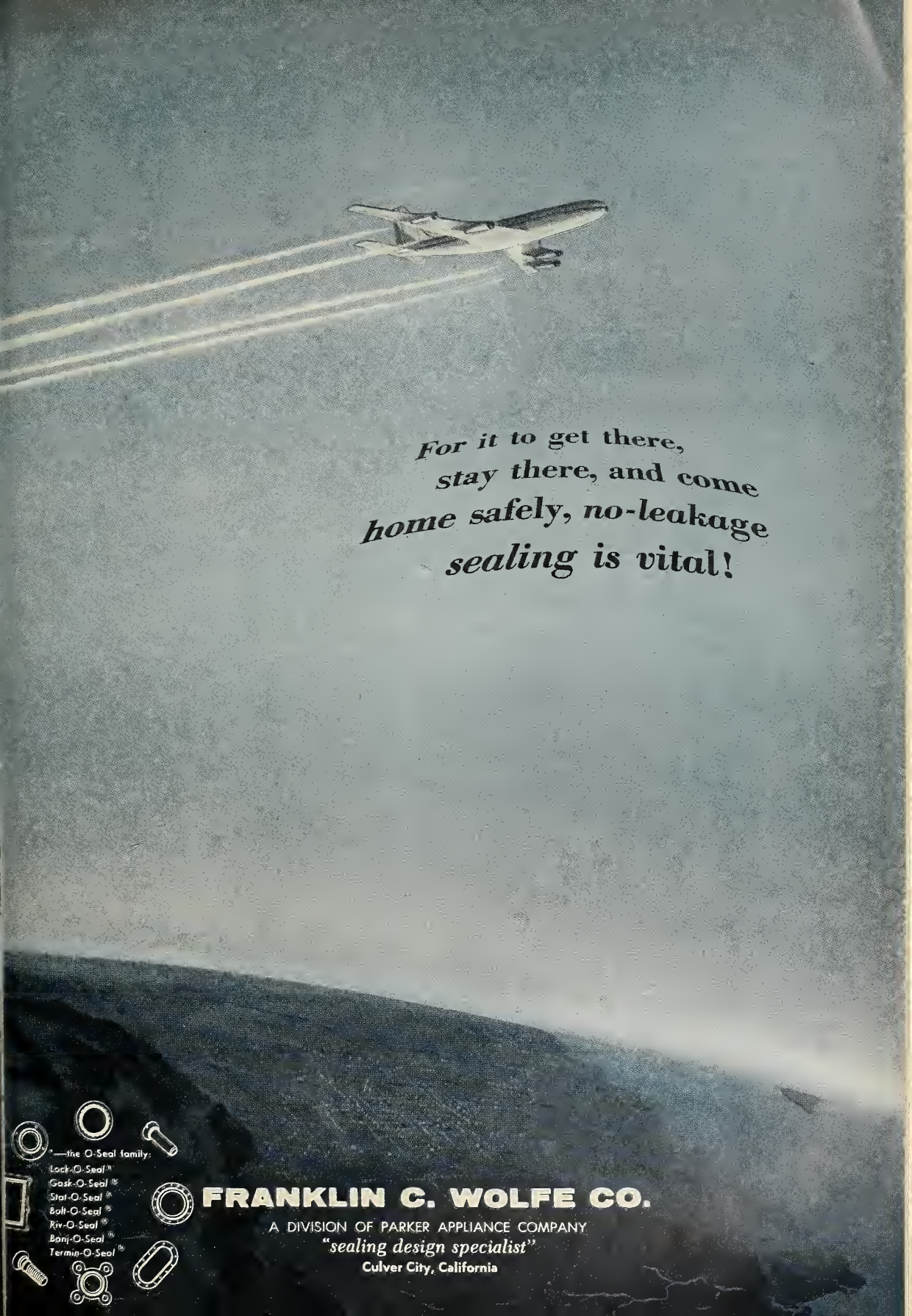
The Soviet man of the future will build on the moon a number of solar- and atom-energy stations, with the aid of which the moon's light, water, and other necessities will be furnished. Aluminum, glass, plastics, oxygen and nitrogen will all come from lunar ores.

But the main industry of the future Red lunar settlements as envisaged by Varvarov will be the manufacture of space ships and of fuel for such ships.

Durant Named Assistant To Avco Lab Director

Frederick C. Durant III has been named executive assistant to the director of the Avco Research Laboratory, a unit of the research and advanced development division, Avco Manufacturing Corp.

Durant, a contributing editor to m/r and author of the Astronautics column, was formerly with Arthur D. Little, Inc.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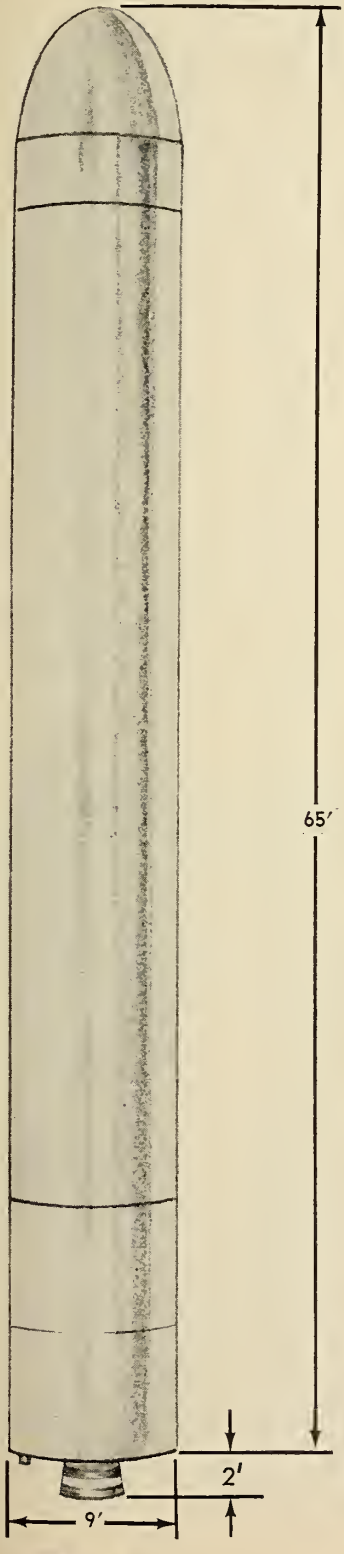


The operational future of the *Jupiter* is a matter of tremendous speculation as m/r goes to press. Its future lies in the hands of the special Committee on Missiles Study comprised of William H. Holaday, special aide to the Secretary of Defense for Guided Missiles, Maj. Gen. John B. Medaris of ABMA, and Maj. Gen. Benjamin A. Schriever of the Air Force.

The committee's function: study the merits of the *Jupiter* and *Thor* programs and recommend either one or a combination of both. The committee met on Sept. 26th for a ten-day session. Officials have expressed confidence that a decision will be reached by the middle of October.

The decision will of necessity be based on many parameters. Not the least will be politics. Also important is the performance record in the check-out labs and during static and flight tests at Cape Canaveral. The latter have been well publicized by alert, observant members of the press.

On the basis of flight duration, the *Jupiter* leads.

If the nation's IRBM evolves from an integration of the two missiles, the question is: what components of each will be used? Also, how long will this increase the missile's development time?

Much is known about the two missile systems. Enough information is available at least to convince the missile engineer that an arbitrary decision based on overoptimism could be detrimental and should be avoided at all costs.

The *Jupiter* is a finless constant-diameter cylinder topped with a bluff nose cone for housing its nuclear warhead (see drawing). It is slightly over 60 feet in length and nine feet in diameter. The tank section is entirely constructed of welded heavy gauge aluminum. The lower engine section is heavily reinforced with longitudinal stiffeners to overcome engine vibration.

The guidance and control package, located in a small section above the alcohol tank, is a product of the Ford Instrument Co., a division of Sperry-Rand. The guidance gyros are air-lubricated and were developed by ABMA and FICo. The anti-slosh device, developed and adopted after failure of the first two *Jupiter* tests, is the ultimate in simplicity. Developed at ABMA, it was included in a flight *Jupiter* six days after conception.

An outstanding achievement of the project is the small auxiliary power gas generator which has undergone extensive testing at ABMA's component test lab. The early V-2 problem of freezing LOX valves was still plaguing ABMA engineers during the development of the *Redstone* and in the early stages of the *Jupiter* program. All new valves are now subjected to a "bath" of LOX for long periods before acceptance. Throughout the *Jupiter* development program Chrysler Corp. engineers have worked side-by-side with ABMA personnel in order to achieve switchover to production status with a minimum delay. Reports are Chrysler can be in production within four months.

Radioplane XQ-4 (left) shown with the turboprop RP-77D drone and the RP-76 rocket drone.

Radioplane Drones Approach Flight Tests

Radioplane is scheduled to reach the flight test stage on one of its most important target drone developments shortly after the first of the year.

Two vehicles are involved, the high-altitude, rocket-propelled RP-76 and the turboprop RP-77DL. The two are to be matched for air-launch in Radioplane's Oscura flight service project for the Army.

The project gets its name from the Oscura Range in New Mexico, where Radioplane is to provide integrated flight and maintenance services in connection with the Army training of personnel in surface-to-air missile firing.

The Oscura contract is considered a highly significant step forward in the services provided to the military establishment by private industry and quite a feather in Radioplane's cap. It is one of the first contracts to call for flight operation of target aircraft by an industrial team for missile firing trials. Under its terms, Radioplane provides not only aerial targets and ground support equipment, but flight operators, a training program and maintenance service.

The final target drone will be the RP-76, a 300-pound plastic vehicle powered by an Aerojet 35-pound-thrust solid-propellant rocket motor. It will be carried aloft by the RP-77DL. The latter is powered by a Boeing 502-10E free turbine turboprop engine and is capable of 385 knots at 40,000 feet.

When a predetermined altitude is reached the RP-76 will be launched as a target for the *Nike* missile and the RP-77DL will be recovered by a parachute system. The RP-76 may also be recovered by the same method if it is not destroyed by the missile.

Both of the Oscura-project drones stem from Radioplane's RP-70, which was developed as a private enterprise with the company's own funds. A Navy version of the RP-76, called the XKD4R-1, has been delivered in evaluation quantities to Point Mugu. The RP-77DL is a later model of the RP-77D modified to carry a greater payload. Radioplane also is modifying the zero launcher designed for the RP-77D to permit attaching the RP-76 under the belly of the newer RP-77DL.

Lead time on the Oscura project is about 18 months, which means that actual operations on the *Nike* range will get under way about the first of 1959. Radioplane will establish headquarters for the project in El Paso, Texas.

Missile Firings Accelerated at Cape Canaveral

The last days of summer at Cape Canaveral went out with the smoke and roar of rocket engines. The launching pads on the Cape were a beehive of activity as the Army, Navy and Air Force stepped up the pace of missile firings during September.

During this period the "grand stand" location of the beach watchers less than two miles north of the launching area was constantly occupied. Reports indicate that most of the firings were successful—good news for many projects.

The most sought-after and the most heavily financed missile in this country's arsenal, Convair's *Atlas* ICBM, rebelled and marred the impressive September firing record. In a firing that fell short of the performance by the *Atlas* flight in June, the missile was destroyed less than a mile above the launching pad.

As in the previous flight, only the booster engines were being tested. Descriptions of the *Atlas's* flight behavior indicate that the engines suffered a propellant-flow interruption with a resultant falling off of thrust. The merger of the two exhaust flames into a single billowing mass, as the missile discontinued its vertical ascent, is indicative of propellant-line rupture. If this is what happened, the *Atlas* probably destroyed itself before the safety officer could respond. Meanwhile, *Atlas* number three is being readied for firing in the near future.

The *Thor* IRBM, one of the most controversial missiles in missile history, apparently made its first successful flight. Description and photos of the missile indicate that it is similar in configuration to its competitor, the Army-developed Air Force *Jupiter*. Major visual difference is the addition of small triangular fins discernible in the launch photos.

Advance reports on the *Jupiter-Thor* decision say missiles will be "married." Gen. Schriever has said that the two missiles are basically identical. Engineers close to the projects tend to disagree with Schriever's statement. Principle difference, in addition to the fins on the *Thor*, is in body outline and guidance components. The *Thor* has a tapering body in contrast to the constant-diameter cylinder outline of the *Jupiter*. This could create a major bottleneck when combining the missiles.

A newcomer to Cape Canaveral was the Navy's *Polaris* FBM. A staged test vehicle built by Thiokol, its firing was reported a complete success (see page 37).

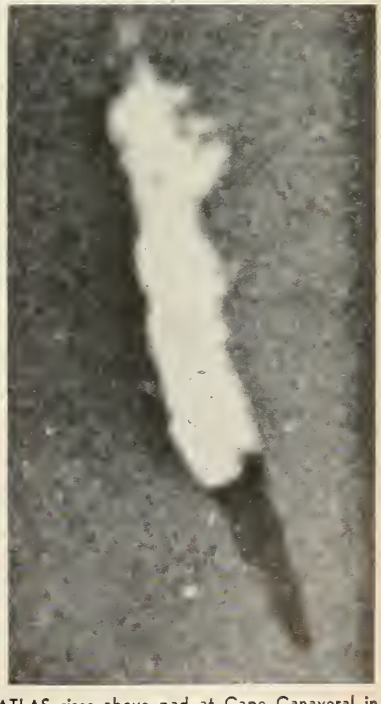
The *Navaho*, determined to make its death glorious and prolonged, had its second successful firing. Both flights have been made since the project was cancelled. Five *Navahos*, in varying stages of completion, were at NAA's plant when the project was slashed. The $15 million attributed to the phase-out of the project apparently is being well spent.

Adding impetus to the firing tempo, a *Snark* intercontinental cruise missile blasted from its zero-length launcher in a smooth climb. Shortly after dropping its solid-booster rockets, it disappeared into a cloud bank. Two jet chase planes followed the *Snark* in what may have been a successful flight. The *Snark* will be activated into operational squadrons before the end of the year.

The *Bomarc*, long-range surface-to-air missile, made a high-climbing long-distance intercept flight over the Atlantic after an unhampered launching. This was the first successful firing against a jet drone aircraft. The *Bomarc*, a regular visitor to Cape Canaveral, will soon start rolling through production assembly in Seattle.

The Army with its spectacular successes in the preceding months was slightly overshadowed during September with only a *Redstone* firing. At least two more firings of the *Jupiter* are expected in the weeks to come.

Good news for the IRBM program—Air Force THOR leaves pad in first successful flight. Taper of body and small fins can be seen.



Bad news for the ICBM program—Air Force ATLAS rises above pad at Cape Canaveral in second unsuccessful attempt. The two booster engines thrust the ATLAS skyward (left). At 5000 ft. it makes tilt to east, flame increases, and seconds later it explodes.

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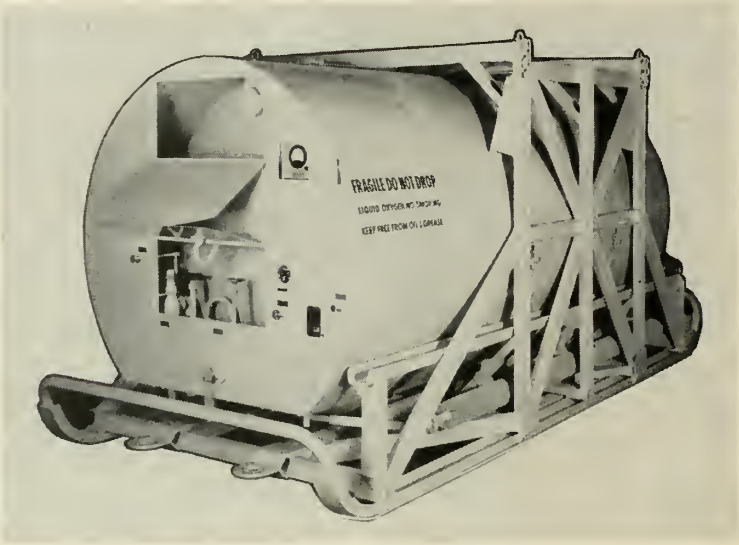

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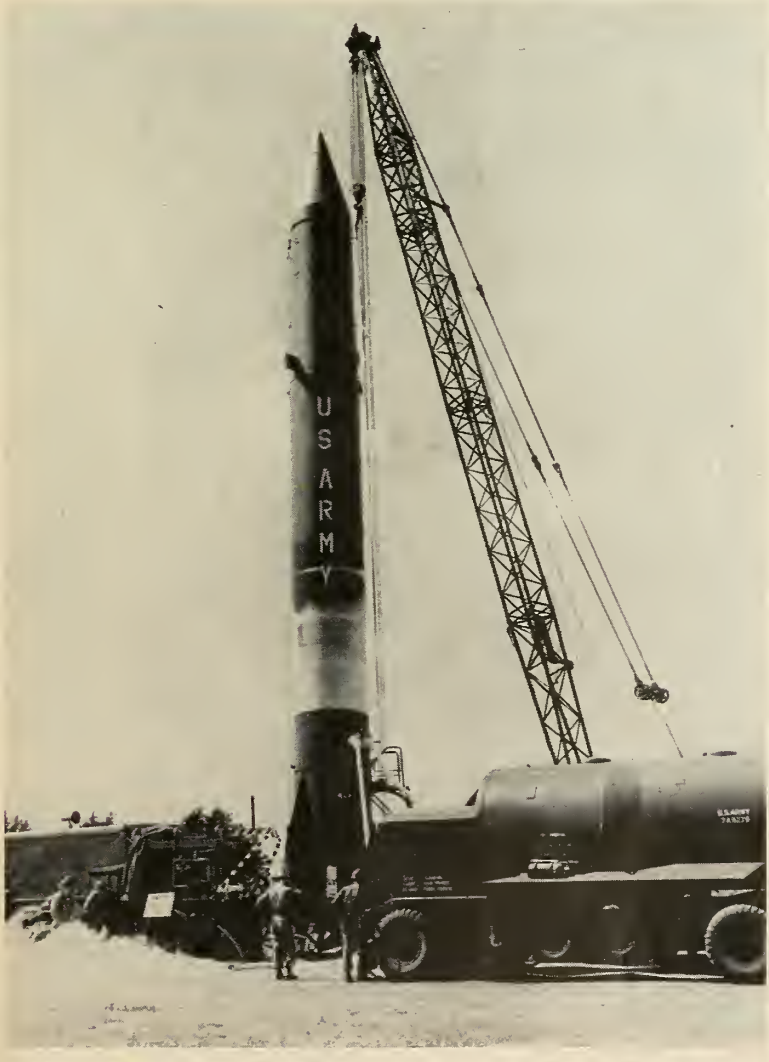
Army Activates First *Redstone* Group

HUNTSVILLE, Ala.—The Army's first heavy-missile group, equipped to use the 200-mile *Redstone* weapons system, was formally activated here on Sept. 18 under gray hurricane skies. It is the first unit to be fully equipped for combat use of the big missile developed here by Dr. Wernher von Braun and his team of former German scientists. It is the 40th Field Artillery Missile Group.

The backlash from Hurricane Esther held off long enough for an impressive ceremony, involving the 650 officers and men of the new group and a like number from Redstone Arsenal, to be carried out in the presence of the commander of the Army Ballistic Missile Agency, Maj. Gen. John B. Medaris, on the concrete airstrip of the Arsenal.

An unemphasized feature of the ceremony was the fact that five years of intensive research and development were required before this first armed *Redstone* missile group could become operational. But the historic significance was recognized far beyond the limits of this Southern city. The Associated Press sent a photographer because it had requests for pictures from as far away as Tokyo. All wire services, area dailies and television also covered.

For the 40th itself, the ceremony marked entry into a fourth dimension of warfare. Its unit colors have been carried into World Wars I & II, Korea and now into the age of missiles.



A REDSTONE missile, with frost forming on its skin from the liquid oxygen in the tanks, stands ready for launching. Note the logistical field support equipment that is now operational.

"Liquid Oxygen" Replaces LOX Abbreviation in USAF

The Air Force is endeavoring to replace the abbreviation LOX with the words "liquid oxygen" where rocket fuels are concerned. The correction has been found necessary because of a conflict with the industrial designation LOX, which refers to liquid oxygen explosives.

The Air Force is undertaking the action to prevent dangerous and possibly disastrous results of the conflict. The term LOX will be deleted from all technical orders and directives, including reidentification of containers with the words spelled out, and the development of color coding for liquid oxygen containers, pipes and systems.

Thor-Jupiter Engine Now in Production

NEOSHO, Mo.—*Thor* engine production is underway at North American Aviation's $13.2-million Rocketdyne plant. The office and 228,000-square-foot facility was occupied in Feb. 1957. Ground on the 200-acre test site was broken a year ago and the large test stand is nearing completion and awaits its first firing.

Tests on the gas-generator units have already been made in the bank of special components test stands. LOX for the *Thor-Jupiter* engine will be trucked in from Tulsa, Okla.

The Neosho plant is located on 1785 acres of the northeast corner of Fort Crowder. The plant now employs about 720 workers with that figure expected to reach 800 by June of 1958. Despite the fact that start-up is just underway, things at Neosho have been described as quiet pending some sort of decision on the *Thor-Jupiter* IRBM.

Features of the plant include chemical milling facilities, a large center-of-thrust measuring jig, and water equipment for checking flow of plumbing, valves, and injectors.

The test facility was inherited from Aerojet, which designed it and had construction already underway when it was decided that North American was to operate the plant. Extensive earthworks are used to provide shelter for personnel and to ring the storage and test stand areas. The large vertical test stand uses a water-cooled steel flame-deflector. Work is nearing completion on the test stand and the instrumentation center is being fitted out with electronic recorders. First firing of the large stand is expected this fall and the first engine may be a hand model from Canoga Park, Calif., or the first prototype from Neosho.

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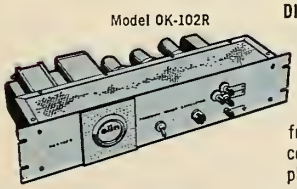

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Underground Missile Factory Delayed

HUNTSVILLE, Ala.—The problem of getting a firm contract from the Army or another branch of the service is delaying the start of a much-discussed but still secret project for construction of an underground missile factory beneath a mountain here near the Army Ballistic Missile Agency and the vast Redstone Arsenal.

It is the so-called "Green Mountain" project, reportedly involving the Army, American Machine & Foundry Co., and Chemstone Corp. Green Mountain is a big ridge, several miles long, in the Blue Ridge chain that extends all the way from Virginia to middle Alabama. Its southern slope runs down to the Tennessee River. It is located just across Highway 231 from Redstone Arsenal. The project was first reported in m/r in earlier issues this year.

Original plans, according to reliable sources here, called for the excavation of thousands of tons of limestone from the mountain's innards to create a vast underground factory which was to be operated by AMF, presumably in conjunction with Redstone Arsenal and ABMA. There were also reports that a "junior Pentagon" for missile defense would be part of the project.

The project involved some complex problems from the beginning. There was the matter of excavating the mountain, converting the limestone taken out into lime and other chemical materials, providing methods of processing and shipping it, plus the purchase of the necessary real estate at reasonable prices and political maneuvering for construction of docks on the Tennessee River by the Alabama Dock Commission.

The land was acquired through some 600 purchases engineered through the Huntsville Industrial Expansion Committee, a group of public-spirited citizens. AMF put up the required money for these transactions and at length acquired full title to the necessary acreage. The State docks were obtained and construction is currently under way.

In its early stages, the project was apparently delayed when Maj. Gen. John B. Medaris, commander of the Army Ballistic Missile Agency, reportedly urged that Madkin Mountain, a smaller ridge situated on the Redstone reservation, be used. This apparently was resolved, and the decision made to go ahead with Green Mountain.

Then the Chemstone Corp. of Cleveland, Ohio, entered the picture. There were negotiations over a period of months, and agreement was purportedly reached for them to supply the facilities for excavation and processing of the rock, using Silas-Mason-Hangar, excavators of Hudson River tunnels, as a subcontractor.

As of late spring, the project seemed assured. At that point, the Army and the Air Force became involved in the *Jupiter-Thor* argument from which stemmed the sensational court-martial of Col. John C. Nickerson, Jr., of ABMA. The Wilson memorandum, assigning operational control of all missiles of more than 200 miles range to the Air Force, had also raised questions about the project.

At this stage, AMF, which is heavily engaged in development and manufacture of guided missile support equipment, control systems, ballistics, auxiliary power supplies and radar antennas, is said to be asking that the Defense Department, the Army or the Air Force make a firm contract for work to be done in the Green Mountain installation. The local leaders who have spurred the project are said to be urging AMF to go ahead with the project, then get a contract. Somewhere between these two positions is the fact that increased land values have already given AMF a profit of as much as $750,000 on the acreage as it now is situated. Also, it is reported that Chemstone and Silas-Mason-Hangar have lost original interest, and that another deal may be made with Flintkote Corp.

A decision on the project may be one result of the settlement of the *Jupiter-Thor* argument.

One Killed, Four Injured In Explosion at RMI

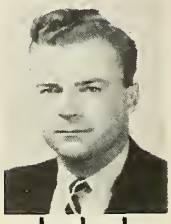
An explosion at RMI's Lake Denmark, N. J. facility recently killed one person and injured six others during a routine operation in the test stand. No engines were being run at the time and material damage was slight.

Killed was Herbert L. Bell, a representative of Chance Vought Aircraft. Most of the injuries were caused by flying metal and spraying propellant. An investigation is underway to determine the cause of the accident.

The RMI personnel injured are William Dellecker, Hjalmar Lagerquist, and Elmer Baierl. Chance Vought representatives injured are Glenn Repp, R. L. Johnson and R. D. Tweedy.

Washington Trends

By Erik Bergaust



WASHINGTON EXPECTS HIGH-ENERGY FUELS WILL DOUBLE boron demand in the next ten years. More boron is underway from U.S. Borax and Chemical Corp. The ore in the 80-million ton-load averages about 25% B_2O_3. Tailings could also yield lithium chemicals. Estimates of USB boron production is about 1-million tons per year. USB had been thinking of a "joint venture"—supposedly with Olin Mathieson—for boron research and production. Recently the boron firm announced that negotiations had broken off "by mutual consent."

PENTAGON IS TALKING ABOUT GOLD-PLATED REACTION ENGINES! Turbojets and possibly ramjets will get North American Aviation's "reflective coatings." Gold coats—thicknesses of 1/100,000 to 25/1,000,000 inch—are being sprayed on engine shrouds or on ceramic parts. The gold coating on the inside protects the engine from corrosion and heat. Rocketry went through this fad some years ago when it was fashionable to have the nozzle plated with gold, chromium, nickel, etc.

SENATOR STUART SYMINGTON (D-MO.) RECENTLY DECLARED Russia is "well ahead" of the U.S. in ICBM development and repeated charges that the Administration has cut back the ICBM program because of economy considerations. An effective anti-missile to ward off ICBMs is "at least ten years away," he said. "The idea that the anti-missile is around the corner, or only five years away, is absolutely false."

YOU ALSO HEAR PENTAGON OFFICIALS DISCUSS infrared counter measures: IRCM system that uses small heat-emitting rockets which can be launched from evading aircraft. Instead of a warhead, the IRCM rocket carries a flare or pyrotechnic (such as thermit) used in current *Sidewinder* tests. The attacking IR rocket will invariably (and wrongly) follow the smaller and higher-temperature flare. Meanwhile, solution-transistors may open an entirely new field in missile guidance. One expert visualizes a chemical system that can adjust to its environment (such as magnetic field, etc.), without outside help. Such systems could operate at high temperature without counter-measure-vulnerable electronics.

A SMALL BUT PROGRESSIVE FIRM ACROSS THE POTOMAC, Atlantic Research, put out a commercial solid-propellant strand burner some time ago. Recently a miniature mixer—for mixing small batches of new solid-propellant formulations—was introduced. Now Atlantic Research has come out with a small, commercial rocket motor. Its name is PET (Propulsion, Experimental Test) and it is being advocated for such sundry purposes as: testing small rockets, spinning larger rockets, acceleration of small masses, subjecting test materials to blast. PET delivers 40 lb. of thrust for one second from 0.213 lb. of "Arcite" composite propellant. It can be stored for 3 years. Ignition is achieved in a matter of milliseconds with a 6-volt dry cell.

GOVERNMENT OFFICIALS HAVE NO COMMENTS about recently reported atomic-rocket work in this country. A German newspaper recently claimed the U.S. is building atomic rockets. The German paper said Rocketdyne was building an atomic-powered missile which may well relegate Russian missiles to the scrap heap "in a very short time." Study contracts on atomic rockets have been let in this country, but we know of no atomic-powered missile in the prototype stage.

WASHINGTON'S NAVY MISSILEERS ARE ALL SMILES since the first *Polaris* test vehicle was successfully fired recently. Naval officials are understood to be working on a stepped-up schedule for atomic-powered subs for the *Polaris* (and for other possible FBMs expected to follow). Big problem is to synchronize missile and sub production so that the two weapons elements will be ready for each other in shortest possible time.

First Steps Taken to Form Missile Association

First steps have been taken to form a missile industries trade association. The first formative meeting was held September 23 in the Virginia Room of the Mayflower Hotel in Washington, D. C. A second is scheduled for October 22. It is expected that with this second meeting a trade association charter will be approved for incorporation.

Originally proposed as the National Industry Conference, NMIC, the organization's name has been changed to Associated Missiles and Rockets Industries, AMRI. Its basic purpose is to represent the interests of rockets, missiles, and space flight industries as a definitive group, including major prime systems contractors, major subsystems contractors and the various important subcontracting and components companies. A concerted effort is being made to bring together a representative cross-section for the October 22 meeting.

The September 23 meeting was attended by some 60 representatives (from about 30 companies) of industry and government. Companies present included: Northrop Aircraft, Inc., Cessna Aircraft Co., Raytheon Manufacturing Co., Aerojet-General Corp., Westinghouse Electric Corp., Ford Instrument Division of Sperry Rand, Thiokol Chemical Corp., Kaiser Industries, Harvey Industries, Haveg Industries, Inc., RCA, Atlantic Research Corp., Cook Development Corp., Aeronutronics Systems, Inc. (Ford Motor Co. subsidary), Cook Electric Co., and others.

The meeting was addressed by representatives from Army, Navy and Air Force concerned with missile budget, mobilization and production planning, who supported the need for such an organization. Attending as individuals were Vice Adm. Charles B. Momsen, USN (ret.), and Col. William O. Davis of the Air Force Office of Scientific Research. Both indicated they thought such an organization would provide a useful service to the missile industry.

Chairing the meeting was Kendall K. Hoyt, an old-time Washington, D. C. aviation consultant and former general manager of the National Aeronautic Association. He is acting as secretary of the proposed missile association.

A certificate of incorporation and a set of by-laws were presented to the September 23 meeting as working papers and as a means of indicating the nature and scope of the proposed organization. These working papers were drawn up free of charge by Andrew G. Haley, who personally feels that the organization should come into existence as long as it will not duplicate the services of the American Rocket Society, the Institute of Aeronautical Sciences and the Aircraft Industries Association.

The question was asked at the meeting: Who is behind this organization? No detailed answer to this was forthcoming. However, investigation reveals that the movement has been largely spontaneous, indicating a widespread feeling for the need of such an organization. From the way that the meeting proceeded, however, it seems fairly obvious that Diversey Engineering Co. is among the association's most enthusiastic supporters. Reports that an editor of Missiles & Rockets magazine agreed to act as a central contact point in the beginning are true. However, American Aviation Publications Inc.—m/r's publisher—points out that this was without authorization or knowledge of the company and that since before the September 23 meeting, no member of m/r's staff has participated in the promotion of the association.

The men who will decide whether it will be JUPITER or THOR—the Committee on Missile Study: Left to right—Maj. Gen. Medaris, William H. Holaday, and Maj. Gen. Schriever.

Red Satellite to Transmit On 40 Megacycles

The IGY satellite to be launched by the USSR will transmit on 40 mc instead of the 108 mc used by the *Vanguard* Satellite. It had been anticipated that the Soviet satellite's instrumentation would be compatible with the minitrack system but it now appears that tracking the Soviet sphere with western equipment will be impractical.

A description of Russia's satellite launching vehicle and launching program was cancelled because no member of their delegation was qualified to discuss the topic, the Reds said.

Methuselah's Speed Scorches Its Paint

Lockheed has announced that its X-7 ramjet missile, dubbed *Methuselah,* has been tested over Alamagordo and its speed was such that the missile's paint was scorched. *Methuselah,* a test vehicle for the *Bomarc* ramjet engine manufactured by Marquardt, was recovered intact by parachute. A solid-propellant rocket engine boosts the missile to speeds suitable for ramjet operation.

NACA Declassifies Exotic Rocket

CLEVELAND, Ohio—NACA has just declassified its exotic propellant work which was published in 1949. The work was done here at the Lewis Flight Propulsion Laboratory with liquid diborane and LOX in a 100-lb. thrust rocket engine.

Several runs were made in an uncooled motor (L*=325 in). Runs of about 6 seconds were made. In the runs, maximum specific impulse resulted at about 35% diborane and 65% LOX, and gave uncorrected values of about 249 lb-sec/lb. Corrected for heat rejection gave 274 sec. This latter value is about 92% theoretical (299 sec).

The fuel was 95% diborane and 5% ethane and ethyl ether. This mixture was estimated to give a performance some 2% lower than for pure diborane. Extensive solid deposit build-up was found in the chamber. Deposits were about 1/32 inch thick, crusty in nature with a smooth dark gray or brown glazed surface. NACA did not say what the deposits were but educated guesses are that it is probably boric oxide slag.

Because of the high heat releases, there were severe burnouts—especially in the nozzle and injector sections. Diborane proved remarkably stable when subjected to heat and shock tests. The boron compound could not be exploded or detonated. The boron work was carried out early in 1948 and probably started the ball rolling on carrying out more work with the boron fuels. Experimental details of the diborane-LOX rocket tests are reported in RM No. E9C11 and are available from NACA in Washington.

Dust May Affect ICBM Behavior

Experiments by Cornell Aeronautical Laboratory, Inc. have suggested that small amounts of dust in the atmosphere may markedly affect behavior of a missile such as the ICBM in re-entry from outer space.

CAL made the observation during research in its hypersonic shock tunnels, which operate at speeds as high as 15 times sound.

Engineers at the laboratory observed that during some tests, small particles of dust in the air were accelerated to high speeds and upon striking a blunt-nose model reflected from the surface back into the air stream.

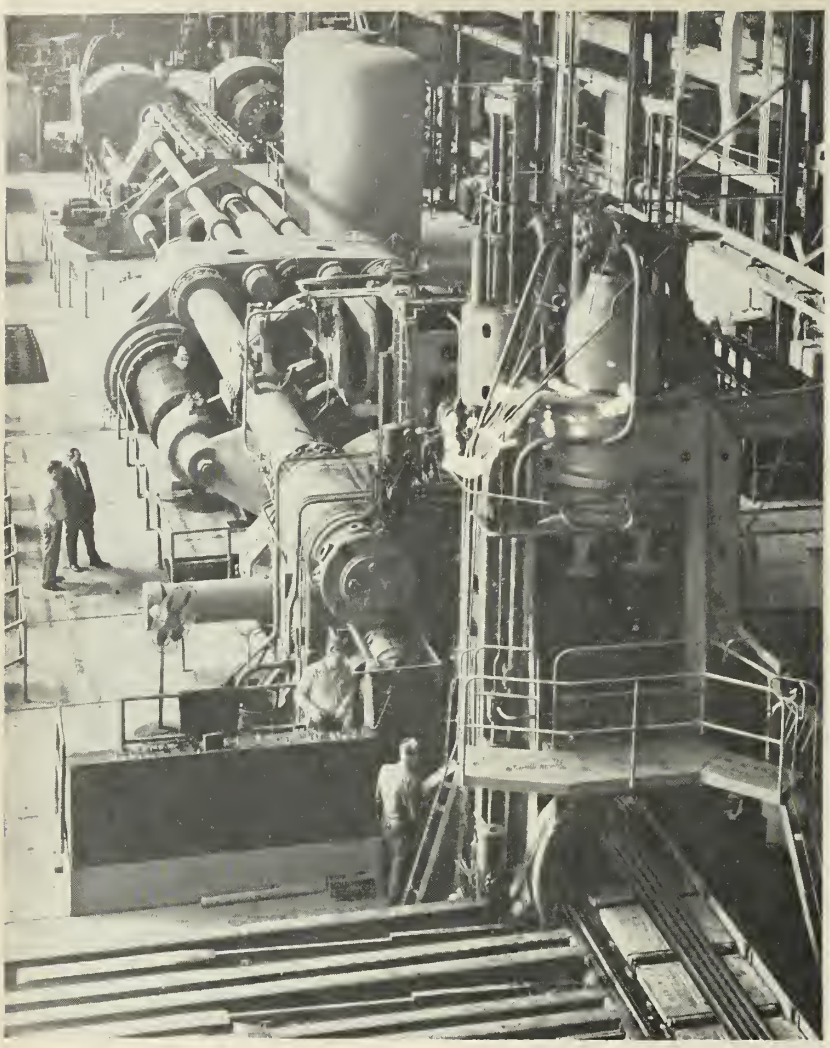
Photographs were taken in CAL's hypersonic tunnels and showed that the wake of the reflected particles created a pointed cone in the air ahead of the model. Although it collapses almost immediately, this cone intersects and disrupts the shock wave that normally builds up in the air around the model's nose.

Such disturbances in the air flow may markedly affect aerodynamic behavior and, if small traces of dust existed in the atmosphere, could conceivably influence the flight of a high speed missile during re-entry from outer space. Such a condition might also affect the transfer of heat, a critical problem of re-entry.

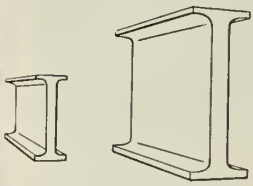
The laboratory revealed these findings recently in a technical paper delivered at a meeting of the Advisory Group for Aeronautical Research and Development of the NATO nations, held in the Netherlands.

New Red Observatory

The Leningrad branch of the Institute of Earth Magnetism, Ionosphere, and Radio-Waves has revealed the opening of a newly built magnetic-variation observatory. The installation is located on the western shore of Lake Ladoga, "in an area remote from industrial establishments and transport, which precludes interference with observations."

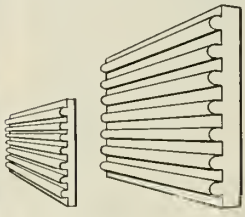


HOW THE 13,200-TON PRESS BOOSTS EXTRUSION CAPACITY



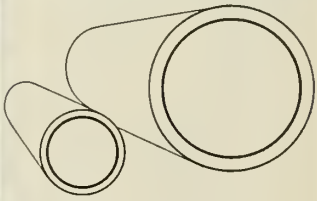
FROM 11″ TO 28″

STRUCTURAL SHAPES



FROM 9″ TO 20″

STIFFENED SECTIONS



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missiles and rockets

AF-Army-Ford Rocket Cracks Shell

In a dramatic demonstration of how much can be done for how little money when inter-service rivalries are set aside in favor of getting on with the job at hand, Air Force Office of Scientific Research's *Far Side* will soon streak to a record-breaking altitude of some 4000 miles.

Delayed by fringe weather conditions from typhoon Faye, AF is poised, ready and waiting to loose its giant helium-filled balloon into the stratosphere. Two hours later at 100,000 feet a 10-rocket, four-stage vehicle will blast loose. Within moments "up" will become "out," and man will crack the atmospheric shell that binds him to the egg called earth.

Carrying an instrumental payload weighing three-and-a-half pounds, this shot is the first of six planned in the current *Far Side* series. The basic configuration, however, with but slight modification is capable of landing dye-markers, flares or other payloads on the moon.

The prime contractor on the project is Aeronutronics Systems, Inc., a Ford Motor Co. subsidiary. The vehicle uses five Thiokol Chemical Co. *Recruit* and five Grand Central Rocket Co. *Arrow II* (developed *Loki*) rockets, all developed with Army Funds. The original proposal was made by Dr. S. Fred Singer of the University of Maryland's Physics Department. Dr. Singer is also supplying some of the instrumentation.

During September it looked as though the project might have to be dropped due to nondiscriminatory across-the-board slashes in allowable expenditures for the first six months of fiscal 1958. AFOSR's budget, however, has been completely reinstated.

One of the most dramatic aspects of *Far Side* is the amount of research gained for the dollars expended. AFOSR has put approximately $800,000 into *Far Side*. Aeronautics has added about $400,000 of its own funds.

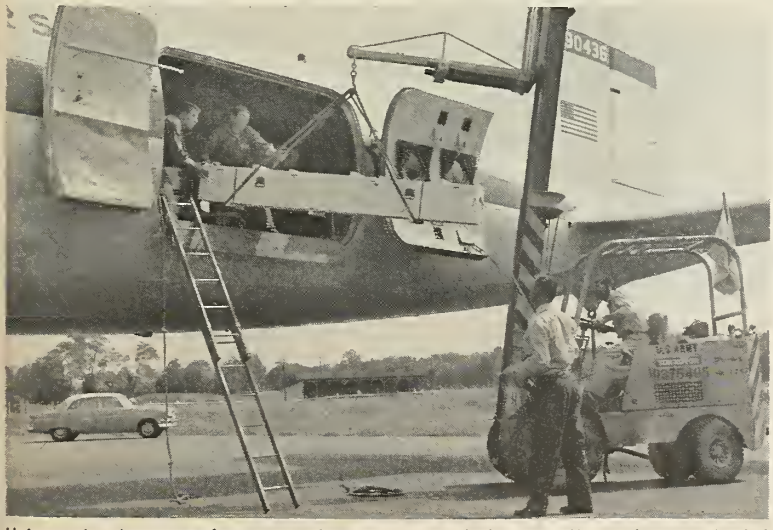
While the firing is largely non-directional—aimed straight up—the vehicle spends a considerable time above the earth's atmosphere, taking something over two hours to make the complete "out-in" circuit. During all this time sensing elements are measuring space conditions which are telemetered back to earth.

Rocketeer Blackmon Does it Anyway

Unencumbered by interservice rivalries, budget limitations and the engineering shortage, Rocketeer Jimmy Blackmon fired his second rocket last month.

The eighteen-year-old rocket expert, whose first rocket never got off the ground due to extra-heavy governmental red tape and too much backpressure, took his second model to a deserted North Carolina beach and launched it with the aid of some friends. He didn't make the mistake of asking the government for clearance this time.

Using a propellant of powder zinc and sulphur, ignited by an automobile battery, the 5½-foot-long vehicle zoomed to 4000 feet at great speed and then fell into the ocean about 400 feet from the launching site.



Unimpressive beginning for a very dramatic event. Thiokol RECRUIT rockets are loaded aboard a DC-7 for shipment to Eniwetok Atoll in the Marshall Islands where they will be staged as FAR SIDE vehicles. Six launchings will be made before first phase of the program is completed. Aeronutronics Systems, Inc., and AFOSR are conducting the tests.

Nike-Hercules Missile Nears Operational Status

FORT TOTTEN, N. Y.—The Army proudly displayed the *Nike-Hercules*, its latest addition to the Continental Air Defense system, during the most complete rundown to date of the Army's role in air defense.

An improved member of the *Nike* family, *Nike-Hercules*, originally designated *Nike B*, is currently undergoing final tests. It is expected to be integrated into existing *Nike* batteries as a supplement to the *Nike-Ajax* within the next year.

Nike-Hercules was reported to have a range more than twice the *Ajax*—approximately 70-75 miles—and 25 per cent higher altitude capability. Its greater velocity and the increased lethality of its atomic warhead will make it one of the nation's most deadly surface-to-air missiles.

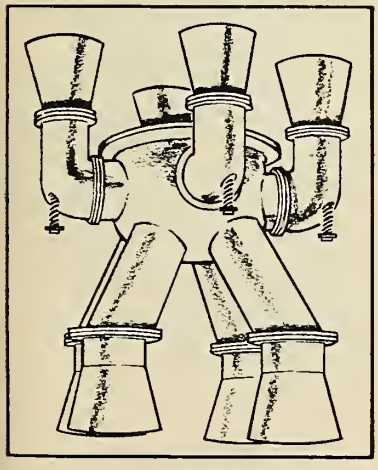
The five-ton, 39-foot missile has solid-propellant boosters and sustainer. Booster is a cluster of four *Ajax* while sustainer is a radical development in solid-propellant motors (see Industry Spotlight p. 145).

The sustainer motor is unique in that the exhaust nozzle is located at the end of a long constant-diameter tube extending from the combustion chamber. This design was motivated by the need to shift the center of gravity of the *Hercules* forward. Pitch, yaw and roll control system is located around the exhaust tube. A single solid-booster motor is currently under development. This will increase the mass ratio and specific impulse of the present four-barreled system.

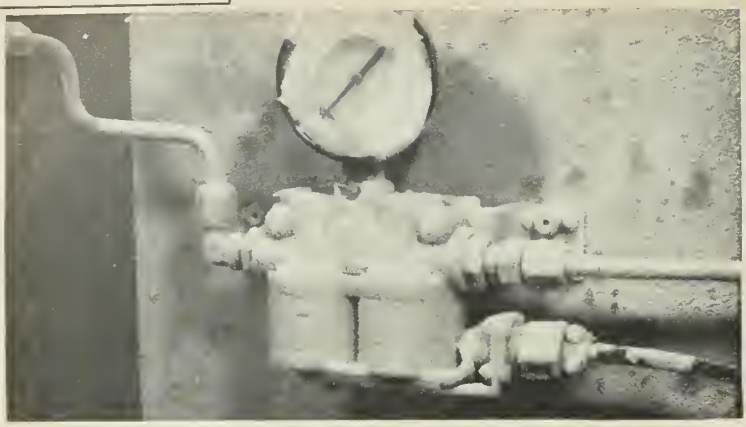
Present defense cutbacks will not slow down the *Hercules* program. Modification of existing sites will be needed before the *Nike-Hercules* can be integrated. Exact modification costs were not known although partial figures indicate costs will be high. Modifications, including new launchers and assembly buildings, will be approximately $40,000 for each site. In addition, a new universal fire control console costing one-half-million dollars will be needed. *Ajax* consoles will be modified.

Army officials announced that present *Nike-Hercules* models cost approximately $15,000, while each mission with an atomic warhead could cost up to $1 million.

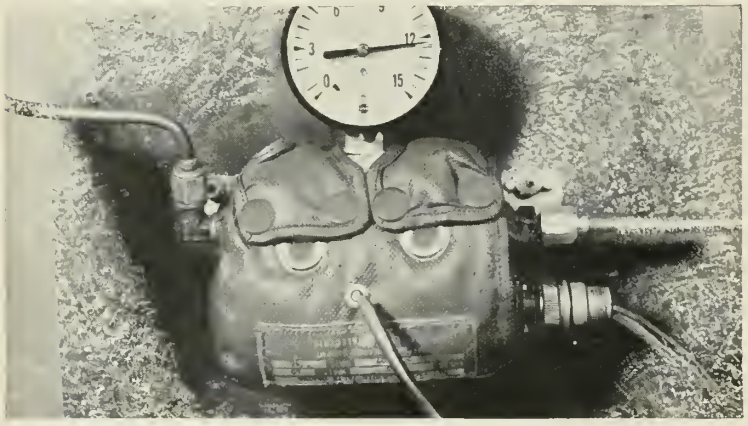
Next addition to the family will be the *Nike-Zeus*. Two models are under development: an anti-missile missile and an intermediate range version. The Army, restricted to point defense, might infringe upon the area defense mission.



This plenum chamber with eight nozzles shows how some of the solid-propellant thinking is going at Thiokol Chemical Co. Four reversing nozzles could be used for either pitch and yaw control, clean separation or both.



FREEZE-UP of solenoid-controlled valve in airborne system at −65°F can choke off vital air supply. Manufacturer faces tight contract delivery schedule.



SPECIAL HEATING unit custom-designed and delivered by G.E. in 5 days enables stock valve to function properly, saves customer time, money.

Explosion Waves Studied

The Air Force is using high-speed photography in attempts to tame explosions and put them to use for propulsion. The ARDC hopes to learn enough about the detonation waves to suggest ways to control them. The research could conceivably lead to the development of smaller and lighter engines.

In order to photograph the waves for study, the AF is utilizing a Beckman & Whitley ultra-speed framing camera that shoots 25 individual photographs in 1/15,000th of a second as the waves pass an eight-inch window in the 25-foot test chamber.

Deserves a Silly Answer*

Seeking reasons for the presence of Dr. Ramo, America's "top guided-missile man" in this country, the News Chronicle diarist got a "Don't know" from the Ministry of Defence, a "Here on pleasure" from the U.S. Embassy and a "Strictly business" from the visitor himself, while British guided weapons spokesmen countered with "Who is Dr. Ramo?" and "How do you spell it?" and the diarist had to end a promising paragraph with, "Maybe he is just admiring the beauties of nature." This had all the others wishing they'd thought of that one at the time.

**Reprinted with permission of PUNCH.*

Five-year-old John Kirby, gazes at the General Electric X-405 rocket engine, which will provide the thrust for the first stage of the three-stage earth satellite projectile.

Afterburner Cooling Assembly Gangs Straight Wall Tubing For High Strength, Light Weight

A minimum weight plus complex fabricating problems were critical factors in the development of this afterburner cooling blast tube assembly.

The space envelope was shallow and wide and over six feet long. The assembly was required to be tested at 28 psig with collapsing pressure of −2.5 psig and at a temperature of 250° F.

Flexonics answered the need by

End view of afterburner cooling assembly. Note rectangular shape of ends.

forming standard High Strength welded tubing into a gang. Ends of the tubes were formed to a rectangular shape to adapt them to the required end fittings. The tubes are held together with welded bands as the illustration of the unit shows. Tabs are provided for mounting in the airframe.

Tubing used in the assembly is 1.625″ O.D. by .011″ wall thickness. Type 321 High Strength stainless steel is used, with ultimate of 100,000 psi.

Facilities are the Key Factor

In the engineering, fabrication and proving of assemblies such as this, facilities are all important. As the pioneer and leading manufacturer of light weight corrosion resistant flexible assemblies and ducting, Flexonics Corporation has facilities second to none.

The engineering skill of Flexonics Corporation is proved by the scores of developments already made ranging from single flex connectors to entire aircraft ducting systems.

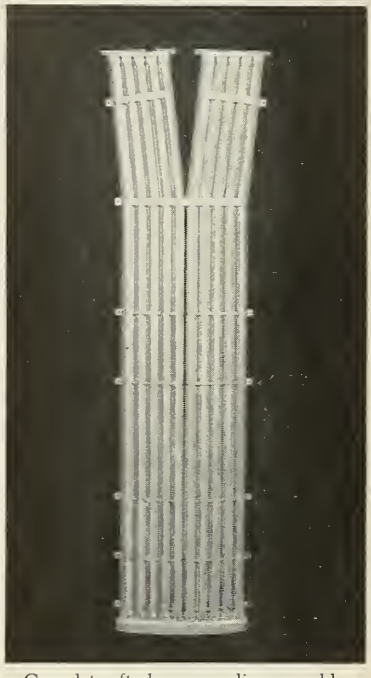
The manufacturing know-how of Flexonics Corporation is proved by the daily trouble free production of intricate assemblies and by such developments as the re-deposition process of forming ducting components.

The ability to prove assemblies before their installation in aircraft and engines is assured by the extensive Flexonics laboratories capable of the most advanced testing procedures.

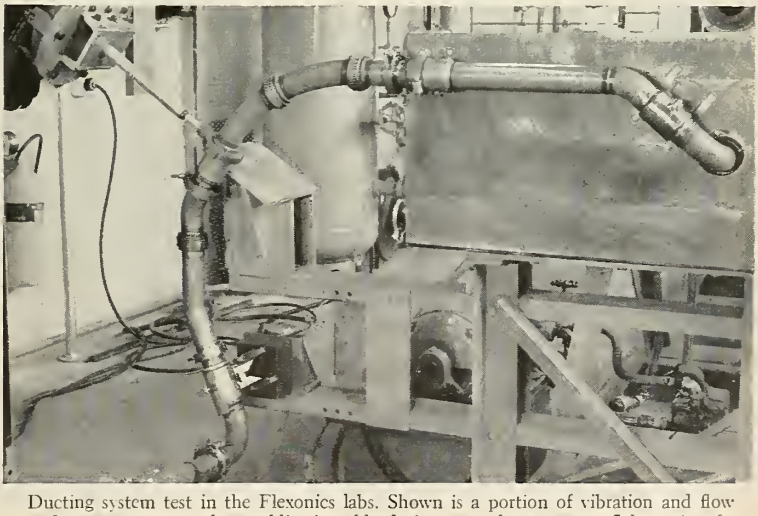
Engineering Assistance

Whenever you have a problem involving aircraft plumbing, take advantage of the know-how and facilities of Flexonics Corporation. For specific recommendations send an outline of your requirements.

For help right at your desk, write for information on how qualified persons can secure copies of the new Flexonics Engineering Manual.



Complete afterburner cooling assembly. Note use of straps to gang the tubing.



Ducting system test in the Flexonics labs. Shown is a portion of vibration and flow under pressure tests of assemblies in a bleed air system for a current fighter aircraft.

Behind the Curtain

by Dr. Albert Parry

Moscow's announcement of the first successful Soviet ICBM test was clearly meant as a threat to us. Do the Soviets know that the threat will only spur us on with our ICBM work? They do. They must feel they have no choice but to brag and threaten. And not only for foreign policy reasons (to queer the disarmament talks; to stop us from doing something about the Syrian mess; to intimidate the UN in the Hungarian debate), but also because of their domestic unrest—particularly the Soviet and satellite youth. Nikita may be saying to his Kremlin colleagues: "Let's make our youths forget their restless cynicism by a bit of ICBM-rattling. Let's make them patriotic and proud about Communism again by telling them we are ahead of America in the ultimate weapon."

•

Russia does not yet have a model of her artificial satellite. Her scientists haven't as yet decided on the size and weight of those Red moons. So said Dr. Valeria Troitskaya, general secretary of the Soviet IGY Committee, on her visit to Toronto. Russia does not yet have rockets ready to launch artificial satellites, declared Dr. Vladimir Kotelnikov while heading a 16-man Soviet delegation to San Francisco's Western Electronics Show and Convention. And this man ought to know. He is chief of the Radio and Electronics Division of the Soviet Academy of Sciences.

Yet, from Leningrad, comes the contradictory news that the Main Astronomical Observatory of the same Academy has begun its final intensive preparations to watch the Soviet satellites once they are launched: 30 special "spyglasses" are being installed on as many platforms at Pulkovo, and teams of observers are being formed under the command of D. Shchegolev, described as "candidate of physico-mathematical sciences." This may suggest that, Drs. Troitskaya and Kotelnikov to the contrary notwithstanding, the Red moment of launching is near.

•

Soviet scientists have lately shown a marked interest in whatever U.S. and West European reports they can find on American research experiments with "weightless airplanes." In the Moscow KOMSOMOLSKAYA PRAVDA young Russian physicist P. Nikitin quotes a West German aviation magazine to the effect that eight commercial American concerns and seven American universities and technical colleges are working on the problem of gravitation and how to defy it by building and flying "nonweight aircraft." According to Nikitin, anti-gravitation forces once invoked "will be sufficient even for interplanetary flying apparatuses." The Soviet scientist calls special attention to "a news item published in AMERICAN AVIATION saying that Avro, a Canadian firm, has begun the construction of a flying disc which will rise vertically" as proof that gravity-defying flights may soon be possible.

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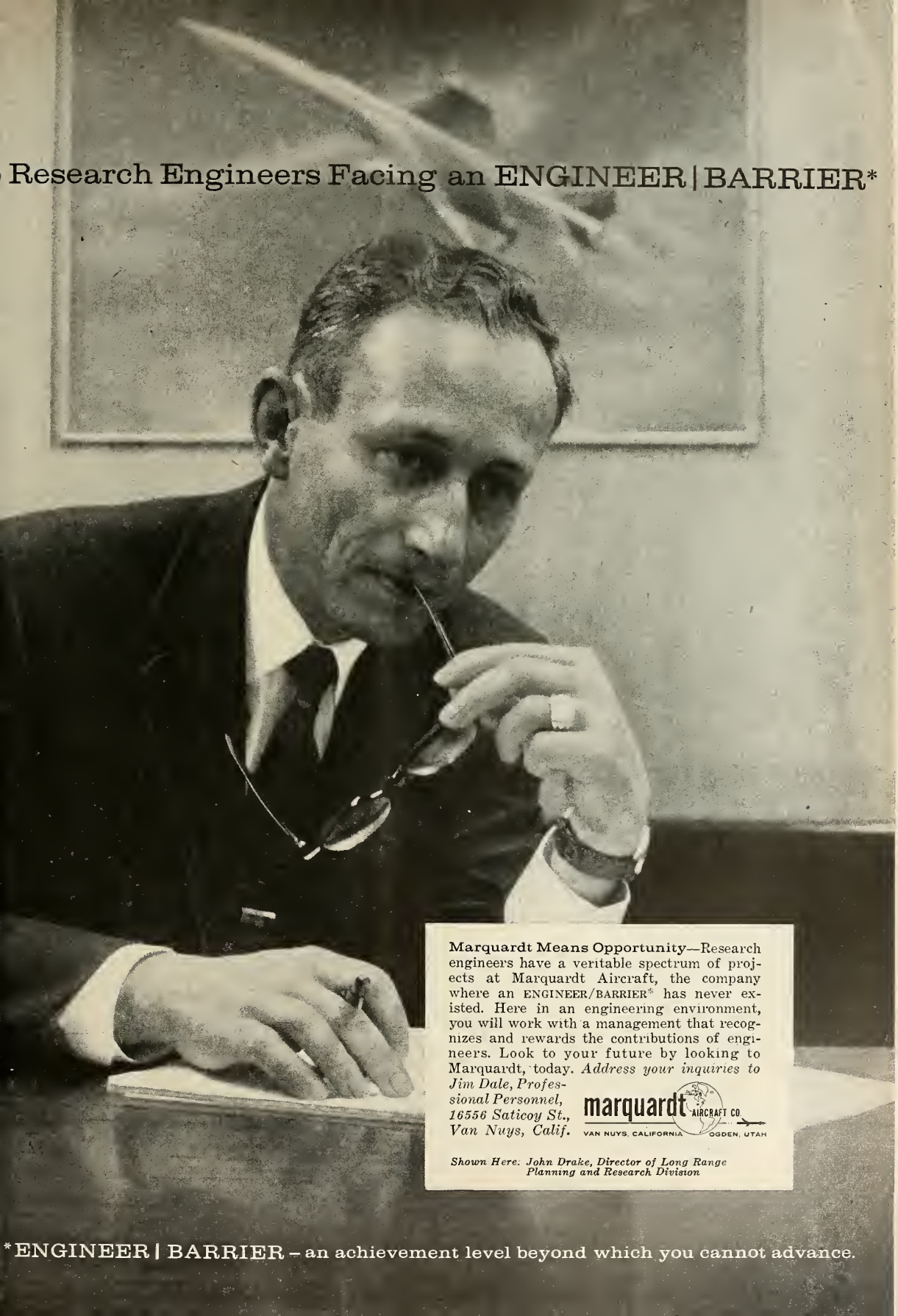
The 1957 program of the Soviet State "Foreign Literature" Publishing House includes publication of a book entitled EXPLORATION OF THE UPPER ATMOSPHERE BY ROCKETS, a Russian translation, apparently, from English.



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Shown Here: John Drake, Director of Long Range Planning and Research Division

*ENGINEER | BARRIER – an achievement level beyond which you cannot advance.

World Astronautics

By Frederick C. Durant III

The recent "first" issue of ASTRONAUTICS was labeled Vol. II, No. 1. Don't search for Vol. I; this designation refers to the series of ASTRONAUTICS published in the thirties, before the title was watered down to: JOURNAL OF THE AMERICAN ROCKET SOCIETY.

Incidentally, the appearance of ASTRONAUTICS has caused the folding of MISSILE AWAY! and AMERICAN ROCKET SOCIETY NEWS, two splendid publications put out by the N.M.-West Texas and So. Cal. Sections of the ARS. The edict originated topside in the ARS and was aimed at maintaining control over all advertising in ARS publications. Some bitter feeling developed in the conflict over rights of sections and the national headquarters of the ARS, but apparently all has been settled amicably. These section publications were a "labor of love" representing many thousands of hours of hard work in the interest of astronautics.

Finally, there are a welter of foreign space flight periodicals issued regularly. WELTRAUMFAHRT represents the German, Austrian and Swiss astronautical societies. RUMFART is published by the Danish Interplanetary Society. The Associazione Scienze Astronautiche (Torino) publishes ASTRONAUTICA, not to be confused with ASTRONAUTICA ACTA, the official organ of the International Astronautical Federation.

The Space Flight Committee of the ARS, under the leadership of Krafft Ehricke, is making remarkable progress in hammering out recommended technical programs for the future. Eleven subcommittees have been organized under the following headings: Space Flight Operations; Spacecraft Systems; Spacecraft Propulsion Physics; Astrionics; Spacecraft Equipment and Reliability; Space Flight Mechanics; Space Physics; Legal Aspects; Sociological Aspects; Training and Education; and Documentation.

Ehricke was successful in obtaining as chairmen for these subcommittees outstanding individuals who were not already members of the Space Flight Committee. Thus, the working strength of the SF Committee has been augmented by a dozen excellent men as chairmen, plus many more individuals selected to membership of the subcommittees. In addition to the activities of these subcommittees, the Space Flight Committee itself is working on a program of action to be presented to the ARS Board. In the past the annual business meeting of the ARS has been rather dull to most casual observers. But at the annual meeting in New York this December it is predicted that some mighty interesting projects and proposals will be forthcoming.

•

Switzerland is known to have two well-developed guided missiles: the Oerlikon-Contraves, Type 50 Series, surface to air missile and the Oerlikon-Contraves-Boelkow *Cobra* antitank weapon. The Swiss guided missile program like the country is small. But also like the country, the program is highly developed. The development costs of these missiles have been borne essentially by private industry. Sales have been made not only to the Swiss government but to a number of other nations, as well. The USAF evaluated 25 of the early Type 50 missiles at Holloman in 1954.

The arms division of Oerlikon is justifiably famous in the arms and munitions world. During World War II the Oerlikon 20 mm. antiaircraft gun was widely manufactured in the U.S. and Great Britain as well as by the Axis countries.

Painting by Chesley Bonestell from the book *The Conquest of Space*, by Willy Ley and Chesley Bonestell, published by the Viking Press ($4.95). © C.B.

How many Fenwal Controls aboard?

You might make a reservation for the first passenger trip to the moon now. But there are still some things to be determined.

We don't give you a list here of all the Fenwal temperature and control devices that may be found on board. But we do know that our past performance in solving the temperature problems on such a high proportion of modern aircraft will stand us in good stead on solving new problems. And, give manufacturers a good sense of security in adopting Fenwal devices.

For instance, in the field of fire and over-heat detection, Fenwal products are well advanced and proven in both unit and continuous types. Fenwal has the men, the equipment and the knowledge to insure fruitful exploration and practical, trustworthy products for today and tomorrow.

It will be encouraging to find, too, that your engineers will get along fine with Fenwal engineers. Our aircraft catalog on request. It's interesting. Fenwal Incorporated, Aviation Products Division, Ashland, Mass.

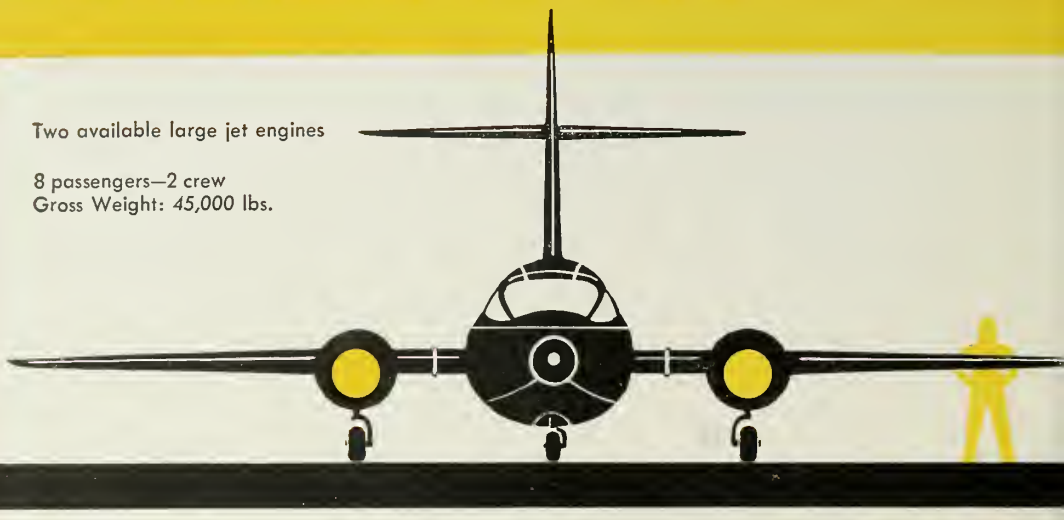
Fenwal

Controls Temperature . . . Precisely

EXAMPLES OF SMALL JET ENGINE WEIGHT LIFTING
ADVANTAGES AND AIRFRAME SHRINKAGE... ON IDENTICAL MISSIONS.

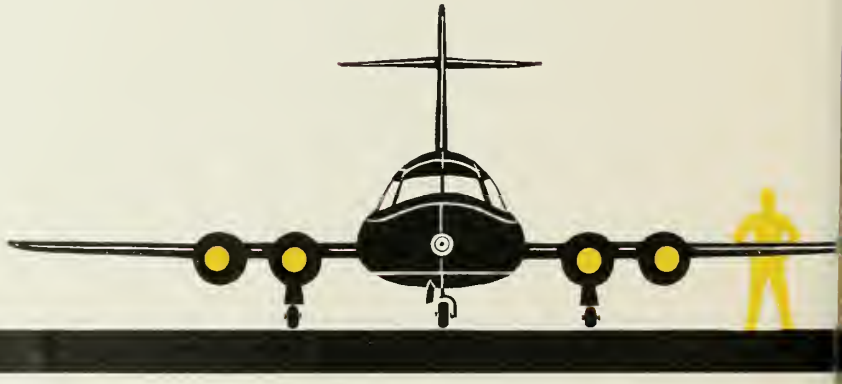
Two available large jet engines

8 passengers—2 crew
Gross Weight: *45,000* lbs.



Four Small Jet Engines

8 passengers—2 crew
Gross Weight: *26,000* lbs.



Two Small Jet Engines

4 passengers—2 crew
Gross Weight: *16,000* lbs.

SMALL JET ENGINES...

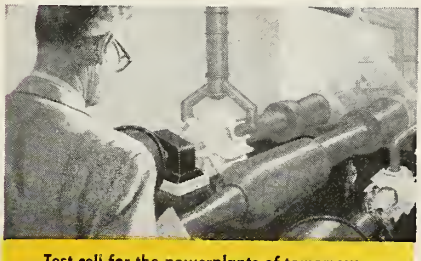
CHAMPION WEIGHT REDUCERS

The new breed of high-performance, lightweight, small jet engines coming to life will broaden the horizons of jet aircraft design, performance. versatility and utility.

Best of all, the new small jets will make possible lighter, less costly aircraft with performance to match the big planes of today. With power/weight ratios as high as 8 to 1 and long range potentials of more than 10 to 1, the small jets may power lightweight fighters, basic and advanced jet trainers, transports of half the size with proportionate savings in weight and cost. As the new airframes shrink, their performance and especially their versatility and utility expand.

Performance and potential in a smaller package . . . this is the promise held out by the new family of small jet engines of the J83 type now under development and test.

Fairchild Engine Division has long been a pioneer in aviation and a pioneer in power and is dedicated to the small jet engine concept.



Test cell for the powerplants of tomorrow—a vital link in the chain of advanced research program at Fairchild Engine Division. Equipment, experience and design ingenuity—these are the elements in Fairchild's pioneering in small jet powerplants.

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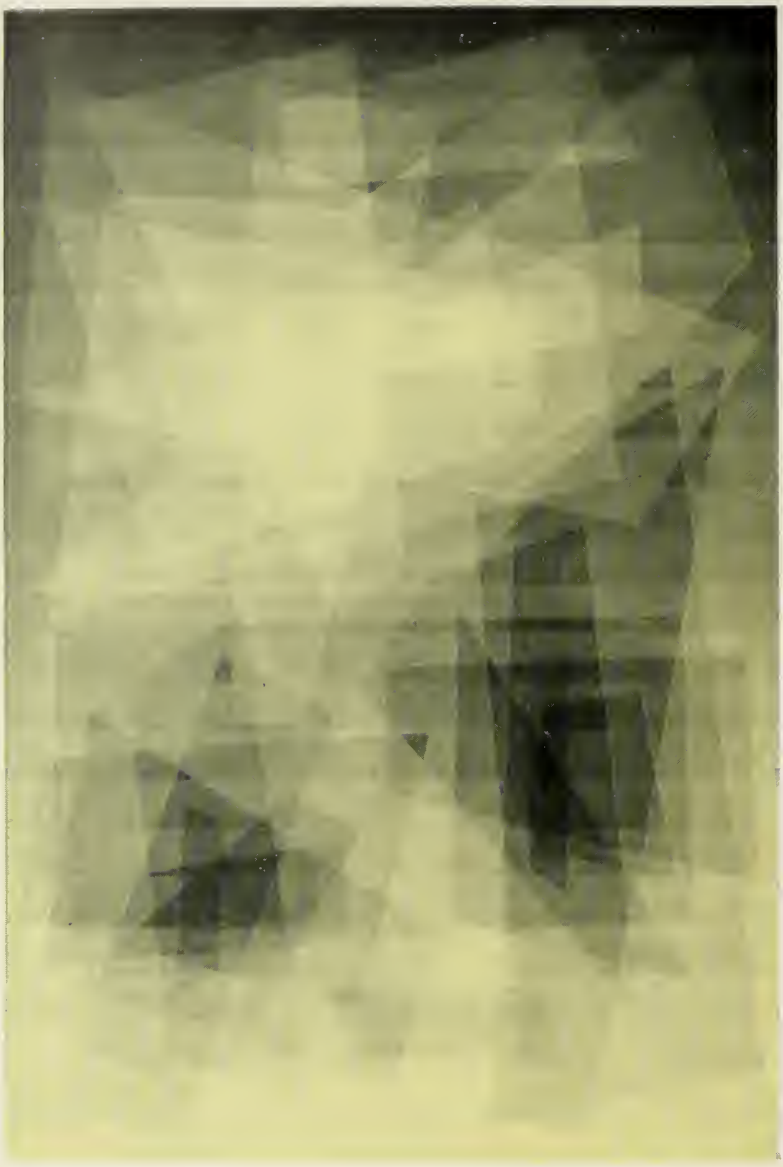
WHERE THE FUTURE IS MEASURED IN LIGHT-YEARS!



"NIMBUS," a new painting by the well-known team of science-artists Simpson-Middleman. In this work, the creators have found new artistic meaning in the Moon and its reflected light. An attempt to capture the polarized nature of moonlight is made. The result, an almost half-light. Collection of the Whitney Museum of American Art, New York.

Work in the world of supersonic flight—at Boeing

Supersonic flight is still in its infancy, and Boeing engineers are engaged in the adventurous task of pushing forward the frontiers of knowledge in this years-ahead world. Underway at Boeing are design projects for top-secret aircraft and missiles far more advanced than any yet developed. Related explorations delve into the required properties and capabilities of materials, fuels and systems not yet in existence. You'd find working on advanced Boeing projects a true adventure—challenging, rewarding, stature-building. Boeing offers this opportunity today to scientists, and to experienced engineers in many categories.

BOEING

Drop a note now, to John C. Sanders, Engineering Personnel Administrator, Boeing Airplane Company, Department R-68 Seattle 24, Washington.

VOL. 2 NO. 10
OCTOBER, 1957

missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS

m/r exclusive:

Report on

Missiles and Rockets Around the Globe

WHAT WE BELIEVE to be the most extensive up-to-date roundup of guided missiles and rocketry around the globe is presented in this issue of m/r. With missiles and rockets manning an ever-increasing segment of our ramparts against aggression, it is important that we note all developments in this field—wherever these developments occur.

MISSILES AND ROCKETS has closely watched the international missile industry with as sharp an eye as it watches the American missile industry. Thanks to our world-wide editorial service, it has been possible for us to keep a sensitive hand on the pulse of the rocket and missile industry around the world.

What is the international missile industry? What is it doing? Who leads in production? Who leads in research?

MISSILES AND ROCKETS has obtained the answers to these questions by sifting hundreds of reports, its editors and contributors having traveled thousands of miles, reporting in many countries. The answers are here on the following pages.

There is not one overall leader of the globe's missile industries. In Europe, Britain leads in the production of guided weapons. France has leadership in the research and development fields. On the other hand, Japan may well lay claim to leadership by her sheer enthusiasm for the future of rocketry. These are leaders. The U.S. has no claim to leadership of all missiles and rockets everywhere. We are challenged by other missile and rocket makers. They are good.

So are the Soviets. In the announcement regarding the ICBM capabilities which they claimed, the Soviet Union said:

"The solution of the problem of designing (intercontinental) ballistic rockets will make it possible to reach remote areas without resorting to a strategic air force, which at the present time is vulnerable to up-to-date means of antiaircraft defense."

Many of the Soviet missiles are as effective as Western missiles, though the high polish may not be there in all instances. As in the case of any weapon, they can kill you just as dead as a "sophisticated" model.

The Soviet arsenal is bristling with weapons that will back up the ICBM: firings of the various IRBM models take place weekly, the Red Fleet uses Arctic waters as a proving ground and test range, and a large portion of the submarine fleet is being equipped for missile handling. These submarines with IRBMs can do what the ICBM is not yet ready to do.

When the Red Army took over the German rocket centers, they sent back everything they could get their hands on. From this data and material, the Russians constructed over 1000 V-2s to acquire production techniques and for training. The Soviet version, the T-1, had an improved engine and greater range. The next step was a two stage IRBM designated the T-2, and from this evolved the T-3 ICBM, the entire program probably resembling an erector set with one assembly being "stacked" upon another.

Hence the USSR, with perhaps the largest strategic air force in the world, rendered it obsolete as soon as the Soviet Army successfully fired one ICBM. Albeit this is propaganda to enhance the effect of the ICBM announcement, it is a sign. And you don't shoot down many missiles with airplanes—just other missiles.

Britain has staked her survival on the guided missile. Sweden will make no more manned interceptors. There are greater stakes on the table—or globe—than anyone would have wagered on missiles just a few short years ago. To protect themselves against loss of this stake, the countries reported on in this exclusive roundup are encouraging rapid expansion of their respective missile industries.

The editors and contributors who have assembled the information presented in m/r's roundup include: Seabrook Hull and Norman Baker, assistant editors; Frank G. McGuire, business news; Alfred J. Zaehringer, rocket engineering; Henry P. Steier, electronics.

Also Frederick C. Durant III, astronautics; Dr. Albert Parry, Soviet affairs; Raymond L. Garthoff, special contributor, former specialist on Soviet Military Affairs for the RAND Corp.; Frederick I. Ordway, Heyward E. Canney and Ronald M. Wakeford, research editors; Franco Fiorio, special contributor on Italian affairs; Anthony Vandyk, international editor; Jean-Marie Riche, Paris; James Hay Stevens, London.

The Editors

RUSSIA . . .

Leading the World in ICBM and Satellite Development?

By Dr. Raymond L. Garthoff

FOLLOWING A PERIOD of tight wartime censorship on any disclosure of the military uses of rockets, Soviet publications in the spring of 1944 began to print articles on long-range rockets. One of the first was an article in April 1944, by the eminent scientist, military technologist and publicist, Dr. G. I. Pokrovsky, Professor Major General of the Engineering Technical Service. Its title: "The Utilization of Long-Range Rockets." This article marked the first concrete evidence of the developing Soviet interest in long-range rockets.

Lt. Gen. M. Gerasimov, an important officer in the ground forces' training program, published an article in May 1946, in the official journal, THE MILITARY HERALD, in which he raised the problem of the influence of atomic weapons and other new military technological developments on the entire military training program. He predicted specifically that: "The significance of rocket artillery, which is difficult to detect but capable of firing projectiles with sufficient accuracy to destroy targets located hundreds *and possibly thousands of kilometers away,* will grow . . ."

In January 1947, another Soviet general, Lieut. Gen. of Artillery P. N. Kuleshov, in an article in FOR DEFENSE stated that: "A great future opens for rocket artillery, *especially for long-range artillery.*" He also spoke of "rocket artillery of *strategic significance* with a range of several hundred kilometers." Finally he cited an American report on German plans for a two-stage ballistic rocket capable of attacking the continental U.S.

A third article, by Maj. Gen. of Aviation E. Tatarchenko, appeared in the official Air Force journal, HERALD OF THE AIR FLEET, in May 1946. He also called attention to the German efforts to create a rocket missile capable of bombing New York.

He stated: "Although this attempt did not meet with success, the very fact that precisely this technical task was set as completely practicable is very important." In addition, he paraphrased a statement by Gen. Arnold to the effect that: In the future it is extremely likely that rockets will be capable of hitting any point on earth, within a two-and-one-half square kilometer target area.

The Soviets use the term "long-range rockets" in describing the V-2 and other ballistic rockets of a few hundred kilometer range. In the GREAT SOVIET ENCYCLOPEDIA (late 1955), German V-2 weapons of World War II with given range of "up to 300 kilometers" are described as "long-range rockets." Consequently, general Soviet statements on long-range rockets, such as by Marshal Zhukov, must be understood as describing weapons with a range of a few hundred to several thousand miles.

The first direct communist reference to intercontinental rocket weapons systems appeared in December 1953, in an East German radio commentary by the military analyst, Egbert von Frankenberg und Proschlitz. Frankenberg stated: "Soviet long-range bombers would reach all points in the operational rear and home zones of the enemy. *The guided twin rocket (sic) suitable for transatlantic delivery has been developed further.*" A few days later (Dec. 22, 1953) the Soviet Government declared in a formal statement that "there exist rocket weapons which contemporary technology permits to be employed at ranges of thousands of kilometers, without the use of aircraft . . ."

The ambiguity was doubtless intentional. In fact, subsequent early statements were still less specific. For example, an article by an anonymous retired general, which appeared in IZVESTIA in January 1954, stated: "The contemporary development of aviation, rocket weapons, and the submarine fleet makes it possible to deal crushing blows across a distance of many thousands of kilometers."

In an article in March 1955, Maj. Gen. Pokrovsky stated that "long-range rockets capable of flying over a thou-

The latest Red statement on long-range missiles was radio Moscow's announcement of the successful test of an Intercontinental Ballistic Missile which went, in part, as follows:

In conformity with the scientific research program, successful tests of an intercontinental ballistic rocket as well as explosions of nuclear and thermonuclear weapons have taken place in the Soviet Union.

A super-long-distance intercontinental multi-stage ballistic rocket was launched a few days ago. The tests of the rocket were successful. They fully confirmed the correctness of the calculations and the selected design.

The rocket flew at a very high, unprecedented altitude. Covering a huge distance in a brief time, the rocket landed in the target area. The results obtained show that it is possible to direct rockets into any part of the world.

The solution of the problem of designing intercontinental ballistic rockets will make it possible to reach remote areas without resorting to a strategic air force, which at the present time is vulnerable to up-to-date means of anti-aircraft defense . . . the Soviet Government express gratitude to a large group of workers who have taken part in designing and manufacturing the intercontinental ballistic rockets, and the complex of facilities for their launching.

A series of explosions of nuclear and thermonuclear (hydrogen) weapons has been staged in the USSR in recent days. In order to insure the safety of the population, the explosions were set off at a high altitude. The tests were successful.

Russian Intermediate-Range Missiles and Upper-Air Vehicles

	Model	Type	Length (ft)	Dia. (in)	Range (Mi)	Status	Notes
Missiles	T-5	BR				P;O	Artillery & antitank. Composite solid propellant rocket.
	ME	G	1.5-2	3.35	1-2	P;O	Recoilless, gun-launched rocket for antitank use. May be obsolete; large numbers in satellite nations & Middle East.
	T-6	BR		5.2	3-5	P;O	Artillery barrage rocket; projector-launched.
	Comet-1	SS			90-100	P;Q	Sub-launched (undersea) solid propellent rocket.
	Comet-2	SS			500-700	P;D	Sub-launched (undersea) solid propellent rocket.
	M-100A	GAR	6-8	6-10	5	P;Q	Guided air-to-air missile; solid propellant rocket.
Research	T-3A	Satellite				P;D	3-4 stages. 1 ton payload. Pole-to-pole orbit, 125-1,000 mile. May use T-2 or T-3 hardware.
	POL-1		10-15	10		T	Mach 4 test vehicle, two stages. Stage 1: cluster of 4 solid propellant rockets; Stage 2: M-100A type.
	POL-2		20-25	25		T	Single-stage rocket similar to T-7A. Geophysical studies from 50-100 miles. Four triangular aft fins, short nose cone; payload 50-100 lb.

BR: Ballistic Rocket
G: Gun
SS: Surface-to-surface
GAR: Guided aircraft rocket
P: Production
O: Operational
O: Qualification testing
D: Development
T: Testing

Russia's Ballistic and Long-Range Aerodynamic Missiles

Model	Mission	Type	Length (ft)	Diameter, Max (ft)	Thurst (lb)	Range (Mi)	Status	Notes
T-1 (M-101)	SS	MRBM	50	5.5	77,000	400	P;O	Single-stage, improved A4 (V-2) LOX-kerosene motor Impulse: 4.6 million lb sec
T-2 (M-103)	SS	IRBM	100-125	15	Stage 1: 254,000 Stage 2: 77,000	1,800	P;Q	Two-stage, improved A-4-A9 Stage 2 is T-1 Impulse: 20.4 million lb sec Wt.: 75-85 tons
T-3 (M-104)	SS	ICBM	100-160			5,000	D;T	Two or three stages May use T-1 or T-2 components Wt.: 100-150 tons
T-4 (M-102)	SS	IRGBM	50	5.5	77,000	500-1,000	P	Winged T-1
T-4A		RB				4,000-10,000	D	Two-stage, improved Saenger antipodal bomber Track launched by rocket sled Bomber wt.: 100 tons Impulse: 60.74 million lb sec
T-7A	SS	SRBM	25	2.5	17,600 for 30-60 sec	30-60	P;O	Total launch wt.: about 8,800 lb Truck launched (vertical) HE or nuclear warhead Solid composite propellant

SS: Surface-to-surface
MRBM: Medium-range ballistic missile
IRBM: Intermediate-range ballistic missile
IRGBM: Intermediate-range glide-ballistic missile
ICBM: Intercontinental ballistic missile
RB: Rocket bomber
SRBM: Short-range ballistic missile
P: In production
O: Operational
Q: In qualification tests
T: Test
D: Development

sand kilometers exist at the present time." In a newspaper article the following month, Gen. Pokrovsky cited the statement of December 1953 as having said that "rocket weapons existed which had a range of thousands of kilometers."

The original was considerably less exact and emphatic than this.

Beginning in January 1956, a new serious line appeared in Soviet published statements. On Jan. 28, 1956, in a broadcast on the East German Radio, Frankenberg asserted that Gen. Doolittle, Senator Jackson, and the Alsop brothers were correct in their stated beliefs that the Soviet Union was ahead of the U.S. in developing intercontinental missiles.

Frankenberg declared that: "The Soviet Army, naturally, has at its disposal rocket artillery and long-range missiles." But he went further: "The overseas bases of the U.S. Strategic Air Command could not at present be protected from destruction by rockets." He did not, on this occasion, state that an intercontinental rocket existed, but by indicating that all overseas U.S. air bases were vulnerable, he implied existence of a Soviet IRBM with at least a 1500-nautical mile range.

In February 1956, at the Twentieth Congress of the Communist Party of the Soviet Union, Anastas Mikoyan spoke of Soviet ability to deliver nuclear and thermonuclear bombs "by aircraft or rocket to any spot on the globe." Marshal Zhukov, on the same occasion, spoke of Soviet possession of "powerful rocket and missile armament of various types, including long-range rockets."

These statements were reiterated by other senior Soviet military leaders, on such occasions as Armed Forces Day in February 1956 and February 1957. These statements did not specifically refer to intercontinental rockets, although the one by Mikoyan strongly indicated their existence.

The most emphatic communist statement up to that time was made in March 1956. In another broadcast Frankenberg stated that the Soviet Bloc "now possesses atomic intercontinental ballistic rockets which are capable of reaching any given point in the territory of an aggressor."

One month later Krushchev said in England: "I am quite sure that we will have a guided missile with a hydrogen bomb that can fall anywhere in the world."

Col. Metreveli admitted in MILITARY KNOWLEDGE (December 1955), that long-range ballistic missiles are "intended for firing against strategic targets disposed in the deep rear of the enemy."

Raymond L. Garthoff, for seven years the specialist on Soviet military affairs for the USAF Project RAND, and author of the authoritative book, SOVIET MILITARY DOCTRINE *(1953), presents here some previously unpublished data. He is probably the only researcher in the West to have surveyed all available military, scientific, and popular periodicals and other literature published in the Soviet Union over the past twenty years. The views expressed by the author are his own.*

Insofar as the IRBM is concerned, its potential for action against SAC overseas air bases has been emphasized. In this connection, Frankenberg's commentary of January 1956 made note of a crucial difference in an attack by the IRBM from attacks by bombers: time would not permit the enemy aircraft to evacuate these bases.

Missiles vs. Bombers

One question which arises in an evaluation of the intermediate and intercontinental ballistic rockets is their role in relation to other weapons systems with similar capabilities, particularly long-range aviation. The question was posed by Maj. Gen. Tatarchenko in the official HERALD OF THE AIR FLEET in 1946: "Can long-range rockets replace bomber aviation?" His comments, although ten years old, remain the most complete Soviet view available. It should be noted, however, that his point of departure was the British and American views on the subject, and that Tatarchenko himself, to a unique degree, sometimes expressed views at variance with the official Soviet concept. This is what he wrote:

One of the arguments for the replacement of bomber aircraft by rockets is that in the future, with perfected "thinking" antiaircraft projectiles, with the use of supersonic jet fighters with powerful artillery armament, giant bombers will simply be an unprofitable and ineffective means of long-range action.

Therefore, it seems that it would be cheaper and more reliable to send a corresponding tonnage of bombs in the form of rocket missiles. These rocket bombs, even if they did not reach their target, would despite their cost, be incomparably cheaper than hundreds of enormous aircraft, to say nothing of the absence of crews.

As is well known, in their time the Germans put into action the very same logical conclusion. Rocket bombs were produced almost exclusively, beginning in 1944, for the bombing of London and the southern part of England. They intended to attack New York, and possibly other metropolitan areas of the eastern coast of the U.S. with rocket bombs.

An underestimation of this mighty means of warfare would be a fatal mistake. To even a moderately educated person it must be clear that this new weapon in 1944-1945 appeared in an extremely primitive early form. One can hardly doubt that in the future it will develop significantly further. But does that mean that long-range bomber aircraft have passed their time, and that rocket bombs will completely replace the bomber in the air? Of course not! As the battleship did not replace the cruiser, nor the mine layer, nor the cutter, nor even the rowboat, similarly even the most grandiose development of rockets will not eliminate the necessity for any class of aircraft, least of all high-speed aircraft—bomber and transport.

High-speed giant aircraft are the foundation of strategic aviation. Missions of this form of aviation are extremely varied and cannot be accomplished with rocket bombs alone. Rocket missiles are a means of destroying stationary targets which occupy considerable area. The realm of use of rocket missiles is fairly specific. Strategic aviation resolves many times more universal missions.

While these may have been Tatarchenko's own ideas, there are indications that in general these views probably represented the attitude of the Soviet Long-Range Air Force staff at that time. Marshal of Aviation Skripko, then Deputy Commander of the Long-Range Air Force, stated in RED STAR later in 1946:

It is entirely obvious that with the contemporary level of technology the operation of formations of long-range aircraft with well-trained crews will without doubt be more effective than the dispatch of "blind missiles" alone. Strategic aviation will develop along with the appearance of new aviation weapons.

And the Soviets have acted accordingly.

More recently, in 1954 and 1955, Soviet military writers have commented on American efforts to build a strategic missile system along with the maintenance of strategic air forces. One writer, Lt. Col. Alexandrov, stated in the HERALD OF THE AIR FLEET that in the view of "some American military specialists . . . guided missiles will, in the future, replace bombers."

On the other hand, Lt. Col. Safonov, upholding the view of aircraft dominance, noted in the same journal that other foreign sources have noted that "even in 1960" ballistic missiles "will have a range not exceeding 500-600 km." and cruise-type guided missiles "not over 1000 km." range. In view of its appearance in late 1954, this gross understatement is curious and interesting. Col. Safonov then concluded with a statement which would appear to be at variance with many calculations on high-yield weapons' accuracy requirements: "An atomic missile, as a big expensive weapon, must

be delivered accurately on the target."

Maj. Gen. G. Pokrovsky said in a book in November 1956: "The German Communist military commentator, Frankenberg, whose allegations of present Soviet possession of an ICBM we have cited, nonetheless also has stated (in January 1956) that the long-range rocket weapon 'can, in certain circumstances, cause havoc, but its accuracy in hitting the target depends on many uncertain factors.' "

In the Soviet view, while the general role of bombers will continue for a long time, missiles will assume the burden of attacks on stationary strategic targets.

In the words of Maj. Gen. Pokrovsky, writing in an authoritative limited-circulation military organ in early 1955: "The destruction of targets, the coordinates of which are known in advance, will more and more be accomplished by pilotless weapons armed with atomic and thermonuclear warheads."

Again in March 1957, Gen. Pokrovsky wrote in the magazine MILITARY KNOWLEDGE of the future employment of long-range missiles against "targets previously known and precisely located on the map."

In early 1957, Engineer Lt. Col. Tiurnin, in RED STAR, noted the following advantages of missiles over bomber aviation: (1) the possibility of using mobile launchers, (2) the all-weather capability of guided missiles, (3) the opportunity for the use of missiles even under conditions of hostile general air superiority, and (4) the possibility of launching surprise blows from concealed launching points.

As one of various improvements in manned bomber systems, Red Star recognizes that: "Aviation guided missiles (air-to-surface missiles) can be employed for operations against strategically important targets having strong air defense."

One alleged Soviet source, the authenticity of which is still undetermined, is purported to be a pamphlet, presumably written by the Soviet Air Force command, published in October 1953: THOUGHTS ON AIR STRATEGY. This is said to state that the long-range bomber is obsolete, and that the ICBM is faster, simpler, less expensive and less vulnerable.

American development is said to be inferior and is criticized. In conclusion it is said, "Today's giant air bases will become bomber cemeteries in a future war." While the authenticity of this source is undetermined, the conclusions would seem consonant with Soviet thinking, with the important qualification of their reference to the future.

For the present and immediate future, it is clear that the Soviets are continuing to consider necessary the procurement of large numbers of long-range manned bombers of the *Badger, Bison,* and *Bear* types.

In the distant future another possibility is seen: nuclear propulsion of rocket missiles. As early as September 1945, Lt. Gen. of Artillery Nesterenko raised this possibility in the authoritative MILITARY THOUGHT. Again, in early 1947, Lt. Gen. of Artillery Kuleshov wrote about the possibility of using nuclear propulsion to "increase the speed, range, and power of rocket projectiles." A long silence followed during the period of intensive postwar censorship (1947-1953), but since 1954, a number of Soviet sources have written with implicit optimism of the possibility of nuclear propulsion for rockets.

One general statement, in 1954, mentioned rockets' potential for accuracy and unlimited range. Professor Kosmodemiansky wrote in a booklet: "Rocket projectiles can be shot to any distance. Contemporary successes of radar and teleguidance make possible the achievement of satisfactory accuracy in hitting the designated target."

It is from this perspective that the Soviets see the growing role of long-range ballistic missiles gradually replacing many but not all the missions of piloted bombers.

USSR Army Gets IRBM, ICBM

As we have observed, in the early postwar period several artillery generals stressed the importance of long-range missiles. In the postwar research and development program, both artillery and air force officers and institutions have played important roles. Chief Marshal of Artillery Voronov has been reported, at least as of several years ago, to have headed the whole missile program. Marshal of Artillery Yakovlev has also been active in this work.

Development of rocket propulsion units, and such work on guided pilotless bombers as has been done, have been directed by the appropriate air force agencies. Work on ballistic rockets has apparently been conducted under artillery supervision. The head of the Technical Sciences Section of the USSR Academy of Sciences is Academician A. A. Blagonravov.

Recently, several Soviet generals and marshals of artillery have been permitted to state publicly (in Col. Gen. Fomin's words in November 1956) that "long-range rocket weapons of intermediate and strategic types . . . constitute *a form of artillery*. Now artillery can be employed . . . beyond the limits of the tactical zone of operations of the ground forces."

Col. Gen. Samsonov similarly spoke of long-range rockets as "a variant of rocket-firing guns. Thus we witness a new qualitative leap in the development of *artillery*."

Marshal of Artillery Chistiakov declared that "rocket artillery can be employed for firing atomic projectiles not only in the tactical zone of operations of the ground forces and in their interests, but also *along with* (not as part of) long-range aviation for strategic purposes." No air force spokesmen have been permitted to make similar statements.

Ultimately the ICBM (and probably the IRBM) may well be absorbed in an autonomous long-range force combining this ballistic missile artillery with long-range manned (and, if employed, pilotless) bomber aviation. Meanwhile, the ground forces have operational control over all ballistic missiles up to about 1000-mile range, and probably will get some of the IRBMs.

The Soviet Navy has been permitted to develop and adapt both ballistic and guided missiles up to and probably including an IRBM for use from submarine and surface vessels, and possibly for coastal defense (which is a naval mission in the USSR). For submarine launching, emphasis to date has been on nonballistic guided missiles.

One of many statements reflecting the Soviet interest in submarine missile launching was made by Rear Adm. Pavlovich (March 1957) in SOVIET FLEET: "The possibility of using submarines for action against industrial and administrative centers of the enemy by long-range guided missiles has advanced a whole series of new requirements in combat ordnance." In addition the Soviet Navy has been developing an air-to-surface missile for use against enemy ships at sea.

IRBM, ICBM Invulnerability

General Pokrovsky in SCIENCE AND TECHNOLOGY IN CONTEMPORARY WARS, a book published in October 1956, has spelled out most explicitly the Soviet evaluation of relative invulnerability. He stated:

> In firing long-range rockets each rocket can be launched from an individual launching pad, and moreover these launching platforms can be constructed relatively quickly, quite dispersed, and well concealed. Their detection by the enemy, prior to the launching of the rocket, can be made difficult, and in any case more difficult than the detection of airfields. Therefore it will be very difficult for the enemy to prevent the launching of a rocket.

As regards interception of a missile once launched, he calls attention to the fact that:

> . . . in flight, a long-range rocket has

extremely great speed . . . One can suppose that a long-range rocket, launched by the enemy by surprise, will be detected by radar only several tens of seconds before the moment of detonation, and too little time will remain for a normal alarm and shelter of people. Thus a long-range rocket in practice achieves surprise of attack on a distant target. A massed blow of long-range rockets, launched by surprise by an aggressor against a peaceful country will be especially powerful because in peacetime the launching pads and rockets on these launchers can be prepared in concealment without possibility of reconnaissance and destruction by the defender . . .

The speed of a long-range rocket prevents its interception and destruction by conventional flying means, artillery fire, *or any other means*. It is possible that some counterweapon will be found. However, without doubt for quite awhile the probability of destruction of the rockets cannot be very great.

Defense Against U.S. Missiles

Until very recently there have been virtually no Russian reports on specific problems of defense against American ballistic and guided strategic missiles. In a rare statement (December 1956) an East German radio commentator declared that while defenses exist against guided missiles, "no defense exists against ballistic rockets. No absolutely effective weapon exists at present to counter this type of rocket weapon."

Since spring 1957 a few brief reports have been made of such defense measures through Soviet sources.

Maj. Gen. Pokrovsky, who has on other occasions been permitted to break through censorship (for example, to discuss long-range missiles, in March and April 1944), first mentioned this problem, in the March 1957 issue of MILITARY KNOWLEDGE.

In discussing American nuclear delivery systems, he stressed "the great difficulty" of intercepting long-range missiles, but without elaboration. Later in March, Lt. Col. Engineer Nikolaev wrote an article in SOVIET AVIATION, "Problems of Interception of Intercontinental Pilotless Means of Attack."

This awkward Soviet designation includes, of course, both cruise-type guided missiles and ballistic rockets. Col. Nikolaev's main theme is that basically the problem of defense and interception is the same as against bombers, and the weapons systems are thus fighters and antiaircraft artillery rockets.

On the whole, his report is important only for the fact of its existence. But one point is of interest. He declares that: "It is necessary to note that in the event of the explosion of a thermonuclear warhead even at a distance of 30 to 40 kilometers from the air defense weapons, the latter will receive significant damage and will be overcome (sic) by radioactive contamination."

It is curious that he doesn't note the similar effect of an intercepted but detonated charge on the *primary* target, but limits his comment to the effect on the air defense installation. This could mean that the Soviet air defenses are so deployed that they might be subject to damage in cases where the primary targets are not.

These comments on problems of defense against missile attack cover only some aspects of active defense. It is still true, and well appreciated by the Soviets, that (in the recent words of Rear Adm. Kruchenykh) "defense against missiles must consist in dealing pre-emptive blows on their launchers;" that is, hit them before they can be fired.

In a book published in November 1956, Maj. Gen. Pokrovsky stated:

The most effective defense against such long-range rockets is by means of their destruction in the storage places, on the paths of their transport, and on the launching platforms, where the preparation for each firing takes a rather long time. Unfortunately, one must keep in mind that the launching platforms for long-range rockets do not require very complicated preliminary equipping, and therefore, can be deployed in the most unexpected places, where helicopters can quickly bring the components of the rocket and the necessary equipment for assembly and firing. Long-range rockets can also be launched from warships, in particular from submarines.

Soviet Claims

Since early 1956, the Soviets and the East German Communists have on several occasions bragged that America lagged behind the USSR in missile development. The most extreme boasts have been made in East German commentaries. Thus, military commentator Frankenberg in January 1956, cited statements of Gen. Doolittle, Sen. Jackson, and the Alsop brothers to the effect that Soviet progress is ahead of that in the U.S. and that these were statements "whose correctness need not be doubted." In March 1956, he said that in rocket development "the USSR can never be overtaken" by the West. Another commentary was made by Kurt Shulz in December, 1956. He said:

In recent years it was believed in the U.S. that guided missiles were superior to ballistic missiles as regards range and accuracy. Accordingly, missiles controlled (guided) by various devices were created in the U.S. But all of these techniques have considerable shortcomings. They call for elaborate electronic devices built into the rocket, and for a close-knit radar network for guiding the missile. The main weakness is the high degree of vulnerability of the apparatus to electronic interference of all kinds (ECM). The Americans have only recently realized their mistake and concentrated all their efforts on the making of unguided ballistic rockets. *They are lagging ten years behind the Soviet Union, which took this path from the outset* (e.g., right after the war).

Another East German commentator, in June 1957, explained continued American interest in overseas bases, as follows:

There is, first of all, the *inadequate range and insufficient reliability* of U.S. intercontinental missiles. The intercontinental *Atlas* missile, with a range of from 6000 to 8000 kilometers, will be ready for use by the forces only in three years' time, according to U.S. reports, and it is a moot point whether these reports are based on facts. The constant chain of disaster, to which a large part of the newly developed U.S. missiles and remote control devices have recently fallen victim, will not be without effect on the further development of these weapons.

Meanwhile, since acquisition of "medium-range rocket weapons," it is said that "even greater progress has been made in developing rocket weapons in the Soviet Union. Western reports speak of two missiles with a range of 3000 to 10,000 kilometers."

Such statements as these serve a propaganda purpose and must be considered in that light. But it is true that information available, such as the account of former German scientists who worked on missile development in the Soviet Union from 1946 to 1953, do indicate an early and continuing Soviet stress on ballistic rockets, and after a few years practically none on nonballistic guided missiles.

Soviet accounts have, on a few recent occasions, also criticized alleged American inferiority in the missile field, although not with the same intensity and scope (nor disclosure of their own work) as have the East German Communist sources.

In February 1957, when Radio Moscow interviewed Academician A. A. Blagonravov (who is also a lieutenant general of artillery technical services), he stated:

The data at our disposal (not otherwise identified) show in many instances much more efficient results in this direction (experimental stratospheric rockets) than those achieved abroad—this makes our experiments more valuable than the American ones.

Similarly, late in May 1957, SOVIET AVIATION criticized the *Nike* as vulnerable to evasive action by high speed modern aircraft, and concluded that "as it now exists, the highly praised *Nike* system is far from perfect." ★

CANADA . . .

No Missiles – but Facilities and Experience

By George Shaw

OTTAWA, Que.—Canada's guided missile industry is pretty much a collection of odds and ends from the missile program in the U.S. and U.K., and though there is evidence of some original research in the field, there is no missile.

The one attempt to develop a missile in that country began in early 1951, when a group of scientists in the Canadian Armament Research and Development Establishment at Valcartier, Que., embarked on a project to create an all-Canadian air-to-air missile. Called the *Velvet Glove*, the weapon was geared specifically to the Avro CF-100 interceptor.

In all, some $24 million and about five-years' work were poured into the project before a change in government policy brought about its termination. Supporters of *Velvet Glove* insist that it was superior to the *Sparrow 2*, for which the Canadian government is currently negotiating.

Critics of the weapon maintain that *VG* was obsolescent when work first began on it in 1951, and they go so far as to say that the government lacked faith in the missile to the extent of blocking production of the almost-finished product.

Unhappily, very few of the arguments for and against the *Velvet Glove* will ever be proved or disproved, for even at this late date an unrealistic "security blanket" shrouds all but a few minor details of the weapon. And, too, many of the people involved in the project would be happy to forget *Velvet Glove* and turn to production of the *Sparrow 2*.

Production of the *Sparrow* might possibly have been started months ago but for the Canadian government's insistence that the entire missile be handed over under a single-type certificate. Many of its components are produced under separate certificates, and the process of bringing them together under one certificate has already consumed about a year.

Latest estimate is that the *Sparrow* will not go into production in Canada until at least the middle of next year.

Meanwhile, to further complicate the missile picture, Canada has acquired a new government, the first change in more than 20 years. The new defense minister has stated publicly that his department will take "a close look" at all contracts made in the recent past and affecting the present defense production picture. The contracts for *Sparrow* production have been negotiated but to date none has been signed, and one plant official said, "without a signature we can't do a thing."

The possible over-all prime contractor for *Sparrow* will be Canadair, since that company handled the *VG* contract and has gained more experience in missile hardware production than any other company in Canada. Canadian Westinghouse was prime contractor under Canadair for the electronics systems.

NIKE to defend Canadian cities.

Other companies involved in the old project were Avro, de Havilland Canada and Computing Devices of Canada. Government agencies, beside CARDE, were Defense Research Board, National Aeronautical Establishment and the RCAF. Former superintendent of the Ballistics Wing, CARDE, and leader of the original research team was Gordon D. Watson. Watson is now director of weapons research at Defense Research Board headquarters in Ottawa.

Most everyone in touch with the old *VG* project is agreed on one point: missile or no missile, the money was well spent.

Today the Defense Research Board has a core of experienced and able scientists and engineers who have had a hand in building a missile. That experience could not have been gained in any other way.

DRB and RCAF have acquired valuable know-how in testing and firing ballistic missiles and have established facilities and ranges for handling any future weapons effectively.

Canadian industrial concerns have gained firsthand knowledge of the problems and techniques of missile production. The companies involved in the *Velvet Glove* program can swing into production of a weapon such as *Sparrow* with a minimum of delay, and they all seem very anxious to "get started."

Testing centers for any future missiles will, no doubt, be the same as for *VG*. CARDE has a ground-test ballistic range at Valcartier equipped for making resonance studies, speed tests and other tests than can be made with ground facilities.

Point Petre Range, near Picton,

NIKE control plane (L) and Canadian crew (R) at joint Canadian/American exercise in the use of NIKE missile at Churchill, Manitoba.

Ont., is a short-range test-firing facility located near the Royal Canadian Artillery center at Petawawa, Ont., and close to the RCAF station at Trenton.

RCAF Station Cold Lake, Alberta, played a major role in the air firing tests of *Velvet Glove*. Station Cold Lake is the only RCAF base completely planned in the postwar period and is one of the most modern training and testing establishments in the world.

Development of the Cold Lake establishment was initiated to satisfy a critical need for a weapons range and proving ground to replace the older, inadequate ranges the services found themselves with after World War II.

Operated by RCAF Air Defense Command, Station Cold Lake is home base for the Weapons Practice Unit, Operational Training Unit and the Central Experimental and Proving Establishment. The station also operates a practice range about 30 miles north of Cold Lake which is 114 miles long and 40 miles wide.

In conjunction with the Primrose Lake range, nearby Cold Lake range is used to evaluate rockets and missiles where air-to-air firing is desired and long range tracking is necessary. Telemetering and ground-controlled intercept stations are maintained at the ranges, as well as modern high-speed photographic tracking equipment.

Each of the nine CF-100 squadrons in Canada visits the Cold Lake station periodically to practice the latest methods in lead-collision course interception, rocket-firing practice and missile testing. Reliability of the CF-100's fire-control system is tested periodically on the vast ranges.

Primrose Lake, a few miles north of Cold Lake, was the primary tracking and control range used in the *Velvet Glove* project and presumably will be used in the new *Sparrow* program when it is instituted next year. Sparrows have already been tested at the Cold Lake and Primrose establishments and it is extremely likely that RCAF units are currently engaged in exercises with the missile.

Located along the shores of Primrose Lake are nine theodolite stations used in checking velocity, trajectory paths and homing characteristics of guided missiles. The theodolites have a clear-day range of 50 miles, and are automatically synchronized for continuous tracking and computing. Digital computers are used in connection with the theodolites for rapid and automatic computation of flight data.

Summing up the missile situation in Canada is greatly simplified by the absence of a home-grown product.

Great Britain and the U.S. frequently test operational missiles jointly with the Canadian Armed Forces, and several hundred Canadians have been in U.S. Army missile centers.

Much up-to-date material on missiles and atomic research is on loan to Canada from the U.K. and U.S., and exchange agreements between the countries have kept Canadian scientists abreast of developments in the two fields.

Canada's security system is effective but cumbersome. More experience in declassification of projects such as *Velvet Glove* should eventually result in a more realistic approach to security matters in general.

Enough information on missiles is now available to Canadian scientists to warrant original research on a large scale. However, the population of Canada is about one tenth that of the United States, with a national economy to match. All-out participation in missile research would not be economically feasible.

The logical approach to the missile question seems to be the one they are taking—to use the experience gained with *Velvet Glove* to produce and weaponize finished missiles available to them from Great Britain and the U.S. ★

Canadair test lab with VG model in foreground (L); Rocket being propelled by sabot on CARDE Range (C); Resonance test on rocket (R).

AUSTRALIA . . .

Proving Ground for Commonwealth Missiles

By Seabrook Hull

AUSTRALIA'S MISSILE problems are unique to the country. Its opulation—therefore, its budget—is mited. Its industrial ability cannot roperly cope with missile systems of oo complex a nature. However, hrough its Woomera test range it is aking a major contribution to West-rn missile progress.

And though its population is small less than 10 million), its land mass equiring defense approximates that f the U.S. Obviously, Australia can-ot consider its missile problems from he point of view of playing the top ole in any future war. It must consider self as part of a coordinated alliance —as part of the British Commonwealth f Nations on the one hand, and as art of the Southeast Asian Treaty Organization on the other. Its major eed, therefore, is for tactical missiles, articularly for air defense.

In missile development, its major ontribution to date is the *Jindivik*, a igh-subsonic pilotless aircraft. Origi-ally conceived as an interceptor mis-sile, its primary mission now is as a target drone. However, studies are under way to determine its feasibility as a surface-to-surface missile of the *Matador-Regulus* type.

One of Australia's biggest missile worries at the moment is for the defense of its major cities—particularly Sidney. For this purpose it will go ahead and is already conducting studies of missiles like *Talos, Nike* and the United Kingdom's *Bloodhound*. No decision has been reached as to which one is favored. But cost and availability, as well as operational ability, are factors. Target for the study is to start installing missiles around Australian cities sometime in 1959.

Royal Australian Air Force prefers the de Havilland *Firestreak* for air-to-air work. This heat seeker may be completely manufactured in Australia. Certain components are already locally made.

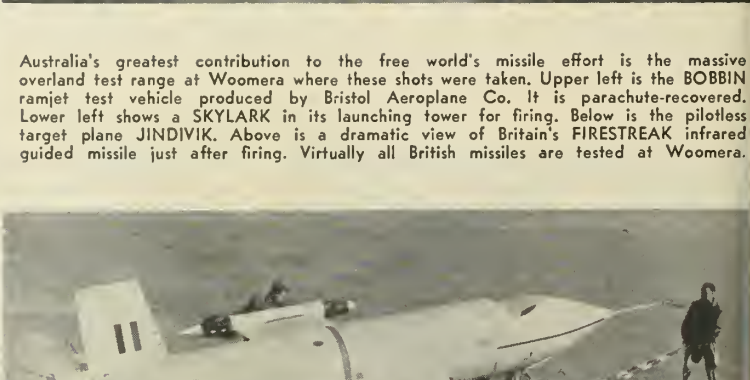
The Australian Government does not yet know whether it will buy these missiles outright from abroad or whether they will request licensing authority and manufacture them in Australia. "It all depends on their complexity and demand on natural resources."

Meanwhile, Australia's missile program has not been without its advantages. It recently sold ten *Jindivik* "pilotless aircraft" to Sweden for £500,000 ($1,115,000). Price included ground control equipment and spare parts. The *Jindivik* can top 50,000 feet.

Meanwhile, if any nation has room to spare for an overland missile test site, it's Australia. Thus, the Woomera Range in central Australia is of vital importance not only to Australia's but Britain's missile development. Sooner or later, virtually all of Britain's missiles are tested at Woomera. Also, the Woomera base is being used during the International Geophysical Year for satellite tracking and for launching upper-air research rockets such as Britain's *Rockoon*-like system, the *Bobbin*. ★

Missiles don't do much good in this kind of fighting. Australia's missile arsenal is being tailored to her peculiar needs.

Australia's greatest contribution to the free world's missile effort is the massive overland test range at Woomera where these shots were taken. Upper left is the BOBBIN ramjet test vehicle produced by Bristol Aeroplane Co. It is parachute-recovered. Lower left shows a SKYLARK in its launching tower for firing. Below is the pilotless target plane JINDIVIK. Above is a dramatic view of Britain's FIRESTREAK infrared guided missile just after firing. Virtually all British missiles are tested at Woomera.



GREAT BRITAIN . . .

Takes Lead in NATO Missile Production

By James H. Stevens and Ronald C. Wakeford

BRITAIN'S MISSILE POLICY was announced by Defense Minister Duncan Sandys last April. It was simply that in order to economize defense measures and so reduce the annual budget, the UK would:

1) make the English Electric P-1 (and stretched versions of it) the last manned fighter airplane;

2) make the Avro Vulcan B2 and the Handley Page Victor B2 the last manned bombers;

3) make all interception by missile after interim introduction of a single operational AAM, the DH Firestreak (for Royal Navy as well as RAF use);

4) increase range of second-generation V-bombers by Avro stand-off bomb, pending ICBM;

5) abandon area protection of the British Isles, including population centers and even defense plants, in the face of nuclear warhead missile attack;

6) restrict target defense to the bomber (later ICBM) retaliation bases.

Until very recently there was a widespread feeling that the British missile industry was a damp squib. But for many years now the rumblings at Aberporth, South Wales, and Woomera, Central Australia, have indicated that some form of missile research was taking place, but little was said for publication. But recently, photographic and data releases by the Ministry of Supply have shown that the UK is much further advanced than was generally realized.

A few months ago information presented to Parliament by the Minister of Supply named two missiles (*Firestreak* and *Bloodhound*) and another vehicle (unnamed) to be manufactured by the English Electric Co. Details of the *Sea Slug* were made available more recently.

The Society of British Aircraft Constructors (SBAC) has announced that 400 British companies are engaged in missile development and supporting work.

Most notable of the companies manufacturing missiles are: Bristol Aircraft Ltd., English Electric Co., DeHavilland Propeller Ltd., A. V. Roe, Fairey Aviation and Vickers-Armstrongs. Bristol Aircraft has four plants concentrating their efforts on missile work. Ferranti, manufacturers of guidance equipment, which is associating with Bristol on one of its projects, has two plants giving support to the missile program.

Others include: E. K. Cole & Co. Ltd. (*Fireflash* radar), E.M.I. Engineering Development Ltd., The General Electric Co. Ltd., Sir George Godfrey and Partners, Imperial Chemical Industries, McMichael Radio Ltd., Metropolitan Vickers Ltd., The Sperry Gyroscope Co. Ltd., The John Thompson Conveyor Co. Ltd., Vickers-Armstrongs Ltd.—all *Sea Slug* ancillaries.

Rolls-Royce Ltd. (Rocketdyne License), Avica Equipment Ltd., The British Thompson Houston Co. Ltd.,

A development model of Britain's SEA SLUG fires from the forward triple launcher of the HMS Girdle Ness. Note four typically British wrap-around boosters clamped to missile body.

S. G. Brown Ltd., Burnley Aircraft Products Ltd., Delaney Gallay Ltd., Diamond H. Switches Ltd., Dowe Instruments Ltd., Elliott Brothers (London) Ltd., Goodmans Industries Ltd., Graseby Instruments Ltd., High Pressure Components Ltd., Hymatic Engineering Co. Ltd., I. V. Pressure Controllers Ltd., Kelvin and Hughes Ltd., King Aircraft Corp. Ltd., Laporte Chemicals Ltd., Lion Electronic Developments Ltd., Muirhead and Co. Ltd., W Bryan Savage Ltd., Smiths Aircraft Instruments Ltd., Solartron Electronic Group Ltd., Teddington Aircraft Controls Ltd., Vactric (Control Equipment) Ltd., Venner Ltd., W. Vinter Ltd., Western Manufacturing (Reading) Ltd.

Missile Budget Secret

The actual money spent on the missile program has never been revealed, but is "for security reasons" lumped in with the general aviation vote.

The full scope of the operational weapons program has not been revealed, although rumor has it that Vickers-Armstrongs has not only had its *Red Dean* AAM cancelled, but that the company's ICBM—also well ahead—was cancelled.

Missile bases for testing or indoctrination of personnel are either established or are undergoing construction in several areas. Two of the newer facilities are the RAF missile station being completed at North Coates, Lincolnshire, and the joint services test range, South Uist, Outer Hebrides. The former will see service missile trials in 1958. Some missile development testing has been undertaken at the Royal Artillery range at Larkhill.

Just how far Britain has advanced in the missile field, and what its position is in relationship to the U.S effort, has yet to be established. More information will have to be released before a true picture can be drawn.

British separation and boosts, based on the wrap-around principle, aim at maintaining a minimum vehicle length to facilitate launching, handling and transportation. Wrap-around boosting also keeps C. G. shift at separation to a minimum and requires no additional stabilizing fins. Separation by aerodynamic means is somewhat simpler with tandem boost. Air pressure lifts away the booster units to a predetermined angle before separation is achieved.

The Fairey Aviation Co. was probably the first to make a production missile. Background to this work was the *Stooge*.

FIREFLASH

The history of the Fairey *Fireflash*, which was Britain's first operational entry in the air-to-air missile field, dates back to World War II. At this period the Royal Air Force's need for this type of weapon was fully understood and a series of developmental programs was initiated. During 1953, an early version of the vehicle successfully destroyed a *Firefly* drone.

The *Fireflash* is somewhat unique, in that it has no sustainer motor. The solid-propellant boosters of the wrap-around type accelerate the vehicle to maximum velocity and then separate, allowing the missile to coast to the target.

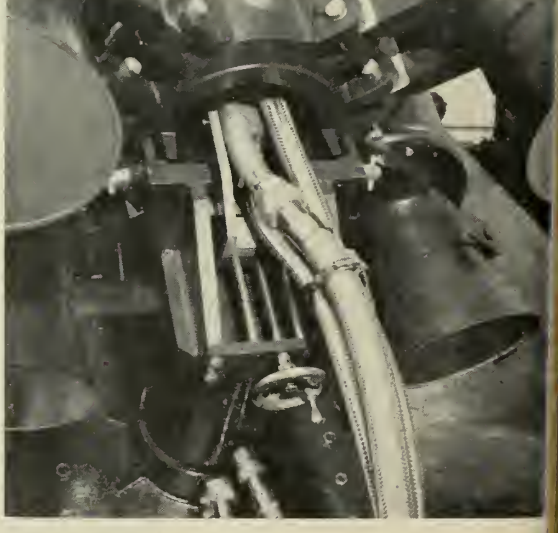
The two boosters jut out well ahead of the proximity-fuzed warhead. The main body is tubular with cruciform wings and guide vanes. This makes a fairly bulky, high-drag missile suited to under-wing carriage, but scarcely to stowage in an internal weapon bay. It uses a Marconi beam-rider guidance system. The missile is homed by the launching airplane and is entirely dependent upon the lock-on capabilities of this aircraft's radar. The equipment includes countermeasures against enemy jamming. *Fireflash* is used on the Supermarine *Swift MK7*, the Hawker *Hunter*, and Australian-built *Avon-Sabre*. It is now a training weapon for Fighter Command.

FIRESTREAK

Another air-to-air missile about which the Ministry of Supply has released information is the *Firestreak*. This missile is produced by DeHavilland Propeller Ltd. Passive homing is achieved by means of an infrared seeker. Geometrically the missile is of conventional form with cruciform-shaped wings and fins. It is slated for delivery to the RAF around the end of 1958. The vehicle is now propelled by a single solid-propellant motor.

It is a rather larger missile than the *Fireflash* because its accelerating rocket motor is mounted inside the body of the weapon itself. It is claimed that apart from the electrical and pneumatic activating and launching circuits, an infrared sensing GW requires no special equipment on the aircraft.

A close-up view of the double-wedge five per cent airfoil hinged wing attachment, booster slipper bracket and front of THOR ramjet.



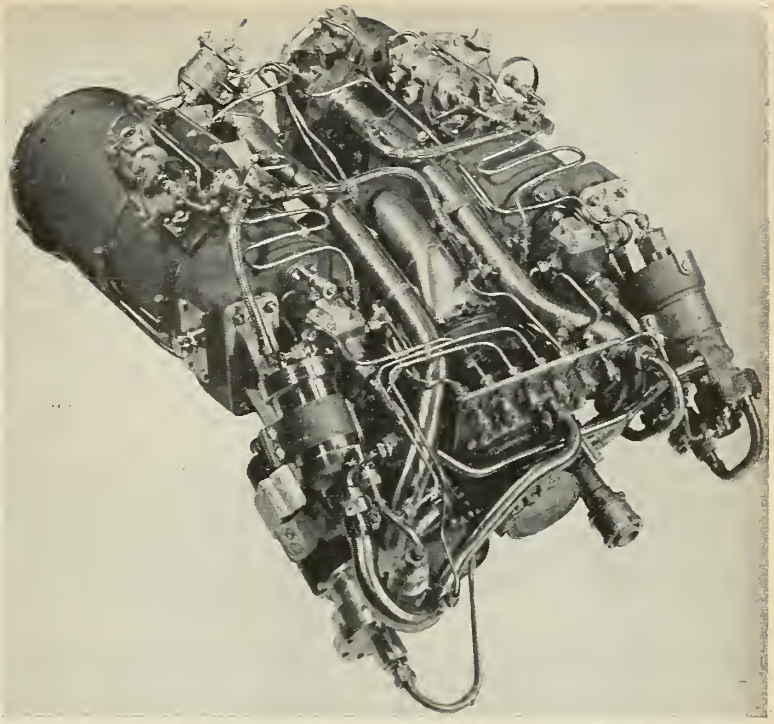
This aft view of BLOODHOUND shows hinged assembly ring f wrap-around boosters as well as hydraulic and pneumatic fittin

As an aircraft, *Firestreak* is a simple supersonic cylinder with cruciform wedge-section wings and tail blades in the same plane. The rearward positioning of the wing is a common supersonic stability feature. Longitudinal strakes appear to be fairings for wing attachments and control leads. Because of the optical nature of infrared wavelengths, the conical nosecap is octagonal in order to provide nondistorting glass "viewing" panels.

Infrared radiation cannot penetrate thick cloud—so prevalent in Northern Europe—but the RAF Air Staff evidently considers that attackers from the East will come in at 50,000 feet, and thick clouds are unknown in the stratosphere.

Two of Britain's RAF fighters, the English Electric P-1 and the all-weather fighter Gloster *Javelin* are scheduled for mating with the *Firestreak*. Royal Navy will also use it on its DH *Sea Vixens*. Range is about eight miles and length approximately seven feet. The *Firestreak* can be teamed with any fighter, the makers claim.

The first production version of the *Firestreak* will shortly be available for export to friendly nations.



Detailed picture of Napier Double SCORPION NSc. D.I. used to attain the altitude in a Rolls Royce Avon-powered CANBERRA. It is a double-barreled version of the NSc. I rocket.

Red Dean

The *Red Dean*, another addition to Britain's air-to-air armament, is believed to have been cancelled. Little information has been released. Vickers-Armstrongs is the contractor. If, as has been reported, this missile has been abandoned, it is probably due to the cancellation of the Gloster *Javelin*. *Red Dean* was tailored to team with this airplane.

Ground-to-Air

Research vehicles bearing such names as RTV 1 & 2, GPV and MTV sparked Britain's surface-to-air missile program and led to such vehicles as *Bloodhound, Thunderbird,* and *Sea Slug*. These missiles are now in production.

Bloodhound

The Bristol Aeroplane Co.'s contribution to the nation's defense against air attack is the *Bloodhound* missile. Ferranti Ltd. manufactures the semi-active guidance system. This missile has been under development since 1949.

Sustaining power is supplied by two Bristol *Thor* ramjet engines of "virtually 100% starting reliability," the Bloodhound being boosted to operating velocity on the order of 1500 feet per second by solid-propellant boosters. Hundreds of rounds have been fired from Aberporth and Woomera. This testing will continue at the new range being constructed at South Uist in the Hebrides.

It is a neat little supersonic airplane: cylindrical blunt-tailed body with ogival nose, tapered stub wings with cut-back tips set well aft, rectangular fixed tail plane and one *Thor* above, the other below the fuselage on short pylons. Unlike the symmetrical cruciform rocket missiles and coaster, which are steered by pitch and yaw without banking, the *Bloodhound* is rolled into a bank and turned by elevator action. The reason for this is that the jets from the two *Thors* make it impossible to mount vertical tail surfaces, while the ramjets themselves prevent the fitting of cruciform wings.

The *Bloodhound* wings have no ailerons because all-moving surfaces are best at supersonic speeds. Roll is by differential displacement of the wings, with pitch control by alteration of wing incidence in unison. Concentration of the jacks and operating equipment at the middle of the aircraft is a highly desirable feature, both mechanically and for weight-control reasons.

Construction is simple, expendable stuff—light-alloy fuselage with fabricated light-alloy wings and tail, which have plywood-filled tips. The wing airfoil is a double-wedge, five per cent thick, unswept and hinged on a tubular spar at the mid-chord point. The tail plane consists of two rectangular units bolted to a mounting ring let into the tail of the fuselage, with a one-inch thick airfoil of flat-plate form with leading and trailing-edge entry wedges.

Bristol Aero-Engines's *Thor* ramjets are fabricated from 18/8 commercial stainless steel, mainly by welding. The powerplant is of elemental supersonic form—just a plain tube with centerbody double-shock air intake and convergent-divergent nozzle. All intakes visible in photographs are either dummies or have been retouched so as to conceal the missile's capabilities. The venturi nozzle is formed by a curved internal plate spot-welded to the skin, which is cooled by a row of joggled holes in the outer surface. On a diameter of 15.75 inches and length of 100 inches, the *Thor*, it has been unofficially stated, is capable of delivering 15,000 pounds thrust at M 2.0 at sea level. It has been tested on the *Bobbin*.

At the front of the mounting pylon of each ramjet is a cylindrical air intake for ram-air, fuel and hydraulic turbopumps.

The *Bloodhound* launcher is a robustly-built unit with a hydraulically powered turntable and elevating ram. The launch angle is constant at 45° and the ramp is locked at this angle by hand-pins in the support-truss hinges. Supplies fed thru the ramp to the missile are high- and low-oil pres-

sures, compressed air and multiple electronics—nearly 100 circuits.

Each of the *Bloodhound's* four boost rockets has a thrust ring (mounting the tail stabilizing fin) hinged to a central mounting ring that fits over the missile's tail. At the front of each rocket case is a ring with a W-shaped bracket that has two fore-and-aft lugs sliding into a slipper casting on the missile. At burnout, the boost assembly slides aft a few inches, the front attachments disengage and the cases umbrella outward, so that the whole assembly falls off backward as a cruciform unit.

The *Bloodhound* will be Britain's first production ground-to-air vehicle. The vehicle is backed up by an excellent radar control system, which integrates acquisition radar, lock-on and tracking radar and the launching site equipment into an automatic launching and firing system. This same system is adaptable to the characteristics of other surface-to-air vehicles in production.

THUNDERBIRD

The second most publicized of Britain's surface-to-air weapons is the *Thunderbird.* This vehicle is a product of the English Electric Co. and is believed to be moving rapidly from development status to full production.

Thunderbird is a beam rider, the guidance system being manufactured by Marconi Co. Ltd., and the liquid-propellant powerplant by D. Napier & Son Ltd. Four wrap-around, finned, solid-propellant booster motors provide launching thrust.

It is a straightforward rocket-propelled missile of "classic" supersonic form. It has a conical-nosed cylindrical body, with symmetrical low-aspect ratio tapered wings set well aft and tapered tail-control blades. Some versions were powered by Napier NRE 17 RTP/kerosene liquid rockets, giving over a ton of thrust, but for ease of operation in the field, RAE solid propellants have now been substituted.

As of this writing, practically no information has been given on *Thunderbird,* but it appears to have semi-active homing guidance, designed, developed, and manufactured by Marconi's Wireless Telegraph Co. The essential difference from the *Bloodhound* is that the *Thunderbird* has its own individual and independent radar so that it can be sited anywhere.

The *Thunderbird's* configuration is similar to English Electric's test vehicles. This would indicate that the overall length is about 20 feet and the diameter, 15 inches.

Built to similar specifications, the *Thunderbird's* performance is expected to be generally of the same order as the *Nike-Hercules.* A self-contained mechanical system for ground support of the missile has been developed in common with American counterparts.

SEA SLUG

The Royal Navy's only entry in the missile field, at least as far as official releases are concerned, is the *Sea Slug.* Many companies had a hand in the construction of this vehicle, the most notable being Armstrong Whitworth (prime contractor), General Electric Co. (guidance), and Sperry Gyroscope Ltd. (control system).

The Admiralty makes the point officially that this is a Navy-designed WS and that the contractors are essentially only suppliers—Armstrong Whitworth having full design responsibility, however, for the aerodynamics.

Sea Slug has movable fins with large rectangular wings and is said to be of medium range capable of reaching any altitude at which an enemy fighter intrudes. Wrap-around solid-fuel boosters are provided which separate as the vehicle becomes supersonic.

Although it was first thought that an Armstrong Siddeley liquid rocket-propellant motor would power the final version, the trend to solid-propellant sustainer motors is also overtaking the *Sea Slug.*

Designed as a fleet defensive weapon, the missile began its sea trails a little over a year ago aboard the *HMS Girdle Ness,* a naval guided weapons ship. *Sea Slugs* are fed to the triple launchers on deck automatically and fired remotely.

Shore-based testing of the vehicles was programmed on the Clausen Rolling Platform, a small ship in itself capable of a 10-degree pitch and 20-degree roll.

Air-to-Surface

The British industry has yet to name its first guided missile of the air-to-surface category, but it is known that A. V. Roe is well on its way to producing the first model. This class of vehicle is commonly referred to in British journals as the "stand off bomb."

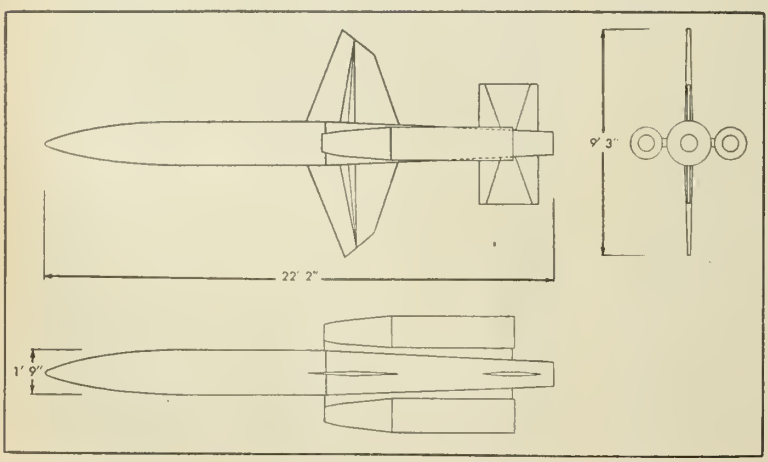
The vehicle is designed to be carried by the RAF's "V" bombers *(Vulcan and Victor),* and it is believed that the missile will be approximately the same size as the *Rascal.*

Surface-to-Surface

Britain probably obtained its start in the surface-to-surface missile business with a 1916-vintage guided airplane. This vehicle, known as the *Aerial Target,* was a radio-controlled monoplane developed at the Royal Aircraft Factory. More in direct line with recent developments were the British firings of V-2's from Cuxhaven, North Germany, just after the war. At this point all references to activity in this field ceased until very recently.

Today the only development along this line is apparently being undertaken by the DeHavilland Co. which is developing a 2000-mile IRBM in conjunction with Rolls Royce for the RAF. Reports suggest that these two companies have been working on the vehicle for five years or more. The vehicle may be powered by a North American rocket engine made by Rolls Royce.

The Ministry of Supply's Ballistic Missile Division is coordinating the surface-to-surface work through the Royal Aircraft Establishment, Farnborough. The IRBM will carry a nuclear warhead. Meanwhile, the U.S. *Honest John* is used for training; the *Corporal,* for bombardment. An anti-tank weapon is being developed by Fairey Aviation in the smaller category of surface-to-surface vehicles. This missile will probably be used for air-to-ground applications also. ★



Plan views of Britain's main ground-to-air missile effort, the Bristol-Ferranti BLOODHOUND.

SWITZERLAND . . .

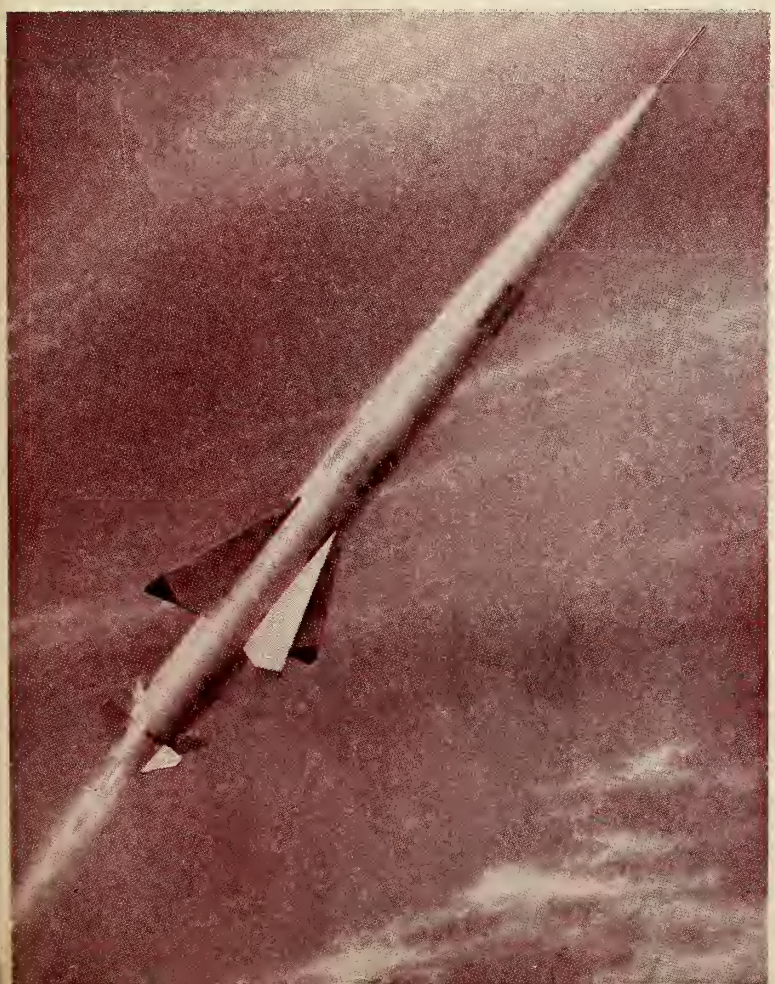
Missile Design with Watchmaker Precision

By Frederick C. Durant III

THE SWISS MISSILE industry and Oerlikon are virtually synonomous. The reputation and achievements of Oerlikon have been carried over from the field of conventional weapons to guided missiles, currently produced by the firm for use by Switzerland and various foreign countries. Of the company's production missiles, two stand out—the Type 50 series SAM and the *Cobra* series antitank rocket.

Development of this antiaircraft weapon commenced shortly after the past war. The Type 54 is a slim, streamlined, rocket-propelled weapon, capable of interdicting aircraft at altitudes up to about 50,000 ft. It is single staged, fired from a dual-position zero-length launcher. Overall dimensions are about 20 ft. long and 16 in. in diameter; launching weight is 770 lbs. The missile has two sets of cruciform wings. The main (forward) wings, which provide lift necessary for controlled flight, move forward to adjust for center of gravity shift during powered flight. The after wings are used for gas-jet steering after burnout.

Oerlikon's Type 54 antiaircraft guided missile.



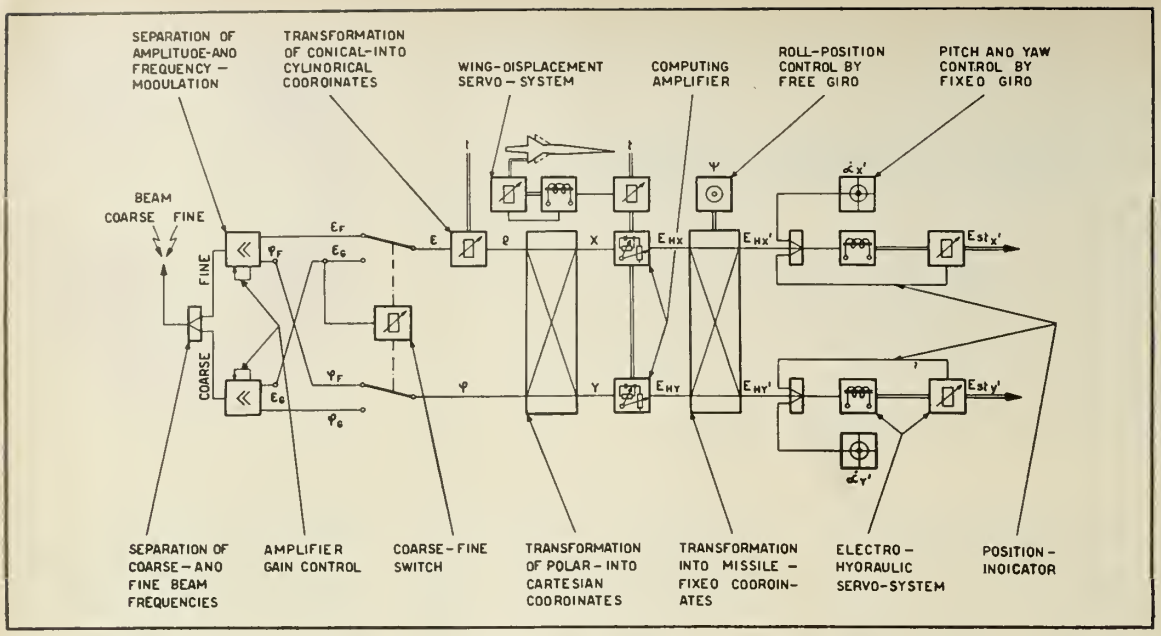
The propulsion unit is a liquid propellant, nitric acid-JP type system which produces a thrust of about 2200 lbs. for 30 seconds. Propellant supply: compressed nitrogen gas at 300 atm. pressure, initially. Specific propellant of the engine is about 12 lb./ton/sec. A starting fuel of triethylamine and xylidine is used to obtain smooth ignition. No booster unit is employed. Burnout altitude is about 30,000 ft.

Fuselage construction is of wound aluminum alloy utilizing metal-bonding adhesive. The wings are of sandwich construction.

Guidance of the Type 54 is a beam-rider system. Ground units operate a radar target tracker and guidance beam path simultaneously. The missile is launched into the guidance beam and rides the center of this beam. The target-tracking radar feeds information on azimuth and elevation angles through a ground computer (to correct for parallax) to the missile guidance beam which guides the missile to target. A proximity fuze fires the warhead if actual impact is not obtained.

This weapon system is complete and has been available for purchase for nearly three years. In addition to Switzerland, Sweden and Italy are also employing this weapon. Japan has recently acquired a license to manufacture. The Type 56 model is an improved version and a newer, Type 57 version is known to be under development.

The *Cobra* is a wire-controlled, solid-propellant rocket antitank weapon.

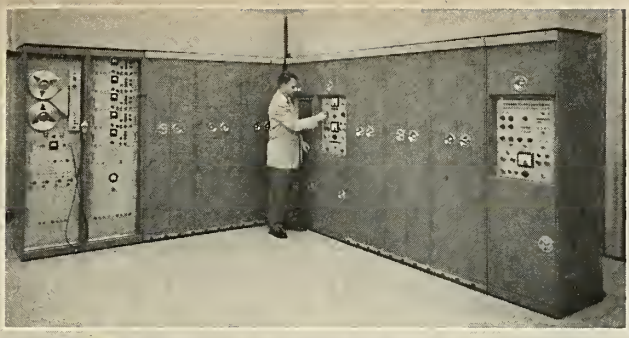


Above is a schematic diagram of the Oerlikon rocket control system showing the main components and their relationship to one another.

Closely resembling the French *SS.10* and *ENTAC* in size and design, the *Cobra* is manufactured by Oerlikon-Contraves-Boelkow. All these weapons are a follow-on of the German World War II development, the *X-4*. Weighing about 24 lbs., maximum range is slightly less than one mile. Maximum velocity is about 190 mph. Like the similar (but shorter-ranged) shoulder-fired Bazooka rocket, an armor-piercing shaped-charge warhead is utilized. The *Cobra* weighs only about one-tenth of the U.S. Army *Dart*, a similar wire-controlled weapon.

Although unguided, mention should be made of the outstanding 5-cm. and 8-cm. FF,FF (forward firing, folding fin) rockets. These highly effective air-to-ground rockets have been developed for the Gloster *Meteor* and *Venom* aircraft. Launching is from streamlined pods. The *Meteor* carries 76 5-cm. rockets which are fired in pairs at intervals of 0.1 sec., the complete salvo occurring in about 3.5 sec. The *Venom* carries two launchers slung beneath the wings, each carrying seven 8-cm. rockets and firing in pairs. Impact-fuzed, shaped-charge warheads are utilized. A proximity fuze is under active development. Electric power to operate a miniature radar unit is obtained from a gas turbine generator driven by gas "bled" from the rocket combustion chamber in flight. The warhead is fired at the moment the reflected radar signal from the target begins to diminish in strength. ★

Two versions of the Oerlikon antiaircraft guided missile shown being launched. The missile is steered by a combined gas-jet rudder. Four cruciform delta-wings produce the lift force necessary for curved flight, while the four rear fins act as steering controls.



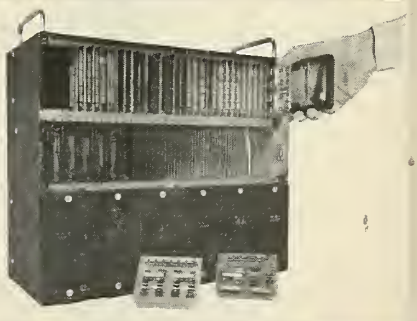
30-channel, analog-digital converter connecting 300-amplifier analog computer to 1103A digital computer

Production of communications equipment in new Los Angeles manufacturing plant

Data Reduction Center designed and built by Ramo-Wooldridge

One of three new research and development buildings completed this year

First unit of Denver manufacturing plant now nearing completion



Input-output unit of the Ramo-Wooldridge RW-30 airborne digital computer

Pictorial **PROGRESS REPORT**

The photographs above illustrate some of the recent developments at Ramo-Wooldridge, both in facilities and in products. Work is in progress on a wide variety of projects, and positions are available for scientists and engineers in the following fields of current activity:

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- Digital Computers and Control Systems
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- Electronic Instrumentation and Test Equipment
- Guided Missile Research and Development
- Automation and Data Processing
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FRANCE . . .

Advancing Missile Science Through Uninhibited Thinking

By Frederick I. Ordway, III

FRANCE has accomplished much, with relatively limited resources, in the missile field. She has realized that success can come only by following certain limited avenues of research and development, and it is obvious to her that it is impossible to attempt to create broad categories of highly costly and complex long-range missiles such as found in the U.S. and USSR.

Like its airplanes, French missiles are specialized, and result from a careful assessment of the kind of war in which the nation might become involved. Keeping this specialization in mind, and looking forward to closer R&D cooperation between European NATO powers, it is probable that French missilry will become an increasingly important factor in European defense in the years to come.

Since the war France has moved into the forefront of world rocketry. They enlisted the aid of a number of German scientists, including Sänger, Sänger-Bredt and Zborowski, but otherwise have developed along independent lines.

Promoters of French rocketry have long been pressed for funds, and have had to work with only limited resources. Money is still short, but recent increases accorded both R&D and production have helped considerably. With what it has available, France has adapted and improved several German concepts and has advanced many new, original and brilliant solutions to their own problems. The crucial electronic industry has enjoyed a particularly spectacular advance in France, which has aided missile development.

With an eye on both economy and the European tactical and strategic picture, France has restricted her rocket programs to those she feels essential and within her means. Light industry has adapted well to the age of missiles. Heavy industry, on the other hand, experienced some difficulties in obtaining qualified personnel, particularly on the worker level. The situation there, however, has improved.

Industry and defense agencies have discovered that closer-than-normal cooperation has become necessary to properly develop the missile field. This has created consequent modifications in habitual French independence, causing some departure from traditional ways of business.

For both the military and the entrepreneur, the missile age has brought important changes in France, both organizationally and mentally. That the country is adapting well, however, seems evident.

Proximity-fuzed PARCA SAM leaves launcher.

Background to Developments

It is hard to tell just when French rocketry began. Before the first World War, Rene Lorin wrote of a reaction propelled rocket plane in the AEROPHILE, a concept later enlarged into book form, and in 1911 Dr. Andre Bing received an important rocket patent. During the war no other country save France employed rockets operationally. Both surface-to-air incendiary rockets and air-to-air *Le Prieur** types flown on *Nieuports* were used against German Zeppelins and captive balloons. There is also 1915's catapult-launched *Torpille aerienne,* which was a primitive, radio-gyro controlled flying bomb, a World War I V-1. This 1100-pound SSM could carry a 440-pound payload. The French also used 27 and 34 mm signal rockets from 1914 on.

In 1912 Robert Esnault-Pelterie spoke before the French Physical Society on rocketry and in 1927 gave his famed lecture to the French Astronomical Society on the subject "Exploration of the Very High Atmospheric Regions by Rockets and the Possibility of Interplanetary Travel." This was later enlarged and published as a book.

** Invented by Navy Lieutenant Vaisseau Y. le Prieur, Nieuport Scouts carried four rockets on each side. In one engagement in the spring of 1916 four enemy balloons were set afire by these early AAMs. See* LA CONQUETE DE L'ESPACE, *V. Coissac, Tours, 1916.*

French rocket-astronautical promoter-author Ananoff (right) at first IAF Congress.

During the 1930s Damblanc and others made important contributions to rocket literature. Damblanc, incidentally, was first to photograph multistage rocket separation. Esnault-Pelterie worked with the Armament Fabrication Technical Services at St. Cloud and, having developed a light alloy motor, made many experiments with gasoline-ether and liquid oxygen propellant combinations, starting in 1934. Firing took place at the French Army Proving Ground.

In 1937 an astronautical-rocket exposition took place at Paris' Palais de la Decouverte. Rocket-propelled bombs were studied by Rougeron and J. J. Barre who, with the aid of Arnould, Genty and Dubouloz, conducted a static test on the EA-41 rocket during 1941 under the noses of the Germans. I.M. Tercet tested small powder rockets. The EA-41 was unguided, fin-stabilized, and ten feet long. Immediately following V-E day, a 35-mile flight was made near Toulon in Southern France, at a maximum thrust of 2200 pounds for some 13 seconds firing time.

Rocket-Astronautical Activities

While rocket developments in Germany and America followed the growth of rocket and interplanetary societies, France's society movement seemed almost entirely apart.

In 1945 Ananoff and Monier created the Astronautics Section of the University Aero-Clubs Association of France. With an imposing list of technical and scientific advisors and an editorial staff, some progress was made and four issues of the journal L'ASTRONEF were published. But, by late 1947, the section was dissolved, and again French rocketry at the society level foundered.

Since 1955 everything has changed. Leading French scientists, engineers and military authorities have joined together to form the French Astronautical Society, and the BULLETIN D'ASTRONAUTIQUE, of much higher caliber than previous society publications, is now published. In December 1956 a great International Congress of Rockets and Guided Missiles was held in Paris, where experts gathered from all over the world. A full-fledged journal FUSEES ET RECHERCHE AERONAUTIQUE has been appearing quarterly since June 1956, often more than 100 pages in length, with technical and semitechnical articles by French and foreign experts.

French Missile Developments

French missiles can be divided into six categories or missions. These include air-to-air, air-to-surface, surface-to-air, surface-to-surface, drone and special test vehicles, and upper atmosphere sounding rockets. Rocket-powered, manned airplanes will not be considered in this article. For ease of reference, many details have been placed in the accompanying charts.

Air-to-Air Missiles

The Matra M.04 is produced by Sud-Aviation and the Society Matra. It is 2/3 scale model of a development missile that has surface-to-air and air-to-air applications. An SEPR 2750-pound thrust rocket motor supplies thrust for 14 seconds on liquid propellants. It has all-metal construction, duralumin skin, and gyro-controlled aerodynamic tail vanes and

'Veronique' liquid propellant engine firing.

SNCA du Nord's CT.10, a thoroughly proven target plane recoverable by parachute.

French Missile Arsenal

Designation	Contractors	Agency	Velocity	Range/ Altitude miles	Weight lb.	Length ft.	Diameter in.	Powerplant	Thrust lb.	Firing Time sec.	Remarks
Air-to-Air Missiles											
M(AA).20	MATRA	Air Force	Mach 1-2	1		15		liquid SEPR	2755	14	For use on Mystere A, B. In production.
M.04	MATRA	Air Force	1118 mph		1015	15'1"	16	liquid SEPR	2755	14	Tested on Voutour, Grognard. Can be parachute recovered. 245 lb. payload.
M(R).051	MATRA	Air Force	Mach 1.5		350	9'10½"		solid			Used on Mirage, Voutour. In production. Solid booster.
M.510	MATRA	Air Force	Mach 1.7		350	9'10"					
M.511	MATRA	Air Force									Secret. Reportedly for use on Trident.
AA.10	SFECMAS, SNCA-N	Air Force									
1524	Sud-Aviation	Air Force									Tested at Colomb-Bechar; successful in destroying drones.
550	Dassault	Air Force						Viper TJ			LPR booster by SEPR.
5103	SFECMAS, SNCA-N	Air Force	Mach 2	3-6½	287	8'2½"	10	solid			Flown on Meteors, Mysteres, Voutours. In production. In-line solid booster. 57 lb. payload.
Air-to-Surface Missiles											
B8-10		Air Force									Radio controlled bomb.
1522	Sud-Aviation	Air Force									Also air-to-air possibilities.
.....	.....	Air Force									Rascal-type rumored.
Surface-to-Air Missiles											
Maruca	SNECMA, DEFA	Navy									
Masalca	SNECMA, DEFA	Navy									
M.043	MATRA, SNCA-N							ramjet			SEPR solid booster.
PARCA	DEFA	Army	Mach 1.7	14	2200	14.7		liquid			Ramp-launched. Uses four solid boosters.
SA.100	Dassault										
SE.1524	Sud-Aviation										
SE.4100	Sud-Aviation		Mach 0.8	7½	287			liquid			A test rocket with solid in-line booster.
5E.4300	Sud-Aviation		near Mach 1	12	2200		18	liquid			A training, Nike-type missile, boosted, 11.1' span.
4400	Sud-Aviation										
422	MATRA										
.....	Sud-Aviation	Air Force						liquid			Presumably the ultimate development of Trident, possibly making it a Bomarc-type missile.
Surface-to-Surface Missiles											
8TZ-411.01	8TZ	Army									Coleopter-like, bazooka-type, two-stage missile.
ENTAC	DEFA	Army	190 mph	1.3				solid			Cable-guided, antitank missile. In production.
Jericho											
Lutin	8TZ		280 mph	3	33	4.25	16	ramjet			Rocket boosted.
Ogre I (8TZ-412.01)	8TZ		600 mph	50	720	6.5	36	ramjet			Photo-reconnaissance missile, liquid rocket boosted.
SE.4200	Sud-Aviation		Mach 1	60-70	660	10		ramjet			Ramp-launched. Accurate. In production. Has two solid boosters.
SE.4500	Sud-Aviation										
5200	SFECMAS	Army									AT missile, wire-guided, range 6500 ft.
SS.10 (5202, 03)	SFECMAS, SNCA-N	Army	190 mph	1.24	35	2'10"	6.3	solid			Antitank, close support rocket. Hollow charge. Very accurate, wire-guided. In service use.
SS.11 (5210)	SFECMAS, SNCA-N	Army	430 mph	2		4		solid			Improved, longer-range version of SS.10. In production. Solid in-line booster. SS.22 version rumored.
Miscellaneous Test Vehicles, Drones											
910	8reguet		500 mph					none			Unpowered glide bomb test vehicle.
CT.10 (Arsenal 5.501)	SNCA-N	Navy	280 mph	30	1452	19'8"		pulsejet	396		Launched from solid rocket boosted carriage. Can be parachute recovered. Target drone, radio guided.
CT.20 (T. S.510)	SNCA-N	Navy	560 mph	125	1444	17'8"	25	turbojet	880		Guided target drone. Flight time is 45 min. Can be controlled within flight path of ±1.6 ft., and can be landed with 0.6 mile circle.
ECA.20	ECA										Guidance test vehicle.
ECA.26	ECA										Guidance and control test vehicle.
ECA.27	ECA										Test vehicle, airplane structure.
EOLE.S1	DEFA										
"Reduced Version"				35	3943	24.4	31.5	liquid rocket	22,820	18.7	See text.
"Normal Version"				125	7497	36.1	31.5	liquid rocket	22,490	45.3	See text.
OPD.320S	ONERA			(100:payload)							Two-stage telementary test vehicle.
S.T. 450	SFECMAS, SNCA-N		Mach 1					ramjet			Parachute recoverable. Two solid boosters.
.....	Turck										Guidance test vehicle.
Upper Atmosphere Research Missiles											
Monica-4 (ATEF-14)	ATEF	Air Force	3100 mph	60	271	16'10"	6¼	solid		25	Four models available.
Veronique (Type NA)	DEFA	Ministry National Defense	3200	84	3180	24	20	liquid rocket	8820	45	Record altitude for European rocket. See text.

hold everything!

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is considered highly successful. Tests have been made at Sahara ranges since 1952, with aircraft like the *Grognard* and *Vautour* having fired it operationally. (It can be parachute-recovered.)

Matra production missiles include the AA.20 and the R.051, the former being liquid propelled, the latter solid powered. The M(AA).20 is carried by the *Mystère A* and *B* fighters, and is thought to be very accurate. The R.051 is a beam rider, incorporates a proximity fuse, is highly accurate, and features canard construction. It, too, arms the *Mystère*. Range is classified, but is believed to be considerable. M.510 has an optical guidance system and is a two-stage affair. M.511 may be used on the *Trident* rocket-powered airplane.

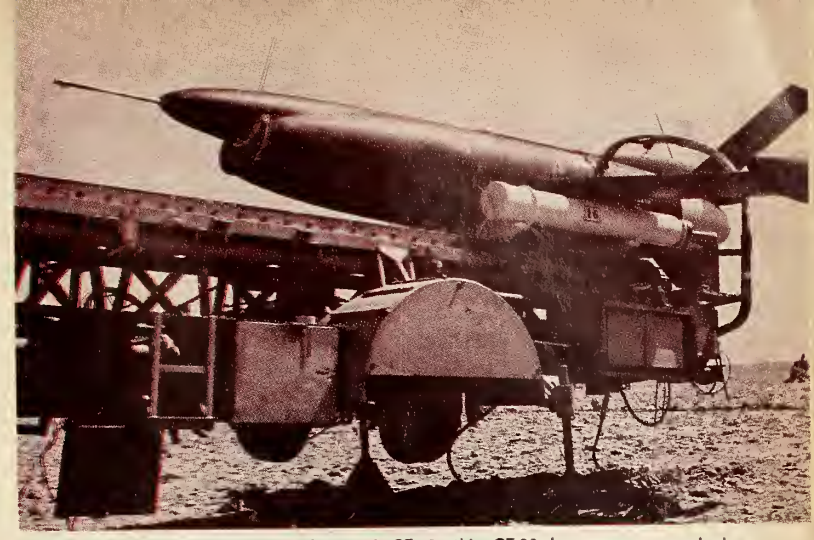
Another program pushed by L'Armée de l'Air is the SFECMAS 5103, built by Nord. Like the R.051, it incorporates a warhead effective over "plusieurs mètres de distance," armed by proximity fuse. It has a cruciform airfoil and is probably a beam-rider. With both a solid sustainer rocket and in-line solid booster, it flies with constant velocity from the time of booster *cutoff; Super-Mystères, Meteors* and *Vautours* are known to have fired it. Little is said about Sud Aviation's 1524 except that it is a development sponsored by L'Armée de l'Air and has been tested successfully. It is possible that the ASM 1522 development also has an air-to-air rôle.

Air-to-Surface Missiles

This is one category of missiles that the French apparently have not investigated thoroughly or at least, little knowledge of their work has been released. Some of their air-to-air missiles can double as ASMs, and such short-range surface-to-surface rockets as the SS.10 are fired from helicopters at low altitudes. The French Navy is now building a helicopter carrier that will not only be outfitted with defensive missiles but will have its helicopters armed with offensive varieties.

The BB.10 represents the latest of a series of guided bombs developed since the war and is used with the *Vautour* fighter-bomber. It features cruciform fins, an annular shroud wing and canard surfaces. The SNCASE (now Sud-Aviation) 1522 is a development about which nothing is known and it may not have been carried forward into operational use. France is rumored to have a *Rascal*-type ASM, but substantiating information is not available.

In effect, then, the French air-to-surface missile picture seems to show the use of small, high velocity rockets adapted from air-to-air use (a good example being SNEB rockets launched from Matra-type 116 pods carried by the *Vautour*), guided bombs, and, if you consider helicopters, SSMs launched from low-altitude platforms.



Later version of the SNCA du Nord CT.10, this CT.20 has greater speed than its predecessor, has been sold in quantity to foreign countries, notably Britain.

Surface-to-Air Missiles

French surface-to-air missiles are designed to fit in between classic air defense ground setups and the intercepter. Most models are in the tactical experimental stage. The leading types are the Sud-Est (now Sud-Aviation) 4300 and LRBA-DEFA's *PARCA*, which stands for Projectile Autopropulse Radioguidé Contre Avion.

Sud's 4100 is a liquid-sustained, solid-boosted experimental type which led into the 4300. Nothing concrete has been given out on the Navy's *Masalca* and *Maruca*.

PARCA has a range of about 12 miles, perhaps 14 at the most, and can bring down a plane flying at an altitude of six miles. It is a beam rider, and the warhead is detonated by proximity fuse. *PARCA* was developed with the aid of LRBA at Vernon, EET-V, l'Atelier de Constructions, Puteaux and EET-B which handled test firings in both France and Colomb-Bechar. Cruciform canard controls are featured with delta fins. The French say little more about 4300 save that its performance is "sensiblement anologue" to that of the American *Nike*, is cruciform type, with no tail, and 45° sweep back. Thrust from its liquid rocket can be regulated. It is now used to train Army guided-missile personnel.

The possible eventual use of the *Trident* rocket-powered airplane as a SAM will not be discussed here, but reserved for a later article devoted to the rocket airplane.

Surface-to-Surface Missiles

Most significant French SSM research has centered on the antitank weapon, with notable success. Both the Army and Air Force have participated in these developments, the latter being interested in the helicopter-to-ground versions as noted earlier.

Within the SS.10 program are the SFECMAS 5200 (Nord) series* and DEFA's *Entac*, both with nearly identical ranges and velocities. They are wire guided, solid propelled, and have shaped charges able to pierce thick tank skins. The 5200 saw action in the Israeli war against Egypt with good results. Commands are relayed along wires, which unwind under the wings. The *Entac* version is now entering production.

SS.10 is highly accurate and needs only a few men for effective operation. Tests made in Colomb-Bechar, North Africa, have been described as 98 per cent accurate. The American Army has adapted the design to its own use.

The French have fired this missile from their SO.1221 *Djinn* and *Alouette* helicopters. Normally, three are carried on a launcher on each side. They have also reportedly been fired from the Dassault 315 *Flament* twin-engined transport and from the Potez 75 tactical support airplane.

The SS.11 (SFECMAS 5210) program is a longer-range version of SS.10 and is under large-scale production for the Army and Air Force. Other than surface-to-surface and air-

** The 5202 is the training version, and 5203 is the operational version.*

to-surface applications, it may be tried out in an air-to-air role. Solid-propelled, an eventual ramjet version is rumored.

Other French SSM projects include Zborowski's BTZ-411.01 bazooka-type missile, his 33 pound *Lutin* army infantry ramjet and the *Ogre 1* long-range photo-reconnaissance ramjet, with liquid rocket booster. This latter is tailless, with barrel-type coleopter rings.

The only moderate-range vehicle known to be under development in France is the SE.4200, which was originally developed by SNCASE (now Sud-Aviation) under the direction of the Direction Technique et Industrielle de l'Aéronautique. Army's Section Technique later tested it and brought it into service. Designed to carry a powerful charge to distances of 60 or more miles, it is launched from a truck-mounted ramp by a solid booster (which drops upon cut-off).

The charge is carried beneath the missile in a pod. It is gyro-stabilized, attitude being maintained by wing-tip controls and elevons. An altimetric device controls altitude. It is hoped that this tailless guided missile will graually replace long-range artillery. There are only rumors of longer-range SSMs under development in France.

There are a number of experimental, test vehicles in France as well as several drones. The Breguet 910 is an unpowered glide bomb which is released from an airplane at 15,000 feet, to glide to the target at subsonic speeds.

This is unusual in that it has prestressed concrete wings. ONERA of Châtillon developed an OPD.320S experimental telemetry test rocket which could carry up to 100 pounds of parachute-recoverable instrumentation. SNCA du Nord has a CT.10 (ARS 5.501) guided target plane that has been thoroughly tested and used, plus an advanced CT.20, both recoverable by parachute. The former uses an Arsenal pulsejet, gives 396 pounds of thrust, and has seen service with the French and British navies. Ramp-launched by two powder rockets on a carriage (recovered after separation by parachute), it is radio controlled and has an auto-pilot.

Should the CT.10 fall in the water, it will float until pickup and, like the *Skokee,* it has a spike in the nose for land recovery. The French use it for antiaircraft artillery and surface-to-air missle training. CT.20 is much like the .10, has a turbojet engine, and is considerably faster. Both have been sold abroad, notably to the British. The Eole-51 was an experimental, fin-stabilized rocket used by DEFA as a test vehicle for *Veronique.* Operating on liquid oxygen and alcohol, it featured sheet-metal construction. The Société SAGEM constructed the missile, and two were fired by CIEES, Colomb-Bechar, in 1952.

ECA. 20, 26 and 27 are all guidance and control test vehicles. The SFECMAS-Nord ST.450 is ramjet powered, solid rocket boosted, and can be parachute recovered.

Atmospheric Sounding Rockets

France has two entries in this field, the *Monica* ATEF-14 and the *Veronique.* The former comprises a series of two- or three-stage solid-propelled rockets, and was named for the daughter of an engineer who worked on the missile. (She was born on the day of the first firing.) It is a low-cost rocket, and, depending on the type and payload, can fly from 55 to 90 miles high. Backed by the Ministère de l'Air, some 15 are expected to be fired during the 1957 part of the International Geophysical Year. Experiments involving cosmic ray and atmospheric physics are performed by *Monica.* A 4-6 channel, AM/FM telemetering system is used.

The *Veronique* holds, as far as is known, the European altitude record of 84 miles, established with rocket NA-14 in February 1954. The missile has variously operated with WFNA and diesel oil or furfuryl alcohol or oil of turpentine, the last being used in the record performance. DEFA, through LRBA, developed *Veronique* in 1949, and it is still undergoing development and modification at the Vernon facility.

Probably the most unique feature of *Veronique* is its intitial stabilization system, which consists of four unwinding cables extending from outriggers attached to the missile. When speed and altitude have been gained, the outriggers are explosively detached, and *Veronique* continues upward, now stabilized by her aerodynamic surfaces.

The first vehicles were fired in 1950, and since that time a number of changes have been introduced.

Veronique's telemetering system can transmit 20 measurements; carrier frequency is 152 m/c; time modulation is converted at the surface station to amplitude modulation; and some 35 information bits can be transmitted per second

New *Veroniques,* the first since 1954, are now being constructed, and by the time this article is printed the first may be ready. Difficulties with the telemetering system, however, may prevent firings until late in the year or early 1958. ★

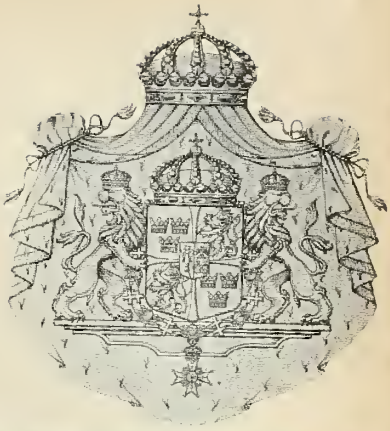
The outstanding antitank missile, SS.10.

International editor for m/r, Anthony Vandyk, examines instrumentation package in Paris.

SWEDEN . . .

From Torpedoes to Antiaircraft Missiles

by **Frank McGuire**



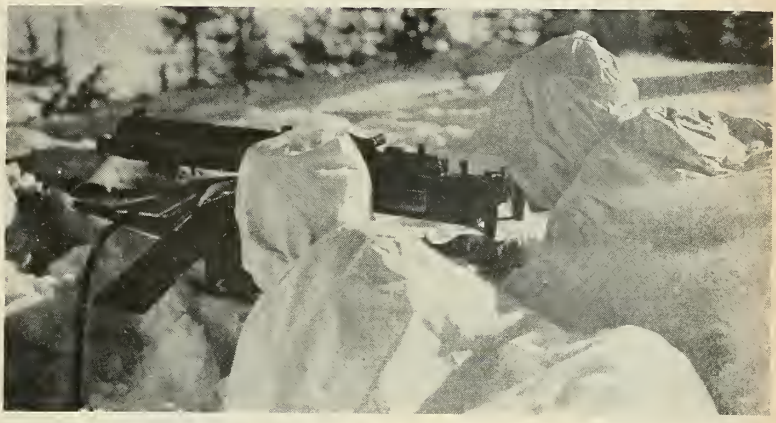
THE MAIN EMPHASIS in Sweden's missile program appears to be on SAMs and missiles for coastal defense. Work has been underway on other types for some time, but not with the high priority placed on aircraft-interceptor missiles in the *Bomarc* and *Nike* classes. Surface-to-surface missiles for naval use have been under study, but application of these to land operations has not been pushed.

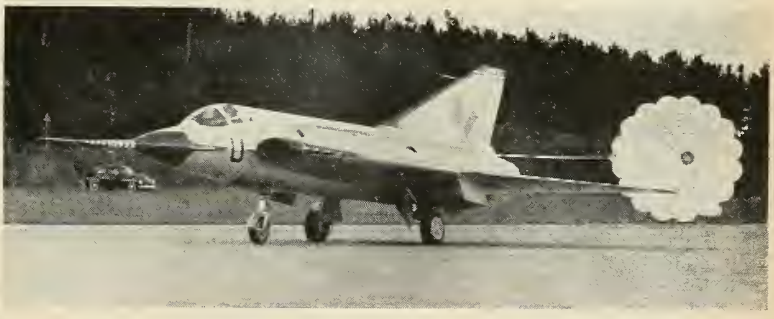
Since 1955 the Swedish Air Force has had under development an interceptor known as *Luftforsvarsrobot,* which is of the *Bomarc* class and capable of very high altitude interception at ranges from 120-150 miles. Other, smaller, missiles are also being developed for antiaircraft defense and some are undoubtedly operational.

Sweden's total missile industry activity includes many areas, but not ICBMs, and puts little dependence on foreign production. An exception to this, however, is the September purchase of ten *Jindiviks* from Australia. Another type drone is being produced by A. B. Flygmal Co.

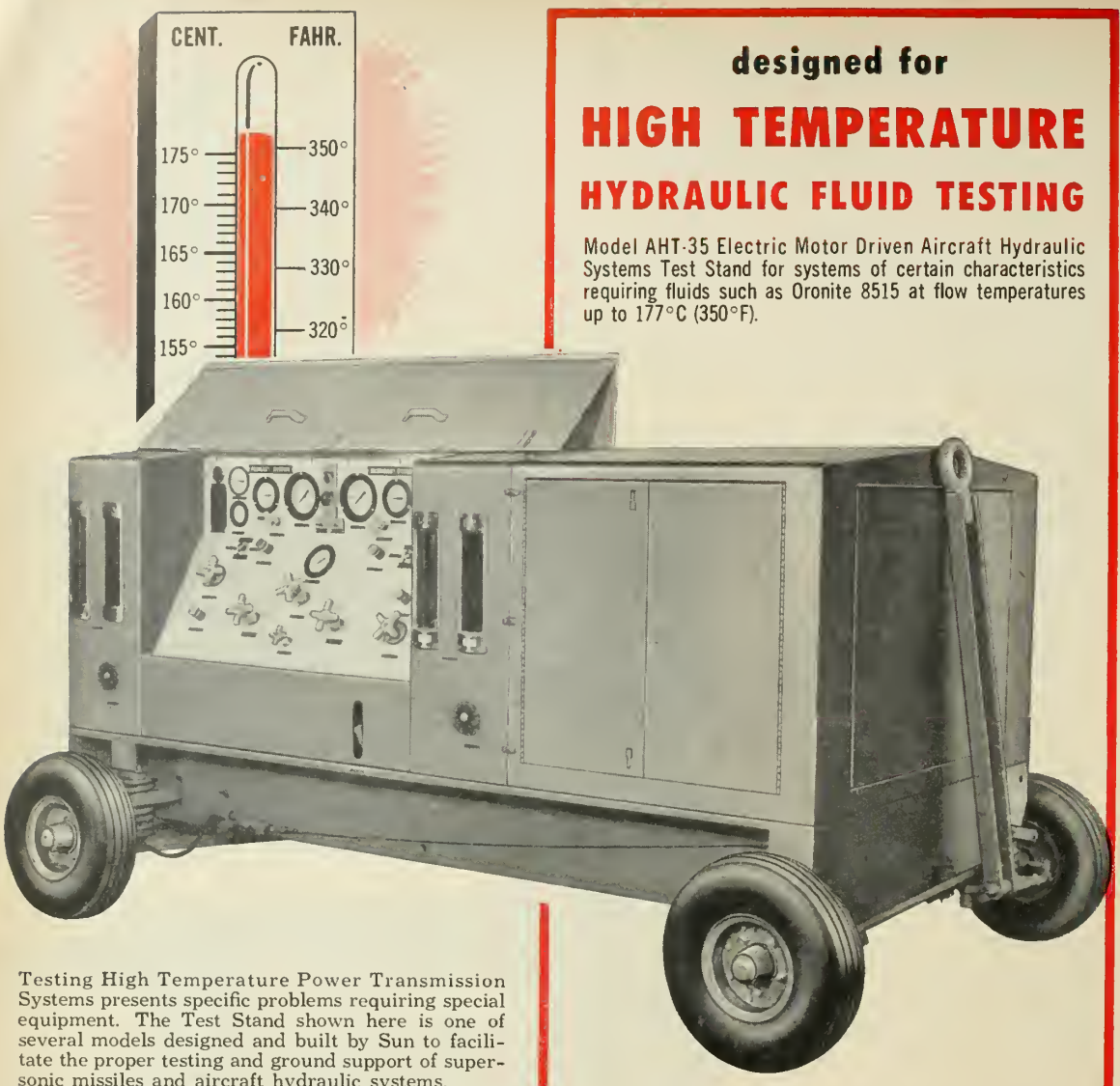
Bofors has developed a guided AAM for use on the J35 interceptor. The Saab A32 *Lansen* all-weather attack aircraft is also equipped to handle Swedish-developed AGM for tactical strikes. One of these aircraft rockets is the *Jaktrobot* (fighter missile), which is due to become operational soon, as is the *Sjorobot* (sea missile) for naval surface-to-surface use.

The Swedish missile industry is also pushing research on ramjets, high-energy fuels and advanced rocket designs. Their propellant materials production is quite adequate for supplying the blossoming missile program. *





Swedish army troops (top) will be supported by tactical missiles like those fired from the SAAB DRAGON, J35 (center). The latest torpedo boat design, the T101, may be equipped with missiles and guided torpedoes.



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JAPAN . . .

From Research Rockets to Missiles for a New Army?

By Frederick I. Ordway III

JAPAN IS WORKING hard to enter the forefront of missile and space-flight sciences. Activities center around three main areas of endeavor: (1) military rocketry, (2) research rocketry, (3) space flight planning.

Tokyo newspapers have made much of recent Japanese efforts to provide the country with adequate missile defenses. The Japan Defense Agency is hoping to legislate a defense secrets preservation law which will permit full production of guided missiles in Japan under license from foreign countries.

Japanese authorities point out that *Nike* and other American types could be employed if there were an adequate security protection system in their country. The government is not, however, limiting its considerations to American rockets, and has expressed interest in Italian (Polverifici Stracchini, S.A. will supply 500 Airone AAMs) and Swiss developments.

The Mitsubishi Electric Machinery Co. has concluded an arrangement with Switzerland's Oerlikon Machine Tool Works Buehre & Cie, whereby Japan will receive patent rights to produce the *Oerlikon-56* SAM and launcher. The contract covers an agreement with Contraves AG of Zurich, an Oerlikon affiliate, which produces missiles and fire control equipment. This has been done under the current equipment modernization program, and should provide Japan with some missile defense by 1959.

If Mitsubishi gets permission from Japan's Foreign Exchange Commission, it will pay 18-million yen (half a million dollars) for patent rights. Oerlikon wants eight per cent patent rights for the *-56* and five per cent of sales of launching and fire control equipment.

Sources close to the Defense Agency believe that during the next few months Japan will purchase a complete *Oerlikon-56* rocket launcher setup for the purpose of making careful studies of the system. Mitsubishi Electric, Mitsubishi Shipbuilding and Engineering, Mitsubishi Heavy Industries, and Mitsubishi Chemical Industries will cooperate in the Japanese missile program.

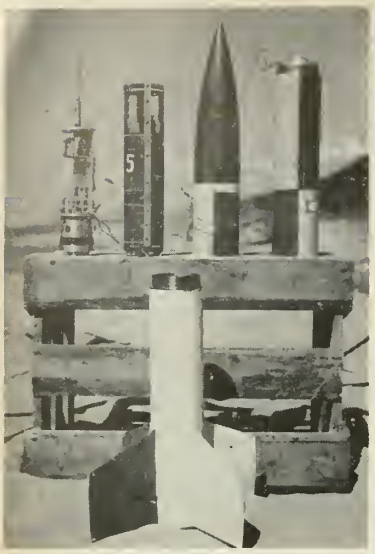
It is interesting to note that Yasjiro Okano, the liquidator of the old Mitsubishi Heavy Industry Co., has been named chief of the Guided Missiles Council, which effects liaison between industry and government.

Pilot production of the first Japanese guided-AAM is expected to get under way by 1959. The missile will be in the *Sparrow* class. By 1960, the Japanese expect to begin production of a *Nike*-type missile for ground-to-air use. The model TMB-0, a radio-controlled test missile, was cancelled after two unsuccessful tests. The TMB-0 was 5'4" long, with a swept-wing span of almost 3 feet. Launching speed was about 410 fps.

Missiles will change Japan's self-defense force.

Research Rocketry

Recent attention has been given to Japanese rocket research (m/r Oct. 1956; JET PROPULSION, March 1957).



The Japan *Rockoon* Committee, in a meeting at Ritkyo University, announced that 30 balloon-launched rockets will be fired during the I.G.Y. They will be released for cosmic ray, ionospheric, and solar radiation research. Three of these will probably be fired from the ship *Ryofu Maru* in the Pacific in August. Besides *Rockoons,* Japan will fire 50 additional I.G.Y. rockets. Some of the pre-I.G.Y. Japanese *Rockoon* tests have been successful. The first left the *Ryofu Maru,* located off the Boso Peninsula (Chiba, Japan) in April, but failed completely.

The second, however, was successful. Eight rubber balloons, each filled with 800 grams of hydrogen, lifted the 3.95-foot-long rocket at a velocity of 985 feet/sec. Firing took place at 65,500 feet, and the rocket reached a peak about 50 miles west of the launching ship. Longer *Sigma*-type rockets will also be used to reach up to about 68 miles.

Japan's surface-launched research missiles include the *Kappa-3* and *Kappa-4,* and *Kappa-5,* two- and three-stage vehicles, respectively. Firings have taken place from Michikawa Beach, where the Tokyo University Rocket Research Center has a test facility. Launched at an angle, *Kappa-3s* have a top speed of Mach 3.7, a firing time of 143 seconds and a range of about 20 miles.

A successful Japanese *Rockoon* test was made at Tateno, near Tsuchiura, Ibaragi-ken, in which cosmic ray experiments were carried out. This rocket was 3.94 feet long, and carried both a Geiger counter and a telemetering device. *Kappa 3* successfully fired at Michikawa Beach, soaring to about 15 miles. It was 16 feet long, and weighed 320 pounds. It was sponsored by Tokyo University.

Kappa-5s, which will be fired in support of the I.G.Y. in October of this year, reach about 80 miles. An intermediate rocket, *Kappa-4,* is 16 feet long and can attain Mach 5 velocities, soaring to some 40 miles.

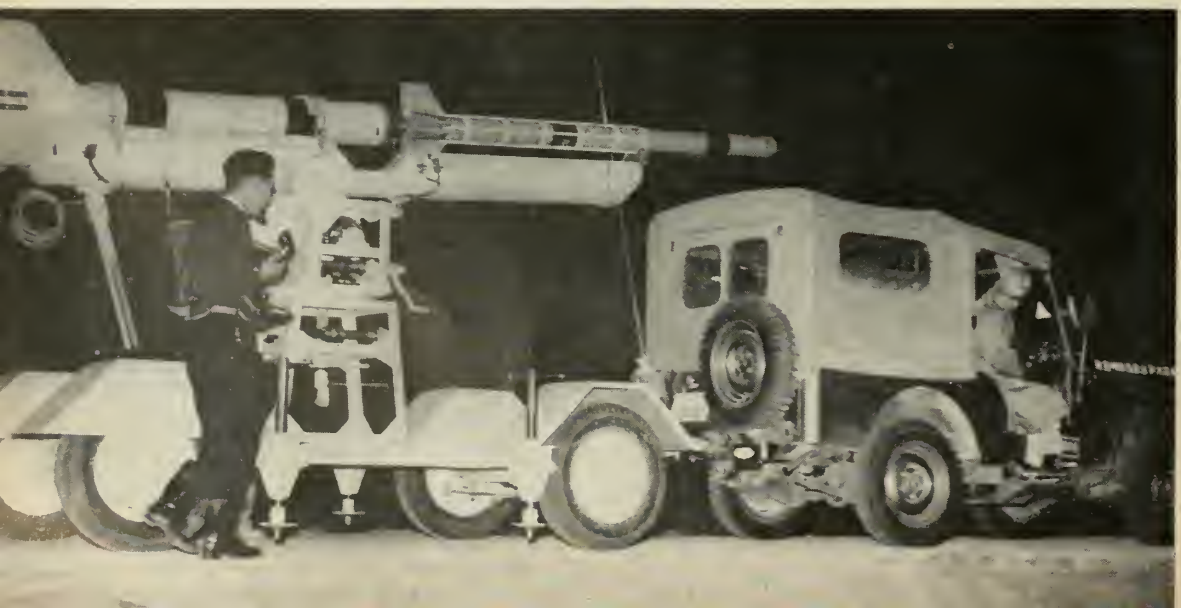
It has been announced that Japan will buy, in addition to its own rockets, five U.S. *WASP*-type rockets to be launched from balloons.

Space Flight

That the Japanese are astronautically minded was made clear by F. C. Durant (m r, Oct. 1956 and Nov. 1956) last fall. The YOMIURI JAPAN NEWS (Tokyo) advises taking off for Mars if (1) life is getting you down and (2) you don't know what to do with the extra money you have in your pockets because of income tax cuts. Sensitive to atomic bombs, the paper goes on to point out an advantage of Mars: ". . . the air (if there is any air) is not already contaminated by radioactive fallout."

In a more serious vein, the Japanese scientists are taking a long look at earth satellite plans. The head of Tokyo Astronomical Observatory and of the Japanese Chapter, Earth Satellite Committee, has recently toured America and Europe and has announced that Japan would be provided with a Schmidt astronomical camera for satellite observations. Earth satellite observation units have been practicing regularly, and feel they are ready to do their part in the world-wide observation program. ★

Left above—Basic components of BABY TELEMETER, early Japanese research rocket. Left—BABY RECOVERY rocket leaves launcher. Below—KAPPA research rocket on launcher-carrier.



ITALY . . .

NATO Missile Effort Off to Slow Start

By Franco Fiorio

IN THE 12 YEARS since the end to World War II, there has been a lot of interest in Italy in the rocket field, by individuals, government and private research groups. Unfortunately, both lack of funds and a coordinated effort by industry, in addition to the absence of a clearcut government program, have resulted in a serious delay in developing the Italian potential in rocketry.

The top government agency in charge of rocket development is the CORAMI (Comitaye Razzi & Missile), a joint group headed by Air Force Lt. Gen. Casero and working directly under the Chairman of the Italian General Staff, Gen. G. Mancinelli. CORAMI, in addition to its planning and programming activities, coordinates the rocket research and development effort of the three services and regulates the use of the new defense rocket and missile test range.

Military security is clamped tight on the research and testing work on the new test range, operated by the Italian Air Force.

Three civilian agencies are also involved in rocket development: SISPRE (Societa Italiana Studio Propulsione a Reazione), a research and production group sponsored jointly by the Italian Dept. of Defense, the Fiat, Finmeccanica and Bombrini-Parodi companies. Former Air Force Chief of Staff, Gen. A. Urbani, ret., is president and general manager is Professor Ing. Matteini, an electronic specialist.

The SISPRE group is looked upon as a potential link between the government and industry for the development of future weapon systems, in a role similar to that of Ramo-Woolridge in the U.S.A.

AIR (Associazione Italiana Razzi) is the Italian Rocket Society, active in the theoretical field and functioning as a representative of the profession. President is Professor Gen. G. A. Crocco and executive Vice President is Dr. A. Eula, Professor of Aerodynamics at the University of Rome.

CAAI (Centro Aeronautica & Atomico Italiano) is a private, nonprofit organization, sponsored by a group of members (260) of the Italian Parliament, by industry leaders, members of the government and independent scientists. It attempts to disseminate basic information on aviation and nuclear matters and to trigger an increase of interest and activity in the studies and production of advanced air vehicles, among them, rockets and missiles. President is the Hon. F. A. Di Bella, Congressman from Sicily; acting Secretary is Dr. G. Partel.

Research and Development

Several companies and private groups are active today in rocket research and development. There is a substantial number of engineers working on individual ideas, but here again lack of funds and coordination are the main obstacles to the achievement of practical results.

The following are some of the most important research groups:

CESPRE (Centro Studi Propulsione a Reazione) is the research branch of SISPRE headed by Gen. Urbani. This group is by far the most important in Italy and is now working on the air-to-air infrared solid-propellant missile C-7 and other classified projects.

Contraves Italiana is the Italian subsidiary of the Swiss company by the same name, which is part of the Oerlikon group. This company is developing a later model of the surface-to-air liquid-propellant missile, well known in the U.S. where it was introduced some years ago by Oerlikon Co.

BPD (Bombrini Parodi Delfino) is the largest Italian manufacturer of ammunition, explosives, and propellants, producer of the standard solid-propellant (bibase-ballistite type-M7) used by the Italian services. BPD is now conducting classified research in the field of solid propellants of improved characteristics.

Stacchini Co., formerly a producer of TNT charges for aircraft bombs, has entered the rocket area, in cooperation with Italjet. In the past years it has developed a family of unguided rockets of many types, powered by the standard BPD bibase solid propellant. None of these went beyond the testing stage. Only exception is the order from Japan for the *Airone* rocket, a cheap, solid-propellant (BPD) surface-to-surface unguided missile. Range of the *Airone* is reported to be over six miles. No other data are available. In addition to this activity, the Stacchini Co. has also sponsored research work on experimental rockets designed by Prof. Salvadori of the University of Rome.

Contin Co. is a small activity beyond the outskirts of Rome engaged in an experimental project on a small liquid-propelled research rocket. The

Globe Aerostatique . . . 1783

Montgolfier's vanguard project

A sheep, a duck, a rooster—the first payload carried aloft for atmospheric research. Louis XVI, his queen and his court, were astonished witnesses as Joseph Montgolfier's smoke-filled balloon rose in majesty 1500 feet over Versailles. The passengers? unharmed (except the rooster, kicked by the sheep).

Project Vanguard, 1957, is an equally momentous "first"—an attempt to place a 21-pound satellite in an orbit 300 miles up. Aerojet-General, designer-builder of the famed Aerobee-Hi, will supply vital second-stage propulsion systems for Vanguard launchings during the International Geophysical Year.

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rocket was designed by Dr. Sivori of the University of Rome, under the supervision of Italy's leader in Italian rocketry, Gen. Prof. G. A. Crocco.

Motofides S.p.a. in Livorno, part of the Fiat group and manufacturer of torpedoes for the Italian Navy, has been sponsoring a research project headed by Dr. Ing. A. Robotti. The project has designed a series of liquid-propelled, surface-to-air rockets of clean configuration and fair characteristics. The propellant is nitric acid and aniline. Design emphasizes low production costs and ease of maintenance and operation. An experimental order for an undisclosed number of *Robotti* unguided rockets and launchers has been awarded to Motofides by the Armed Forces. Diameter of the rocket is 40-50 in. and the length 15-16 ft. Speed is supersonic.

Boscari Co., headed by Dr. Ing. F. Salvini, one of the little known but outstanding pioneers of the Italian rocketry, boasts several interesting developments. Among them is a patented new type of multibase solid propellant, designated S-I, with excellent stability, low hygroscopic sensitivity and high shock resistance. Its low combustion pressure (1/3 of the ballistite type propellant's pressure, at equal volume and temperature) affords substantial savings in the structural weight of the combustion chambers.

Other Boscari developments include an underwater fishing rocket gun and a fragmentless plastic Bazooka practice head, capable of registering hits in color on the target. In cooperation with the Hispano Suiza Co. and the Italian Industrie Meccaniche Napolitane (INM), the Boscari Co. has developed a *Katyuscia* type of multibarrel (20) rocket, designated HSS-R 80/100, which has since been adopted by the Dutch and Egyptian Armies.

Production Facilities

Only a handful of firms are currently producing rockets in Italy on a mass production basis.

BPD (Bombrine Parodi Delfino) makes *Scar* 2:75-in. airborne practice rockets for the services. Boscari is subcontractor for the practice head.

Boscari makes standard bazooka practice rockets with plastic heads for the Italian Army. Subcontractor for the solid propellant is BPD.

Italjet, a group formed by the Stacchini, Motofides and Aerojet-General, make JATO units for NATO offshore requirements.

Despite this token activity, there are several indications, including a renewed interest by the Italian Defense Ministry, that the rocket business will increase substantially within the next few years in Italy, both in the research and in the production fields. ★


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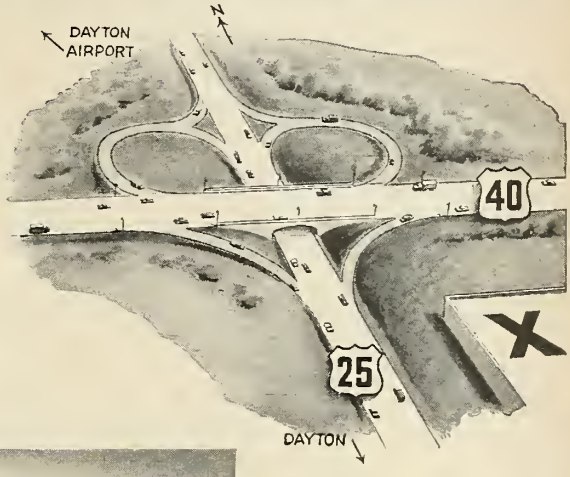

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Foreign Surface-To-Air Missiles

MISSILE		Code	Date	Maker	LENGTH (feet) Missile	Booster	Total	DIAMETER body, average (inches)	SPAN wing or f max. (fe
	(E)	AWA		1	17.6				
	(E)	AWSG		1, 2					
Bloodhound	(E)			34	15.0*			15.7*	5.3
Bobbin	(E)			34					
Bomarc	(US)	IM-99	1952	3, 32, 35, 40	47			36.0	18.2
British SAR 2"	(E)		1937						
British SAR 3"	(E)	UP	1938		4.0				
British SAR 5"	(E)				6.0				
British SAP	(E)		1916	36					
EE Guided Rocket	(E)		1954	37					
Enzian	(G)	E4	1944	5	31	7.0	31.0	7.	33.
Enzian	(G)	E5	1944	5					
Feuerlilie	(G)	25	1941	6	4.16	3.		7.	2.9
Feuerlilie	(G)	55	1943	6	15.75			21.6	7.5
Funryu	(J)	Model 4			13.1			23.6	5.2
Gapa (rocket)	(US)	A	1945	3	10.	6.4	16.4	12.0	2.4
Gapa (rocket)	(US)	B		3	19.	8.0	27.0		
Gapa (ramjet)	(US)		1948	3	26.			12.0	
Hawk	(US)		1956	7, 21, 39	16.3			14.0	4.9
Hecht	(G)		1941	6	6.5			9.9	2.5
Japanese SAR	(J)	A	1944						
Japanese SAR	(J)	B	1944						
Japanese SAR	(J)	C	1944					4.73	
Lark	(US)	XSAM-N-2	1949	8, 9	14.0	4.0		18.0	6.
Little Joe	(US)	KAN-1 & KAN-2	1944	10	11.34			22.7	7.
Loki	(US)		1949	11, 12				2.99	
Lop-Gap	(E)	A			14.0			9.5	2.
	(F)	M.04†	1949	13	15.0			16.0	5.
	(R)	M-1	1947		15.0			22.0	14.
Maruca	(F)		1956	14					
Masalca	(F)		1956	14					
Matra	(F)	M.04?†		13					
	(S)	MX-1868	1954	15	16.0			40.8	4.
Nike-Ajax (A)	(US)	SAMA-7	1950	9, 16, 17, 35	20.0			12.0	5.
Nike-Hercules (B)	(US)	SAMA-25	1954	9, 16, 33, 35	25.0			25.0	
Nike-Zeus (II)	(US)		1956	9, 16, 17					
Oerlikon SAR	(S)		1953	15					
Oerlikon	(S)		1950	15	16.5			15.0	
Oerlikon	(S)	54	1954	15	19.7			15.6	4.
Orione SAR	(I)		1956?	18	6.0			3.25	15.
Parca	(F)		1956?	19					5.
Rheintochter	(G)	R-1	1944	6	13.2	7.5	20.7	21.6	9
Rheintochter	(G)	R-3	1944	6.20	16.4	4.2	20.6	21.6	10
Rheintochter	(G)	R-3F	1944	6					
Russian SAR	(R)		1954						
Schmetterling	(G)	Hs-117	1944	22, 23	12.5	8.0		14.0	6
	(F)	SE-1524	1955	24					
	(F)	SE-4100	1956	24					
	(F)	SE-4300*	1956	24	13.5	11.2	24.7†	25.7	11
Sea Slug	(E)		1955		19.5			20.0	
	(R)	T-7	1955		23.0			25.0	
Taifun (Willy Ley)	(G)	F	1944		6.4			3.92	
Taifun (Gatland)	(G)	F	1944		6.28			3.94	
Talos (ramjet)	(US)	XSAM-N-6	1952	10, 11, 25, 26	15.0	10.0	25.0	18.0	4
Tartar	(US)		1954	27, 42	9.75	10.5	20.25	9.0	3
Terrier	(US)	SAM-N-7	1951	4, 27, 38, 41	13.0	14.0	27.0	12.0	4
Thiamat	(US)	MX-570	1946	28	14.3				
Thunderbird	(E)		1957	37	20.0*	6.0	20.0	24.0*	6
TMA-O-AC	(J)		1956						
US Anti-Missile Missile	(US)		1956	9, 27, 29					
Wasserfall	(G)	C2-E2	1942	30	25.7			33.6	8
Window SAR	(US)		1943		4.45			3.5	
Wizard (project)	(US)		1943?	31					
Z-Battery SAR	(E)		1943		6.0			4.0	

Conversion Data on the Manufacturer's Column in the Table of Surface-to-Air Missiles

No.	Maker
1	Armstrong-Whitworth
2	Sperry Gyroscope
3	Boeing
4	Reeves Instrument
5	Messerschmitt
6	Rheinmetall-Borsig
7	Raytheon
8	Fairchild Aircraft
9	Bell Telephone Labs
10	McDonnell Aircraft
11	Bendix Aviation
12	Grand Central Rocket
13	MATRA
14	SNECMA
15	Oerlikon
16	Douglas
17	Bell Aircraft
18	Polverfici Giovanni Stacchini
19	DEFA
20	Konrad
21	Northrop
22	Henschel
23	Bavarian Motor Works
24	SNCASE
25	Johns Hopkins University
26	Farnsworth
27	Convair
28	NACA
29	North American
30	Peenemünde
31	U of Michigan
32	Marquardt
33	Western Electric
34	Bristol Aircraft Ltd.
35	Acrojet-General
36	RFC Experimental W
37	English Electric Co.
38	Northern Ordnance,
39	Thiokol
40	Westinghouse
41	Kellogg
42	Allegheny Ballistics

tential — Experimental — Actual

WEIGHT (pounds) le	Booster	Payload	CEILING (feet)	RANGE (miles)	VELOCITY	THRUST (pounds) Missile	Booster	BURNING TIME (sec) Missile-Booster		GUIDANCE TYPE	PROPELLANTS Fuel	Oxidizer
				20								
										SRH		
)	6,500		80,000	200+	Mach 2.5+					RC, RH		
)											Cordite	
)				4.								
			50,000		Mach 2.0					BR		
)	794	1,050	47,600	16-24	920 mph	4,400	3,300	70	7	RC	Visol	HNO_3
		550				5,500		56			Gasoline	HNO_3
5	38.6					1,100		6		RC	Diglycol Dinitrate	
3			26,400	4.5	1020 mph	2,200	4,400	25	6		Alcohol	LOX
)		440	82,000	18.0	Mach .9	3,300		60		RC	Hydrazine Methonal	Peroxide
)		200			Mach 2.5					H		
			"Stratosphere"	22.0						RC		
)					677 mph	130		25		RC	Peroxide	
5.4		4						0.37				
3.2		2.2						0.37				
2.6		7.5		1.0				0.90				
)				10.0	Subsonic		1,000			RC, SRH	Aniline	RFNA
		100.0	10,560	2.0	410 mph		1,000			RC		
			100,000					0.8				
					1,000 mph	1,000		25.0	4		Methanol	LOX
)					1,100 mph	2,750		14.0				
)	1,850.0		47,600		Mach 1.3	3,400	3,275	30.0	15.0		Hydrazine	Peroxide
5			66,000	12.0	850 mph	2,200				BR		
)		300.0	47,500	25.0	1,500 mph	2,600		35.0		RC, SRH	Analine	HNO_3
				50.0	2,200 mph					RC		
			31,700	2.5								
)		44	66,000	12.5	1,705 mph					BR	Paraffine oil	HNO_3
2			60,000	15.5		2,200		30.0		BR	Kerosene	HNO_3
)			65,000							RC		
)	902.0	235	21,150	24.0	810 mph	8,800	165,000	10.0	.6	RC	diglycol	HNO_3?
)	970.0	350?	42,300		922 mph	3,900	62,000	45.0	.9	RC	Visol	HNO_3
						4,500				RC		
				37.5		17,000						
)	200	55	47,600	20.0	470 mph	840	750	30.0	4.0	RC	Tonka	HNO_3
										RC		
			39,400		Mach 0.8							
)			65,000		Subsonic							
)			60,000			17,600		40.0			amine	HNO_3
		40	47,600	7.5		3,200		3.0			butyl ether	acid
.6			52,800			1,850		2.5			cordite	
			75,000	40.0	Mach 4.0					BR, RH		
			75,000	15.0	Mach 2.5	1,000				BR		
					620 mph	200	7,200	45.0	3.5	H		
			13,000									
			47,600	31.0		17,160		45.0		BR	analine	HNO_3
			5,400	.51	1160 mph							
.0		20	2,115					4.0				

Legend

e: estimated (by photo measurement and calculation)
†: without spike
‡: is reportedly an SAM with booster attached
IM: interceptor missile
UP: unrotating projectile
XSAM: experimental surface-to-air missile
(E): England
(US): United States
(G): Germany
(J): Japan
(F): France
(R): Russia
(S): Switzerland
(I): Italy
SRH: semiactive radar homing
RC: radio command
RH: radar homing
BR: beam rider
H: homing
RFNA: red fuming nitric acid
SAR: surface-to-air rocket (unguided)
SAP: surface-to-air plane (radio drone designed to ram Zeppelins)
EE: English Electric

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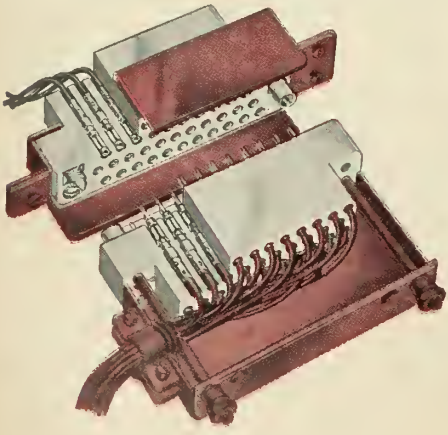

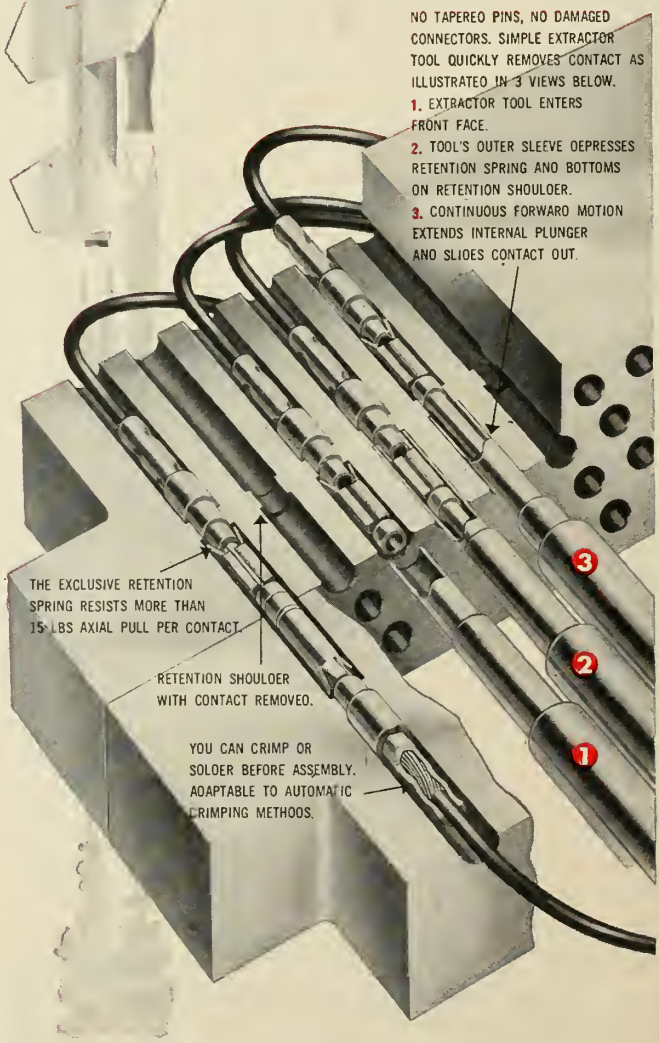

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OFFICES IN PRINCIPAL CITIES THROUGHOUT THE WORLD

Missiles for NATO

Ordnance Guided Missile School Trains NATO Personnel

By Norman L. Baker

THE U.S. ARMY Ordnance Guided Missile School of Redstone Arsenal, the Army's only activity devoted exclusively to guided-missile training, has taken on the international look in recent months. Since the school was formed in 1952 students from this nation's armed forces and from five foreign nations have received training at the school.

Students from NATO nations are the latest addition to OGMS. First

LEFT—OGMS Corporal instructing group of Italian officers during class in NIKE-AJAX familiarization. BELOW—MISSILES AND ROCKETS editor Norman L. Baker interviews Maj. Ejvin Larsen, 1st Lt. Herman Dangaard and Lt. Bert Okholm, part of the initial contingent of personnel from Denmark to enroll at OGMS. The first Danes and Norwegians are receiving training to qualify them as interpreters for the main body of students.

foreign students to be enrolled were from Great Britain and Canada. The first British class graduated in March 1956. This year students from Norway, Denmark and Italy have enrolled in the first step toward initiation of the NATO training program.

The first of the NATO personnel are comprised entirely of officers carefully selected from their country's armed forces. Representing only a handful of the NATO personnel that will eventually be trained at OGMS, the first groups will later be utilized as interpreters and instructors for the personnel that will follow.

NATO training is currently concentrated on the *Nike-Ajax* surface-to-air missile. This training is restricted to the supply, repair and maintenance aspects of the missile system. The operational phase of training is conducted at Fort Bliss, Texas. Later, the units trained at Bliss and OGMS will be merged into complete missile-systems units and will receive additional instruction before returning to their home countries.

With the exception of two officers, all personnel interviewed by m/r editors are being exposed to guided missiles for the first time.

Although none of the officers were volunteers, when ordered to leave their homes and attend the OGMS they expressed eagerness for the assignment. Most are married and are living with their families in homes around the Huntsville area. Morale is very high, apparently due to enthusiasm for their assignments and for the opportunity of visiting the U.S.

A per diem payroll allotment puts

1st Lt. Domenico Loda and 2nd Lt. Virgili Luigi of the Italian Air Force, students at OGMS, who were impressed by the NIKE-AJAX.

Officers of the Italian Air Force probe the "insides" of a NIKE-AJAX surface-to-air during a class in repair and maintenance.

the NATO officers salary on a comparable basis with that of the U.S. officer. This has avoided a compromise in their standard of living. A minor complaint of the officers was the lack of those foods that can be found in abundance only in their home countries. Several of the trainees have made previous trips to the U.S. and have had only minor difficulty acquainting themselves with our customs.

The NATO personnel are taking the same courses as the American students with the same completion date scheduled. The basic prerequisites for the NATO students are identical to U.S. Army personnel requirements, with the additional stipulation that they have a general knowledge of electronics and mathematics.

The Italians, latest group to enroll, are all Air Force personnel. In Italy the Air Force has complete jurisdiction over all guided missiles. Three major branches of the Italian Air Force are represented in this class—flying, service and engineering. All have technical backgrounds: some are thoroughly trained in electronics and others in radar. A notable feature of the officers' background is that all are in a career category and have expressed the desire to continue their profession in the guided-missile field.

The first groups of Norwegians and Danes are here primarily as interpreters. They are serving a dual purpose in being here. When finished with their present courses, they will remain as interpreters for the main body of students due to arrive in the next few months.

On returning home, these men will hold a unique and respectful position in their countries' armed services. The Netherlands may be the next NATO country to send personnel to OGMS for training. These men will be technicians from the Dutch Air Force selected for training in the *Nike-Ajax* system.

There is no doubt in anyone's mind

at OGMS that the NATO training operation can be anything but a complete success. Minor language difficulties, which will be eliminated when the interpreter staff is trained, are compensated by the enthusiasm and dedication expressed by the NATO students.

One of the instructors stated, "The NATO students are constantly looking ahead, staying one step ahead of the instructor, anticipating the next move. The students utilize the full time allocated when taking exams. They weigh every possibility on each question and then constantly review their decisions."

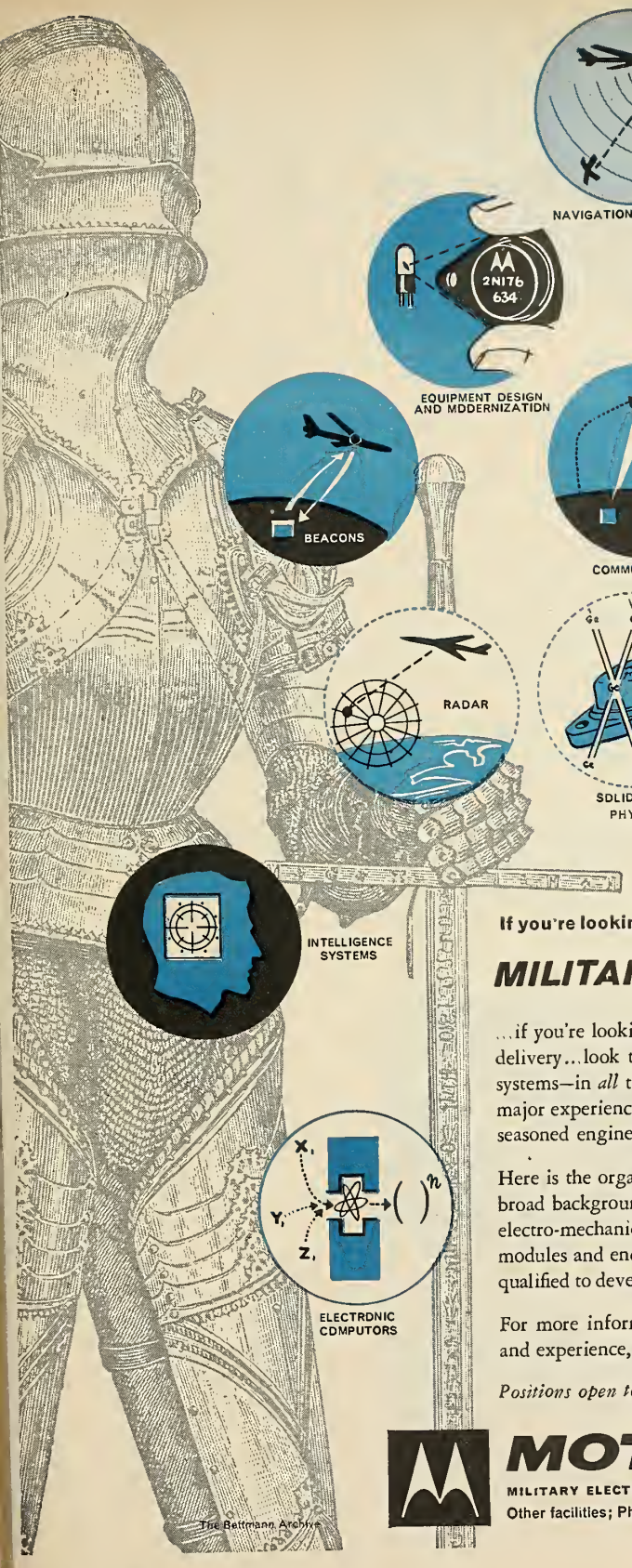
NATO training at OGMS currently comprises only a minor portion of the school's facilities and enrollment. OGMS has more than doubled in size in less than two years and is expected to double again in the next year. Total strength of the school stands just under 1750 persons compared to less than 800 in July 1955. Present number of students in training is in excess of 500 as opposed to 282 in July 1955 and 348 in July 1956. The remaining number make up the permanent party of staff, faculty, office, advisory personnel and the Unit Training Center staff. UTC is a division of OGMS devoted to training completely formed military units.

Personnel figures also include nine civilian contracting firms located on the base. OGMS employs approximately 100 field representatives from Philco, RCA, Firestone, Gilfillan, AASLI, Douglas, Western Electric, Chrysler, and North American.

OGMS now conducts 23 courses of instruction on the *Nike-Ajax*, *Corporal*, and *Redstone* missile system. Five units are currently undergoing training in the Unit Training Center. Plans are being formulated for adding the *Nike*, *Hercules*, *Dart*, and *Lacrosse* missile systems within the near future.

In preparing for the increased training load that will follow as a result of the addition of new missile systems, OGMS is in the midst of a $15-million building program. The construction program includes three class and laboratory buildings, two shop buildings, a technical library, a training aids shop, a special electronics-maintenance shop, and a special wheel vehicle maintenance shop.

Col. Henry S. Newhall, Commandant of OGMS, commenting on the present expansion program, stated, "These facilities will provide for new missile systems as they are developed by the Army. For, as new systems are added to the Army's arsenal of long range weapons, additional courses will be added to the school." ★



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The French Air Force CT 20 in the assembly area of the SNCA du Nord manufacturing plant. The CT 20 is one of the most advanced target missiles now in production in France.

French Missile Production

By Jean-Marie Riche

PARIS—Although the French authorities are very reluctant to discuss their progress in the missile field, the concentrated efforts of their aviation industry during the past ten years is beginning to pay off. Some of the hardware resulting from this work has now reached the production stage. And in one field—antitank weapons—the products are described as among the best existing in the world.

Some information has been released about the SS 10 and SS 11 antitank missiles. At the recent Salon de l'Aviation in LeBourget, the SS 10 was on display with two air-to-air weapons of SNCA du Nord and Matra which are now reaching the production stage. Some experimental vehicles were also shown, stressing French interest in other directions. The practical meaning of this research effort is not known.

French policy in the missile field was, however, outlined earlier this year by the present premier of France, then the defense minister, Bourges-Maunoury. The head of the French government was the first politician to warn the nation that it was entering the missile age. "The conclusion of the present research effort should be the production of an arsenal of defensive and retaliation weapon-systems without which French independence could not be guaranteed." The French are now at work on the development and construction of a surface-to-surface strategic missile (sol-sol strategique), with a range estimated between 1600 and 2000 nautical miles. This is a formidable challenge for industry. Production will require pooling of efforts by the major aviation and electronics manufacturers. This weapon, which may be armed with nuclear warheads, will help the current experimental work on surface-to-air and air-to-air missiles.

SS 10 (above left) and SS 11 (left) are surface-to-surface antitank, antiemplacement missiles powered by a solid rocket motor. Missiles are controlled by transmitting signals through two wires which unwind from a drum. The MATRA 510 (above) is an air-to-air missile powered by a two-stage solid rocket motor. Missile carrier is the TRIDENT.

French manufacturers have asserted that missiles would be the ultimate result of experimental aircraft like the hybrid interceptor *Trident* of Sud-Aviation, *Leduc 022* and *Griffon* of Nord and like the *Flying Atar* VTO of SNECMA. The first *coleopter*, expected soon, and the *Trident* are equipped to fly by radio-control.

Although missile-minded, French industry is hampered by skimpy appropriations, only a small fraction of what it takes to produce a family of weapons like those in the U.S., the USSR or even Great Britain. More money is going for missile research, however. In 1955, of industry's total research grant, only 22.6 per cent went to missiles. In 1956, this was raised to 30 per cent and in 1957 to 31.6 per cent.

In view of the increased emphasis on missiles, the coming months will see the formation of groups with which aircraft research activities and electronics companies will associate themselves. In some cases, the aircraft companies will absorb research departments of electronics companies. These developments should give a boost to an effort which may have been somewhat delayed through the reluctance of the majority of the industry to

abandon "classic" production items in favor of missiles.

In addition to aviation companies, work has been undertaken in the missiles field by DEFA and the Army Arsenal, which was responsible for the development of the surface-to-air *Parca* missile, whose production status is not clear. ONERA, the French counterpart for NACA, has also produced interesting test vehicles, some of which were on display at the Bourget exhibition.

Testing of French missiles takes place at the Colomb-Bechar range in South Algeria, a well-equipped interarm testing base at the fringe of the Sahara desert.

The SS 10 and SS 11 are surface-to-surface antitank and anti-emplacement weapons designed by SFECMAS, a company now operated by the Societe Nationale de Constructions Aeronautiques du Nord. Equipped with one solid rocket motor for acceleration and one for cruising, they are guided by two isolated electric wires which unwind from a drum. A small gyroscope, especially developed for the missile, is described as its best construction asset. Their warhead is provided with a hollow charge which can pierce armor plates 400-500 mm thick.

In production for about four years, the SS 10 is used as standard antitank equipment by several armies including the French and German. Recently demonstrated to experts of NATO, it has been recommended for general adoption by the NATO forces. The SS 10, whose operation is very simple (guidance by straight visual reference), can be used either as a surface-to-surface antitank or anti-emplacement weapon or, mounted on helicopters or light planes, as an air-to-surface weapon.

The SS 11, derived from the SS 10, is a smaller diameter missile, also guided by wire, but whose range is more than twice that of the SS 10. The velocity of the missile at the end of its cruise is twice that of SS 10. The warhead of the SS 11 is also heavier.

Nord 5103

This missile has been designed by SNCA du Nord for the armament of transsonic, subsonic or supersonic interceptors. It is characterized by its pointed warhead and its four cruciform wings which are sharply swept.

MATRA Type 510

MATRA (Societe Generale de Mecanique-Aviation-Traction), a company closely connected with the Breguet Aircraft Co. has developed several air-to-air missiles from which the M510, now in production, was developed. The initial M04 test model was followed by the M20 model (range: 1 mile; Mach 1.5) which is produced for interceptors in the *Mystere IV* class.

MATRA developed the M051 missile for the *Vautour*. Equipped with beam guidance or homing head, this missile has a length of about 9'10", a weight of 350 lbs. and can reach a very high speed. Propulsion unit is a two-stage solid-propellant rocket motor. The MATRA 510, also of canard design, has a burnout velocity above Mach 2 and an optical homing head. It is part of the *Trident II* weapons system.

SE 4200

This surface-to-surface missile is still on the secret list. The warhead is mounted in a pod under the fuselage. Missile is launched by two boosters from platform.

Specific Data:

Manufacturer:	Sud-Aviation
Mission:	surface-to-surface
Range:	55-60 n. miles
Length:	10'
Span:	7' 1"
Launching Weight:	1400 lbs.
Velocity:	subsonic (Mach 0.9)
Guidance:	radio
Powerplant:	ramjet cruise plus two solid-propellant boosters (take-off)
Status:	in production

Target Missiles

CT 10—Manufactured by SNCA du Nord for about 10 years. Used by the French Air Force, the UK Royal Navy and the services of several other countries. Length: 35'. Velocity: 280 mph.

CT 20—A development of the CT 10, manufactured by SNCA du Nord. Has flight time of one hour. Velocity: Mach VO.9.

SE1502-1523-1524 — air - to - surface target missiles built by Sud-Aviation. ★

The majority of French missiles in production are of the aerodynamic cruise design with rocket boost and jet sustaining engines. Top to bottom—SE 4200, a subsonic ramjet surface-to-surface missile with a range of 60 miles. CT 10, a target missile that has been in production for about 10 years. Velocity 280 mph. CT 20 is a development of the CT 10. The CT 20 is also subsonic with a flight time of one hour. Both missiles are jet propelled with solid propellant rocket boost. CT 10 is similar in configuration to the early V-1. SE 1524 is an air-to-surface missile in limited production by Sud-Aviation.

Propulsion Engineering

By Alfred J. Zachringer

AMMONIA IS SAFE say German researchers. Explosive limits of NH_3-air mixtures are 16-27% while H_2-air is 9-66.3%. The ammonia explosion limits decrease with humidity and are of less force than hydrogen. Few ammonia combustive explosions have been encountered.

FREEZING POINT OF TETRANITROMETHANE can be depressed to −20 by use of an N_2O_4 additive. The nitrogen tetroxide, says an Italian patent, also makes for easier reaction with amines or liquid ammonia when TNA is used as a liquid-rocket propellant.

OXYGEN PLANT SAFETY has been outlined by Linde Co. in Munich. Two big factors in preventing explosions in separating plants are control of initiating conditions and elimination of explosive materials. Former method eliminates mechanical effects, sparks, isolated drying in crevices and removes reactive materials (radicals, ozone, etc.). Latter consists of eliminating hydrocarbons, COS, and H_2S. Acetylene is said to be the most dangerous troublemaker.

MORE AMMONIUM PERCHLORATE for solid propellants is in sight. One Norwegian electrochemical firm is trying to sell the high energy oxidant on the East Coast to Atlantic Research and Thiokol. U.S. capacity for AP, though, is still ample. The Norwegian AP could lead to lower prices thus stimulating use. Continuous nitration process for production of nitroglycerine and other propellant materials has been introduced in Sweden. Nitroglycerine Aktiebolaget (founded by Alfred Nobel in 1884) at Gytorp uses nitration by injection whereby products in nitration stages are removed as a nonexplosive emulsion. Thus, only a small amount of free NG is actually present in the process. The firm can eliminate conventional mounding and need only use a concrete wall to separate the nitrator and the control area. NG is a vital ingredient in modern double-base solid propellants.

BORON FUELS IN BRITAIN: American Potash & Chemical has a subsidiary now going in the UK which may introduce exotic boron fuels and high energy lithium oxidants.

EXOTIC OXIDANTS ARE IN THE WORKS. In addition to studying liquid ozone, Soviets at Moscow State University have bombarded LOZ with atomic hydrogen at −196° C. A deep blue film, which solidifies, results. The solid, colored blue by the LOZ, decomposes violently with oxygen evolution and leaves behind a 30% water solution of hydrogen peroxide. The experiments, which are also underway at other facilities, are aimed at the synthesis of hydrogen superperoxide (H_2O_4). Another project is concerned with the deep thermal decomposition of methane.

AUTOMATIC CONTROLS FOR ROCKETS are being investigated by the Center de Recherches Hydrauliques et Electriques, Paris. Hydraulic servos are controlled by electrical inputs. Particular attention is devoted to synthetic fluids for high-temperature operation. Several models, ranging from 5-20 horsepower, have been built.

NUCLEAR PROPULSION FOR ROCKETS is being studied by the Swiss Oerlikon firm. A design study project has been reported underway.

WORKING FLUIDS FOR ROCKETS were studied intensively by Bremen engineers. At temperatures of 2500-3250°C and pressures of 16-64 atm, gamma is remarkably alike for the gases, hydrogen, water, nitrogen, air, oxygen, hydrogen chloride, and carbon dioxide. At a given temperature, the average molecular weight increases with pressure. With water as a working fluid (at 64 atm & 3250°C), a theoretical velocity of slightly over 12,000 ft/sec is obtained.

EVER HEAR OF A "FIREFLY HUNT"? We just heard that observers who will take part in visual tracking of the *Vanguard*-launched satellite may conduct such hunts. According to a bulletin put out for Moonwatchers, as they are called, the firefly often seriously detracts an observer looking through a tracking telescope. The bulletin said, "At least one Moonwatch group conducts a firefly hunt around the station before the observing session." The firefly's quick flash *could* be mistaken for a passing satellite.

METAL SPINNING

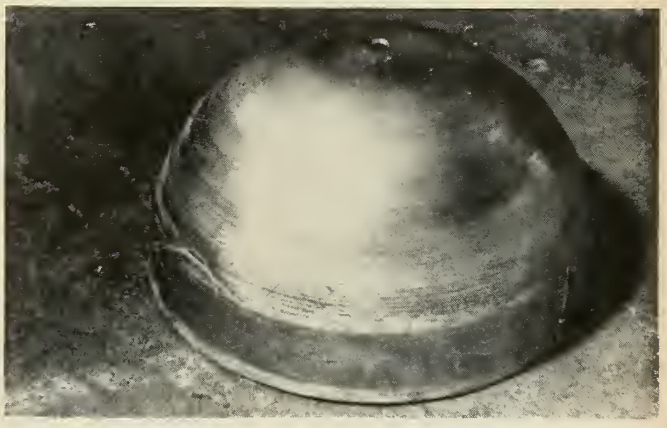
New Imported Equipment Spins Economy into Aircraft and Missile Parts

Welding operations are eliminated, weight is saved, unit cost reduced with new, imported machinery used to spin heavy or thick-walled aircraft and missile parts. Below, missile cylinder was spun "hot" on the lathe. Prior to metal spinning, manufacturers had been wrapping and welding the body, then welding on bottom. This cylinder was made from flat, round blank of ½" aluminum, 60" in diameter. Finished wall thickness is .380" with a 125 finish. Machines are from Germany.

Cold spinning ⅝" aluminum alloy to an 8' finished part for ICBM pressure bulkhead. Used here is Model Plb 1200 hydraulic spinning and planishing lathe. German manufacturers are Leifeld & Co.

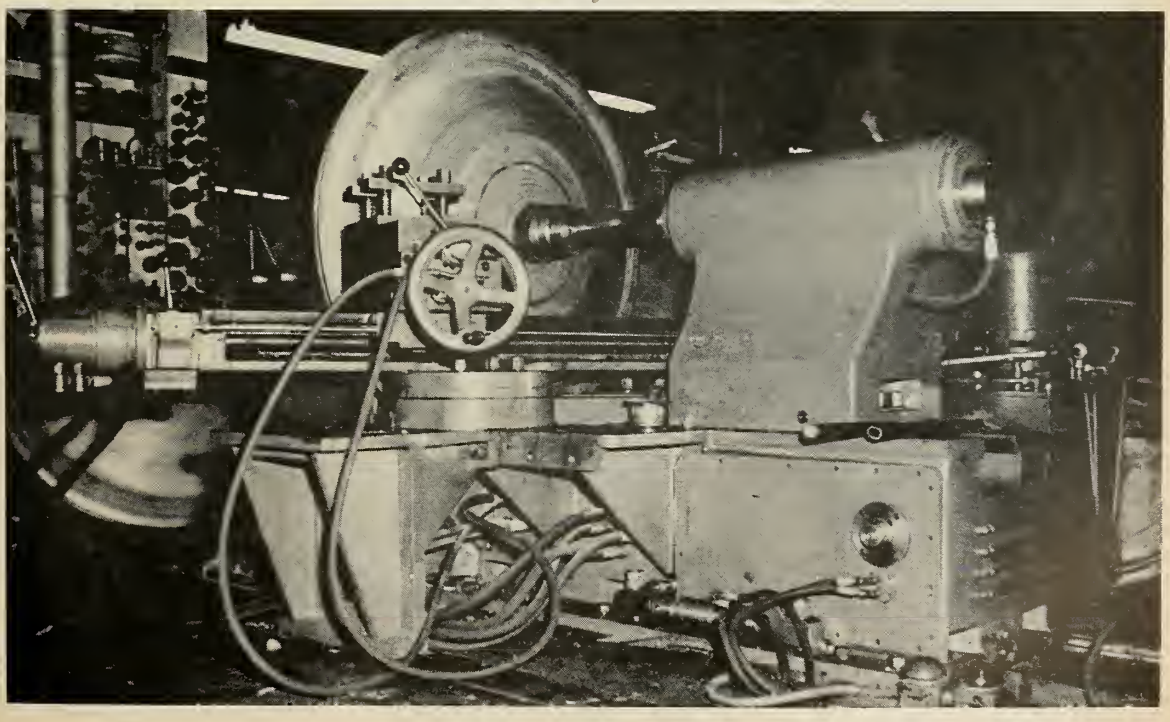
Right, cone of ⅝" magnesium, hot spun in two parts on LEICO Model Plb 1200. Previous to new method, welded heavy or thick-walled parts caused warpage which in turn required an inside and out operation. The machines are now being used in many parts of U.S.A.

Titanium hemisphere 3/8" thick, hot spun on LEICO Model Plb 600 lathe. New process makes it possible to finish one symmetrical piece to the point where it is ready to use as it leaves the lathe. First complete metal spinning set up in this country was Hydro Metal Spinning Corporation's installation of five lathes and one hydraulic flow turning machine in Los Angeles, Calif.



Stainless steel 1/4" type 304 hot spun on LEICO Model Plb 600. Spinning diameters possible run from 52" to 130 1/4", available through various sizes of the fully hydraulic machines. They can produce 5/8" aluminum and magnesium, 3/8" titanium and 7/8" cold rolled stainless steel sheets.

Picture below shows a high efficiency metal spinning and planishing lathe, Model Plb 1200. This machine will cut the fabrication cost of aircraft and missile parts. The company's representative in the United States is Albert H. Wilhelm, 1020 W. 20th St., Los Angeles, Calif.



COLD FORMING in missile production

COLD FORMING processes originally developed by Norris-Thermador Corp. for the fabrication of cartridge cases are now beginning to be used to produce cheaper and better metal components for rockets and missiles.

One good example is the new-type body being made for Aerojet-General Corp.'s long-established JATO unit. Formerly welded together from four separate parts, the chamber for the 15KS-1000 is now being drawn in one single piece in the large capacity presses at Norris-Thermador's Vernon, Calif., plant.

This method of forming makes possible lighter weight and a substantial cost saving for Aerojet. With no welds, the chamber has improved reliability.

Norris-Thermador manufactures a wide variety of products ranging from bath tubs to electronics equipment. It makes all the automobile wheels for all cars assembled on the West coast. Its first ordnance contract—1000-pound practice bombs for the Navy—turned out to be an unprofitable venture, but provided the company with much valuable experience. On its second Navy contract—for $1-million worth of aluminum cartridge containers—Norris-Thermador, then known as Norris Stamping and Manufacturing Co., developed the ingenious methods and machinery to produce deep drawn seamless containers, an achievement considered impossible at that time.

Evidence of the company's resourcefulness was demonstrated again when it solved one of the biggest production problems of World War II by developing low cost methods of producing satisfactory antiaircraft cartridge cases from steel instead of brass.

Not long ago, Norris-Thermador turned out its 55th million artillery-size cartridge case. But at the end of Korea, it found itself with 13 lines of shell cases and dwindling orders in this particular phase of its operations. That's when its government products department focused its sights on the rocket field. Subsequent production includes more than 2 million rocket motor tubes for the widely used 2.75-inch *Mighty Mouse*, produced by the cold drawn process.

Norris-Thermador makes both the JATO chamber and the aft cap for Aerojet's Navy JATO unit, each in one-piece operations. The chamber is cold formed with an integral spud section from an AISI 4130 steel blank. The aft cap is cold formed from a mild steel blank. Using this process, Norris-Thermador guarantees a minimum yield strength of 100,000 psi for the chamber side walls. Day-to-day values actually are 120,000 psi.

This company also has a subcontract from Phillips Petroleum Co. to produce main body and nozzle for the M15-A1 JATO for the Air Force, and a plant for this purpose was built last year in Waco, Tex. For this JATO unit, Norris-Thermador also manufactures the fixtures with which it is fastened to the aircraft. The Phillips-designed JATO, however, incorporates different design and therefore different manufacturing processes than the Aerojet.

Norris-Thermador's ability to draw

The rocket business is basically a low-cost business. As such, it enjoys the privilege of a greater variety of production processes. These pictures show the great number of different shapes that can be made by cold forming and cold extrusions. These are examples of Norris-Thermador's production.

and extrude items with varying wall thicknesses is attracting increased attention from rocket and missile designers. Its cold forming operations extend into the 4130 and 4140 alloy steels as well as in mild steels, aluminum, copper and brass.

"We are just on the threshold of what can be done with metals," said Larry Shiller, chief research and development engineer.

One of Norris-Thermador's newer cold forming projects is for the body of the *Hawk* for Raytheon Manufacturing Co., which has the prime contract on this Army missile. To be built in two pieces of 4130 steel 95 inches long and 14 inches in diameter, with a girth weld, this is reported to be the longest cylindrical item ever formed by deep drawing.

So far, Norris-Thermador's applications have been to small and medium-size rockets or missiles. "But we are alert to the larger sizes," said Donald P. White, vice president of the company's government products division.

Norris-Thermador's Vernon plant is one of the largest and most comprehensive metal forming facilities in the West, with a press department housing mechanical presses ranging from 25 to 400 tons and heavy hydraulic presses ranging from 45 to 6000 tons capacity. Military work constitutes only a small part of Vernon production, but two other plants are devoted entirely to government products. These are the Riverbank Ordnance plant, a joint Army-Navy facility near Modesto, Calif., where Norris-Thermador operates at a very low rate—just enough to maintain an organization which can be rapidly expanded if an emergency should arise—and the JATO plant at Waco, Tex. ★

Parts that can be made by cold processing include nozzles, bulkheads, feed fitments, nose cones, casings, entire motors (in the case of small ones), etc. Directly to left are motor bodies extruded and deep drawn from an AISI 1030 steel slug. Below are cold-worked nozzle plates from AISI heat treated steel.

Project Far Side

Man's first stride into space uses off-the-shelf hardware

By Prof. S. F. Singer

Physics Department
University of Maryland

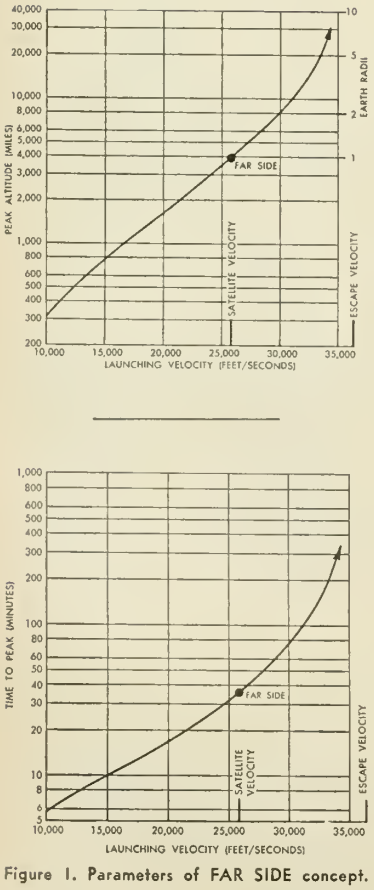


Figure 1. Parameters of FAR SIDE concept.

A NEW DIMENSION has been added to high altitude research: *Far Side,* which will explore space out to one earth radius (4000 miles) and possibly higher. Conceived by scientists of the Air Force Office of Scientific Research and developed by Aeronutronic Systems, Inc., the *Far Side* vehicle is a low-cost solution for reaching the highest altitudes yet attained by man. It is a multistage rocket launched at high altitude to overcome the atmospheric drag; specifically it is a four-stage combination of ten solid rocket motors lifted by a Skyhook balloon to an altitude of over 100,000 feet (m/r August 1957, p. 45).

The 1900-pound vehicle carries only a three-and-a-half-pound payload, but thanks to instrument miniaturization this tiny package buys a lot of scientific research.

High Altitude Vehicles

Because of its extreme altitude capability *Far Side* operates in a class quite different from that of other research rockets such as the *Aerobee, V-2, Viking,* or *Dan* (m/r March 1957). It is designed specifically to explore the exosphere region above the ionosphere, sometimes called the outer ionosphere. This is the region above 250 miles where collisions between atoms become so rare that we can truly speak of it as the boundary of space. While other research rockets investigate the properties of the lower atmosphere and ionosphere, the *Far Side* vehicle studies the nature of the space around the earth, eventually as far as the moon and beyond.

It opens up the possibility of discovering radically new scientific phenomena present in interplanetary space. In a sense these investigations supplement the research to be carried out in the first earth satellites: whereas the earth satellite explores for long periods of time at about 300 miles altitude relatively close to the earth, the *Far Side* vehicle thrusts vertically out into space over ten times as high. It can reach regions which are not accessible to the satellite, but it does not have the long satellite lifetime.

Team Behind Far Side

Project *Far Side* represents the fruitful collaboration of two highly qualified organizations. The Air Force Office of Scientific Research has been working on space problems for some time by supporting research on cosmic rays, plasma physics and interplanetary exploration by means of radio "whistlers."*

This support of basic science according to AFOSR commander Brig. Gen. H. F. Gregory is in accord with the mission of AFOSR "to undertake

** low frequency radio waves produced by lightning discharges and guided along magnetic force lines to the opposite hemisphere (Fig. 8.)*

Fig. 2. Propulsion Study for Escape Vehicle

In this study the same criteria are used as in the *Far Side* design:

1) A four-stage rocket launched from a balloon to obtain maximum effectiveness. (Compare this with a two-stage approach by Kurt Stehling in m/r October 1956.)

2) Solid-propellant motors are used because of greater simplicity and lower cost in the size range considered here.

3) The stages are designed with optimum matching to give the best overall performance in terms of highest velocity with minimum all-up weight.

The following assumptions are made with regard to the propulsion system:

1) The maximum velocity obtainable depends on the maximum weight balloon can carry and the minimum useful weight for the payload. We assume here a 3000-pound maximum balloon load and a payload weight of two-and-a-half pounds.

2) Solid propulsion units are used in this design which have a vacuum specific impulse of 250 seconds and a mass ratio of 0.86.

	STAGE			
	#1	#2	#3	#4
Initial Wt.	2500	416	69.5	11.5
Final Wt.	350	58	9.7	1.6
Propellant Wt.	2150	358	59.8	9.9
Total Wt.*	3000	500	83.5	14.0

Effec. Mass Ratio 0.72
Velocity increase per stage ..... 10,200 ft./sec.

*Incl. weight of following stages and payload.

The final velocity is 40,800 feet per second. This exceeds the escape velocity from the earth, which is 36,000 feet per second near sea level.

This vehicle could therefore escape entirely or attain extremely high altitudes if deflected and returned to the earth by interaction with the moon's gravitational field (Fig. 2).

exploratory and pioneering research to maintain the USAF's dominant technical position," (m/r July 1957, p. 105).

The AFOSR attitude toward space research has also been forcefully stated by Col. William O. Davis, deputy commander, operations, (m/r June 1957), who pointed out that "the space around the earth is becoming our next military environment; there is an intrinsic necessity that we understand this new environment."

Dr. Morton Alperin, who heads the Directorate of Advanced Studies of OSR in Pasadena, Calif., has been laying the groundwork for space research by supporting research on advanced solid propellants of high specific impulse and research on unique and exotic propulsion systems based on magnetohydrodynamic principles.

It was under his guidance that Project *Far Side* was first outlined and put together. The industrial prime contractor, Aeronutronic Systems, Inc., seemed a natural to carry out the development and build and launch the vehicle. Vice president Ernst H. Krause initiated the upper-atmosphere rocket-research program at NRL at the end of World War II.

Its other key scientists are also well known in the upper-atmosphere and cosmic-ray field—men like Montgomery H. Johnson, Ralph J. Havens and Ernest Martinelli. Project manager is Herbert L. Karsch, formerly the technical director of the White Sands Proving Ground, where he was responsible for the early V-2 program and

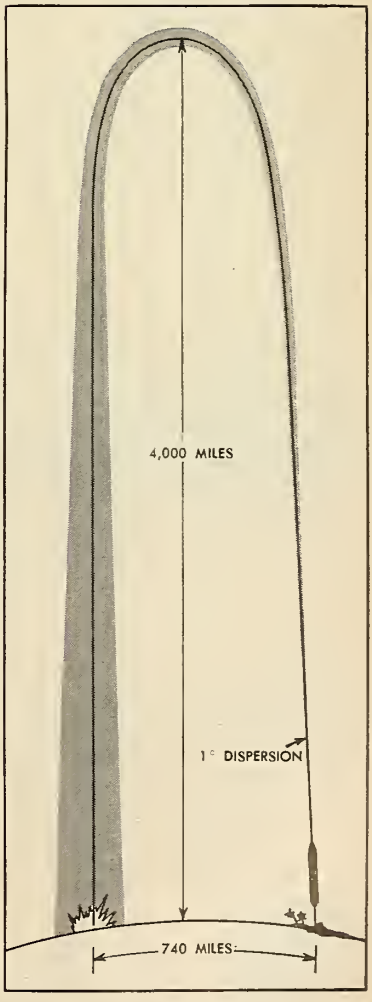


Figure 3. Trajectory of 4000-mile FAR SIDE rocket.

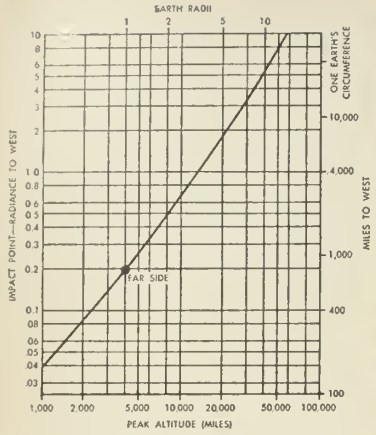


Fig. 4. Relationship of a altitude to impact point.

other rocket programs. In charge of the electronics portion of the *Far Side* program is Harrison Smith, Jr., formerly head of the NRL telemetering program.

Technical Aspects

Together with General Mills' technical staff, these men worked out a unique launching scheme for the 23-foot long, four-stage rocket vehicle. For the critical release phase on the ground they designed a mobile launch truck. Other knotty problems had to be solved: stability during firing, stage separation with minimum dispersion, and intense aerodynamic heating with a maximum velocity of nearly 18,000 miles per hour.

RESEARCH GOALS

Fig. 5. Nature of Outer Ionosphere (controlled mainly by earth's gravitational field and solar radiation).

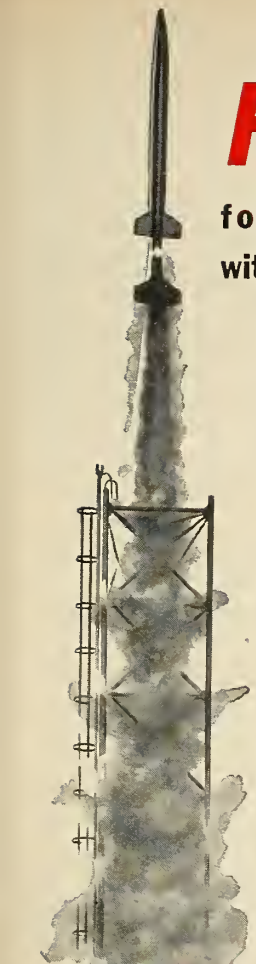
What is the concentration of atoms at different altitude levels? What is the composition? Where does hydrogen take over? What fraction of atoms is ionized? What are the electrical properties? How rapidly does the temperature rise? How fast does the atmosphere evaporate into space? How far up does the gas rotate with the earth? What "winds" exist?

Propulsion

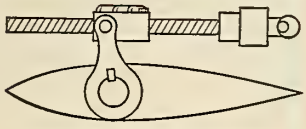
The outstanding performance of the *Far Side* vehicle is possible only

FAIL-SAFE ACTUATION

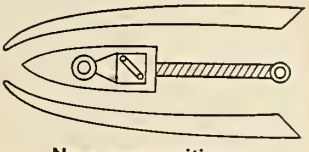
for guidance and control in difficult environments with SAGINAW b/b SCREWS and b/b SPLINES



TYPICAL APPLICATIONS

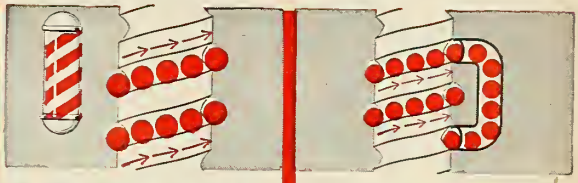


Control surface actuators



Nose cone positioners

Evelon positioners • Afterburner controls • Speed brake actuators • Rocket engine displacement actuators • Clamping mechanisms for missile boosters • Fuel controls (3-dimensional cams) • Black box tuning devices—telemetering and guidance systems • Antenna coupler tuning mechanisms



Nut *glides* on steel balls. Like stripes on a barber pole, the balls travel toward end of nut through spiral "tunnel" formed by concave threads in both screw and mating nut.

At end of trip, one or more tubular guides lead balls diagonally back across outside of nut to starting point, forming closed circuit through which balls recirculate.

1 VITAL POWER SAVINGS. With guaranteed efficiency of 90%, Saginaw b/b Screws are up to 5 times as efficient as Acme screws, require only ⅕ as much torque. This permits much smaller motors with far less drain on the electrical system. Circuitry is greatly simplified.

2 SPACE/WEIGHT REDUCTION. Saginaw b/b Screws permit use of smaller motors and gear boxes; eliminate pumps, accumulators and piping required by hydraulics. In addition, Saginaw b/b Screws themselves are smaller and lighter. Units have been engineered from 1½ in. to 39½ ft. in length.

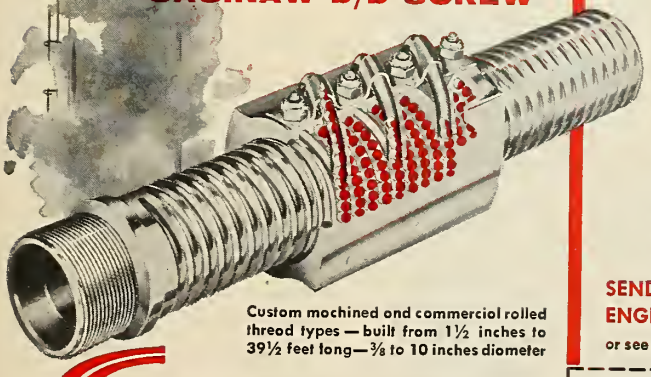
3 PRECISE POSITIONING. Machine-ground Saginaw b/b Screws offer a great advantage over hydraulics or pneumatics because a component can be positioned at a predetermined point with precision. Tolerances on position are held within .0006 in./ft. of travel.

4 TEMPERATURE TOLERANCE. Normal operating range is from −75° to +275° F., but assemblies have been designed in selected materials which function efficiently as high as +900° F. These units are practical where hydraulic fluids have lost efficiency or reached their flash point.

5 LUBRICATION LATITUDE. Even if lubrication fails or cannot originally be provided because of extreme temperatures or other problems, Saginaw b/b Screws will still operate with remarkable efficiency. Saginaw units have been designed, built and qualified for operation without any lubrication.

6 FAIL-SAFE PERFORMANCE. Far less vulnerable than hydraulics. In addition, Saginaw offers three significant advantages over other makes: (1) Gothic arch grooves eliminate dirt sensitivity, increase ball life; (2) yoke deflectors and (3) multiple circuits provide added assurance against operating failure.

SAGINAW b/b SCREW



Custom machined and commercial rolled thread types — built from 1½ inches to 39½ feet long—⅜ to 10 inches diameter

SAGINAW b/b SPLINE

Averages 40 times lower friction coefficient than sliding splines

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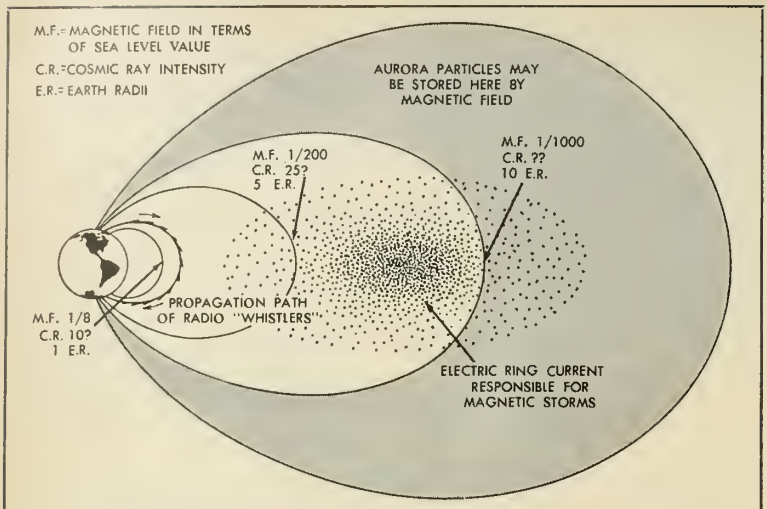


Fig. 6. Radiations in the Outer Ionosphere (controlled mainly by earth's magnetic field)

How rapidly does the magnetic field fall off? Does the ring current exist? How does the cosmic ray intensity increase. What is its value in free space? Where are the auroral particles stored? How are they accelerated before bombarding the ionosphere? Does the space intensity of meteoric dust increase with altitude?

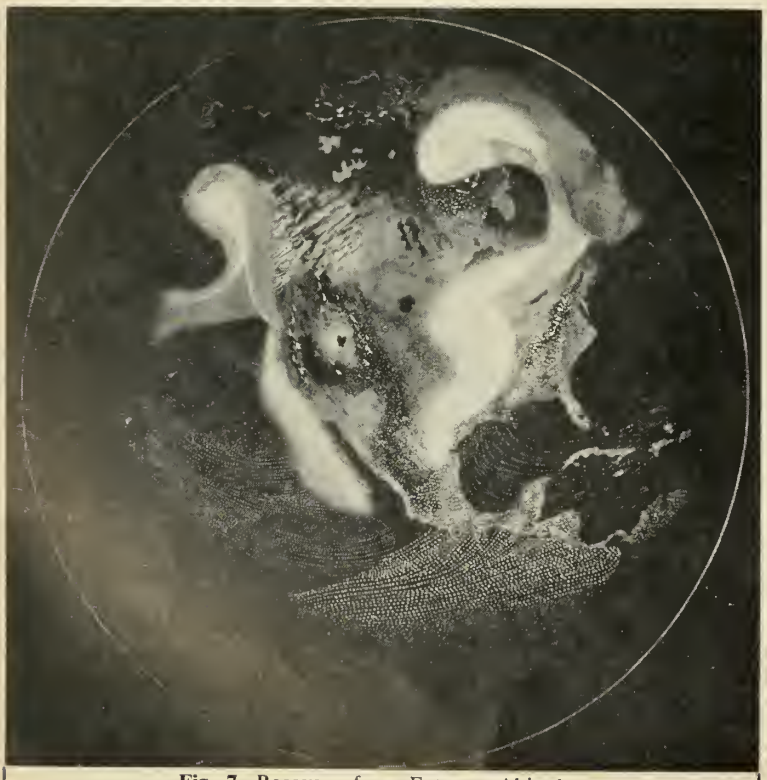


Fig. 7. Recovery from Extreme Altitudes.

Photographic film; high-altitude pictures for weather studies. Cosmic ray emulsions; heavy primary particles; biological specimens (bees, fruit-flies); prolonged exposure to outer space radiation—all will aid science.

because of the excellence of its solid propellant motors. Thiokol's *Recruit* motor is a new achievement in efficiency, mass ratio and specific impulse, while Grand Central's *Arrow* motor duplicates the performance of its bigger brother but on a smaller scale.

The staging design follows a simple optimization principle. One can, to a first approximation, neglect atmospheric drag since the launching takes place above 98 per cent of the atmosphere.* The carrying capability of the launch balloon sets an upper limit to the vehicle weight. With an assumed four-pound payload, optimum performance of a four-stage design demands that each stage represent an increase of impulse by about a factor four. Thus, we achieve the *Far Side* vehicle design.

Since the mass ratio and the specific impulse for each stage are about the same, the velocity increments produced by each stage are about equal. In order to reach a final velocity of five miles per second (which incidentally is also the satellite velocity), a velocity increment of one-and-a-quarter miles per second is required for each stage.

If one deviates from this optimization principle, for instance, by making the velocity increments unequal, the whole combination loses in efficiency and the all-up weight must be greater.

As currently designed, the *Far Side* vehicle represents the most efficient combination of existing high performance rocket motors. By the same token, the *Far Side* vehicle also constitutes the cheapest solution for reaching extreme altitudes. As the performance of solid motors improves, higher velocities, and therefore much higher altitudes, become possible. The *Far Side* design philosophy is illustrated in the table of Fig. 1, which shows that an escape vehicle or moon rocket is easily achieved with motors having a (vacuum) specific impulse of only 250 seconds and a mass ratio of 0.86.

Dynamics and Trajectories

With vehicles reaching such extreme altitudes, the radius of the earth itself (4000 miles) becomes the unit of measurement. Even the word "altitude" loses significance and is replaced by "distance from the earth."

Increasing the altitude beyond one earth radius is not very difficult: only a small increase in velocity is necessary. This can be seen in Fig. 1, or

** Because it will be launched at high altitude, rocket motors can be designed for operation in near vacuum, which increases their specific thrust by approximately 15 per cent.*

by considering that at the peak the initial kinetic energy of the vehicle $\frac{1}{2}MV^2_{Init}$ must all be given up to the potential energy of the gravitational field; i.e. at the peak of trajectory the body has zero velocity and therefore no kinetic energy, but it has a large potential energy because it has been lifted so high up against gravity.

By setting the two energy expressions equal, one can derive the peak altitude very simply in terms of an initial velocity.* It is interesting to note that with an initial velocity equal to the satellite velocity, about 5 miles per second, the vehicle will go up exactly one earth radius. If one were to direct the *Far Side* vehicle horizontally, it would become an artificial earth satellite.

It is seen also from Fig. 1 that an increase in velocity of only 40 per cent, up to seven miles per second will give the vehicle enough kinetic energy to overcome the earth's gravitational field altogether. It now escapes from the earth and never comes back, unless it encounters the moon and becomes redirected as indicated schematically in Fig. 2.

By arranging this "collision" with the moon's gravitational field in a suitable way, one can make the vehicle travel around the far side of the moon and return it near the earth, where it can relay what it has seen by means of radiotelemetry.

To those used to measuring rocket flight times in terms of minutes, the length of time the *Far Side* vehicle spends above the atmosphere may come as a surprise. The initial series of vehicles, which goes to 4000 miles, takes 1960 seconds to reach peak altitude, and therefore spends over an hour above the earth's appreciable atmosphere. Fig. 1 shows the relation between the initial velocity and time to peak ascent.

The high altitudes and long periods of flight affect the location of the vehicle's impact point. Normally a high-altitude rocket lands pretty close to its launching point. We are not concerned with effects of the earth's rotation since the dispersion due to inaccuracies in the thrust and aerodynamic influences is ordinarily much larger. For extremely high altitudes, however, the rotation of the earth becomes of major importance.

If the vehicle is launched at the equator, in addition to its initial velocity derived from the rockets, it also carries a tangential velocity of 0.3 miles per second due to the earth's rotation.

Seen by a distant observer, the vehicle describes a portion of an ellipse, a ballistic trajectory which intersects the earth. It takes the vehicle considerable time to describe its trajectory; in the meantime the earth, and therefore the launching point, will have rotated. Knowing the flight time, we can calculate how far the launcher has turned and determine the impact relative to the launcher.

The results of such a calculation are shown in Fig. 3: a vehicle which has been launched at the equator with an upward velocity of five miles per second, equivalent to the velocity of the *Far Side* vehicle, will impact 740 miles west of the launch point. We also show the impact dispersion in the presence of an assumed one-degree dispersion in the launching angle.

For much higher altitude vehicles the flight time runs many hours. We can, therefore, have the vehicle impact to the east of the launcher. For example, for an altitude of 10 earth radii the vehicle would impact close to the launcher (Fig. 4).

This large dispersion of the impact point is only one of the problems peculiar to these extreme-altitude vehicles. This particular problem can be overcome by launching the vehicle near the pole where the effects of the earth's rotation are negligible.

But the problem of radio communication still remains. The signal power decreases as the inverse square of the distance, so that at an altitude of 4000 miles the power received is only one per cent of that from 400 miles.

Since it is generally not feasible nor economical to increase the transmitter power beyond a certain limit, this drawback can be overcome in one of two ways: the sensitive area of the receiving antenna can be considerably increased to collect more power from the transmitter, or the amount of information transmitted can be reduced and, therefore, the bandwidth of the transmitter as well as that of the receiver. This cuts down noise in receiving circuits.

Scientific Applications

Because of its unique high altitude capabilities, *Far Side* explores for the first time the virtually unknown regions surrounding the earth, sometimes called the outer ionsphere, which reach from the exosphere, 250 miles up, out to about 40,000 miles. We generally consider the region beyond this limit as interplanetary space. But within about 10 earth radii, both the earth's gravitational field and the earth's magnetic

* $\frac{1}{2}V^2_{init} = g_o \frac{hR_e}{h + R_e}$ *where* g_o *is the acceleration of gravity at sea level,* h *the peak altitude above sea level,* R_e *the radius of the earth*

field are strong enough to control what goes on.

The Outer Ionosphere

We know now from measurements with radio whistlers and from measurements of the zodiacal light that this region of the earth is not a vacuum but contains 600-1000 electrons per cc, and the same number of positive ions, mostly protons. In addition, we may have a large admixture of neutral atoms, but until now we have had no means of measuring their concentration.

The measurement of atmospheric density above satellite altitudes is probably the most important contribution of the *Far Side* vehicle. We suspect that there is an inner region in this outer ionosphere where hydrogen is still a minor constituent, but that beyond this inner region hydrogen, because it is the lightest atom, will begin to predominate.

It would be of the greatest importance to find out what percentage of the gas is hydrogen at various altitudes, and what percentage of the gas is ionized so that we can evaluate the degree of ionization, the electric conductivity and the radio propagation properties of the outer ionosphere. Temperature of the gas and winds are of great interest and can be measured by the *Far Side* vehicle.

Earth's Magnetic Field

While the earth's gravitational field is the main controlling factor in this outer ionosphere of the earth, the earth's magnetic field is important because of its influence on the motion of charged particles, many of which come from the sun. First of all, one would want to measure the magnetic field itself to see if it falls off as the inverse cube of the distance.

It is hypothesized that there is an electric ring current flowing around the earth, with its maximum located in the equatorial plane at about seven earth radii (Fig. 6). The current would produce its own magnetic field, which is superimposed on the earth's field. One should perceive, therefore, a different dependence of the magnetic field with distance than is ordinarily calculated.

This ring current is thought to be responsible for the magnetic storms which are observed on the earth during periods of high solar activity. Magnetic storms give rise to radio communication disturbances so that their study is of considerable military and economic importance. Now for the first time, a direct examination of the causes of magnetic storms may be possible.

Cosmic Rays

The earth's magnetic field also greatly affects incoming charged particles. The highest energy particles are the cosmic rays and they are deflected by the earth's field so as to follow very complicated trajectories before they finally reach the earth.

At the equator, however, all except the highest energy particles are turned away by the magnetic field. Therefore, as we go out from the top of the atmosphere at the equator, we see an increase in cosmic ray intensity (Fig. 6). As the magnetic field becomes weaker with increasing altitude, it begins to admit the lower energy cosmic rays. In this way we can measure cosmic ray intensity as a function of altitude and ascertain the number of low-energy cosmic rays as compared to those of high energy, and therefore the energy spectrum of cosmic rays.

A particularly interesting question relates to the presence of very-low-energy cosmic rays. They are normally not observed near the earth although they could come in near the poles, where the magnetic lines of force are vertical and offer no resistance.

If these low energy cosmic rays exist in interplanetary space, we should observe an increase in cosmic ray intensity beyond three or four earth radii.

However, if they are absent, the intensity will flatten beyond that altitude, as shown in Fig. 6.

The *Far Side* experiments could settle this important question. In addition they would give data on the space intensity of cosmic rays, one of the important quantities for space flights.

Auroral Particles

Apart from the cosmic rays, the earth's magnetic field has even greater control over the auroral particles, probably high speed protons, which enter the upper atmosphere near the poles to produce the luminous aurora. The *Far Side* vehicle would be able to establish what region of space these particles occupy and could explore this region by shooting through it.

Very likely magnetic lines of force confine the particles to a narrow band in the auroral zone; but if one goes high enough, one should run into the auroral particles even at the equator Fig. 6).

Such measurements would be of tremendous importance for geophysical theories. One of the outstanding problems is how these particles acquire the necessary high energy to penetrate so deeply into the atmosphere. Probably some kind of acceleration mechanism operates close to the earth, but its exact nature has not yet been determined.

Interplanetary Dust

It may even be possible to check the influence of the earth's magnetic field on larger particles, e.g., interplanetary dust. Current theoretical ideas predict that dust particles will be highly charged by the photoelectric effect of the sun's ultraviolet radiation. In that case, the earth's magnetic field should act on dust particles in the same way as on cosmic rays. One should, therefore, observe an increase in the number of dust particles as one ascends at the equator to higher and higher altitudes similar to that shown in Fig. 6.

Significance of Experiments

Aside from their scientific interest, such measurements as will be possible through *Far Side* are important because they give us some firm figures on the properties of interplanetary space and on the intensity of various radiations in the vicinity of the earth. For example, even though the outer ionosphere can to a first approximation be described as a vacuum, the small amount of ionized gas present there may be of considerable concern to vehicles which navigate this region since it affects radio propagation. Furthermore, the electric charge of a vehicle is controlled by the electron density in its vicinity.

Long Time Exposures

Another unique advantage of the *Far Side* vehicle over ordinary rockets is the long time spent above the atmosphere. In this respect it resembles the earth satellite and, in fact, its applications are similar, e.g., the *Far Side* vehicle can be used to observe the solar ultraviolet and X-rays for time periods in the order of hours. Should unusual conditions such as solar flares develop during the flights, this information will, of course, be detected by the instruments and telemetered to the ground.

Flight-time is also important for certain equipment which requires long exposure, such as cosmic ray emulsions used to detect the small flux of heavy nuclei in the primary cosmic radiation. Balloons have the disadvantage of operating within the atmosphere, but an emulsion carried in the *Far Side* vehicle will receive a long exposure in free space.

Recovery

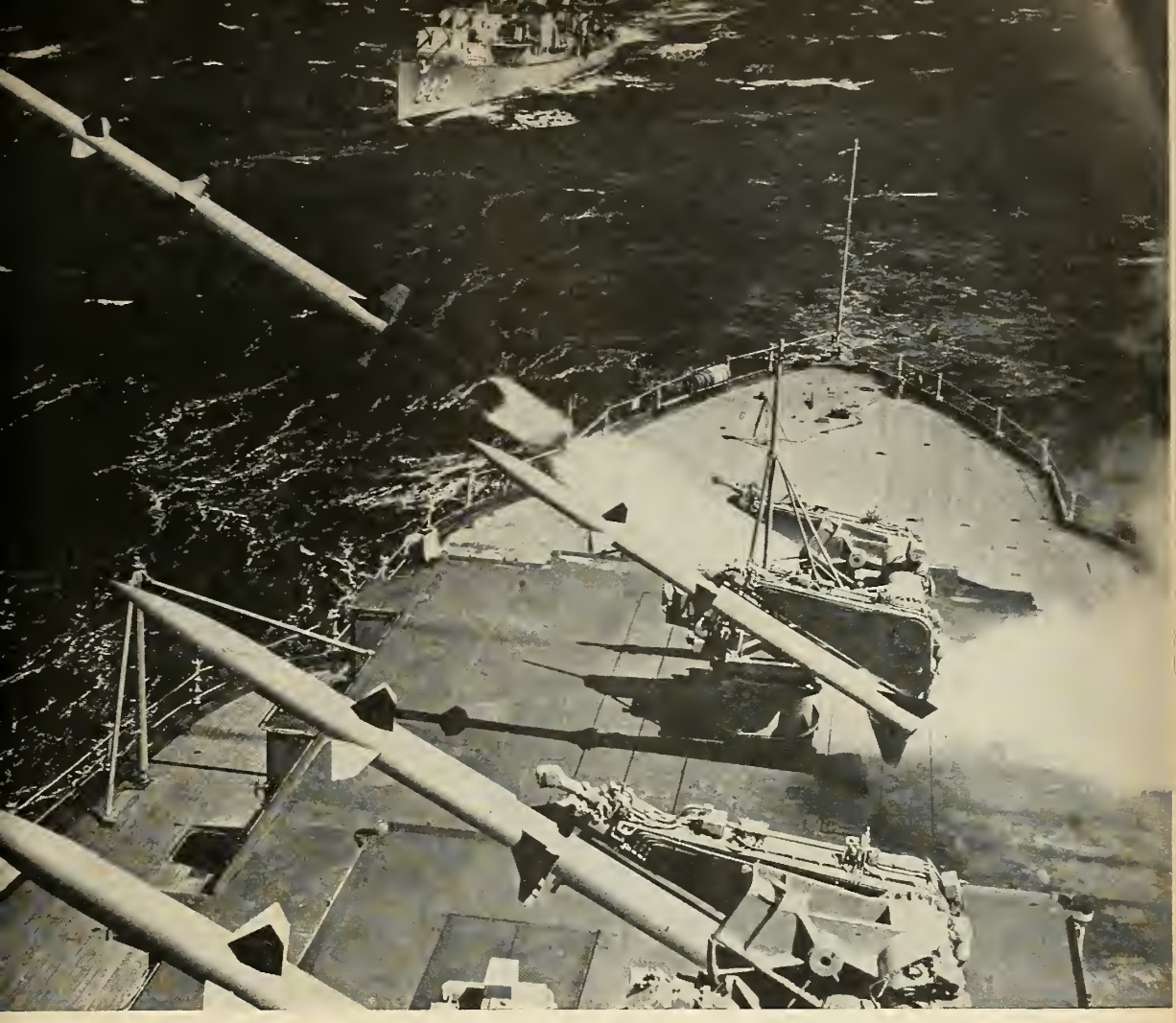
Cosmic ray emulsions must, of course, be recovered; so must many other small scientific payloads exposed at these extreme altitudes.

Of great interest to space-medical research are exposures of small organisms, such as fruit flies or seeds, to the intense cosmic radiation which exists at these high altitudes and to any of the other radiations present. Until now no exposures have simulated exactly the high-intensity flux of heavy cosmic-ray primaries which exists in outer space.

The prospects of designing a re-entry body for the *Far Side* vehicle look very promising, in spite of the small payload allowed. The reason is that the important scientific questions of just what happens when a high-speed body re-enters the atmosphere have now been solved in connection with ICBM programs, and special materials, possessing desirable characteristics at high temperatures, are now perfected.

Recovery of scientific payloads, entering from a 4000-mile altitude with satellite velocity, will undoubtedly be one of the great pioneering achievements of aerophysics technology. It will provide proof of the important scientific applications which can be derived from the current research in the military missiles field. More than that, the successful demonstration of extreme altitude recovery will open the way to more ambitious projects in the recovery of larger payloads, until eventually a manned vehicle is successfully re-entered into the atmosphere.

In more than one sense, therefore, Project *Far Side* is our first thrust into space and an important step in the development of America's spaceflight program. ★



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industry briefs

Breakthrough on *Titan* Scored by Avco

A major theoretical breakthrough on the *Titan* ICBM nose cone has been scored at the Avco research laboratory. The company, which has a contract for the missile's nose cone totalling more than $111 million, has used shock tube experiments and X-17 flight tests for the principal sources of such data.

Security restrictions have prevented disclosure of the exact nature of the breakthrough, but it is known that the problem of heat transfer to the nose cone itself is understood and that the laboratory has constructed prototypes of the nose cone for *Titan* embodying these new concepts. They have the shape now considered feasible for the ballistic missile.

Waste King Organizes New Technical Division

Waste King Corp. has announced consolidation of three manufacturing operations and its advanced engineering and development arm into a new Technical Products Division.

The new division will develop and manufacture mechanical components and assemblies for guided missiles, precision machining of experimental missile and rocket parts and production of complex systems assemblies.

Garrett Builds Missile Valves

Phoenix, Ariz.—Garrett Corp.'s AiResearch Mfg. Co. has opened a new controls building for full scale production of controls for gases and liquids. The plant has about 500 employes working on valves for *Atlas, Titan, Thor, Regulus* and *Bomarc.* Some controls produced are designed for operation at temperatures up to 1000°F near absolute zero.

The completely refrigerated plant is of concrete block and its 40,000 square feet of floor space increase the company's Arizona division to over half a million square feet.

Navy SPR Drone Successfully Tested

The Navy's rocket-powered target drone, the XKDT-1, has been successfully flight-tested at the Naval Air Missile Test Center at Point Mugu. The missile-shaped drone is intended to sharpen the eye of Navy fighter pilots and operates near the speed of sound at altitudes up to 50,000 feet.

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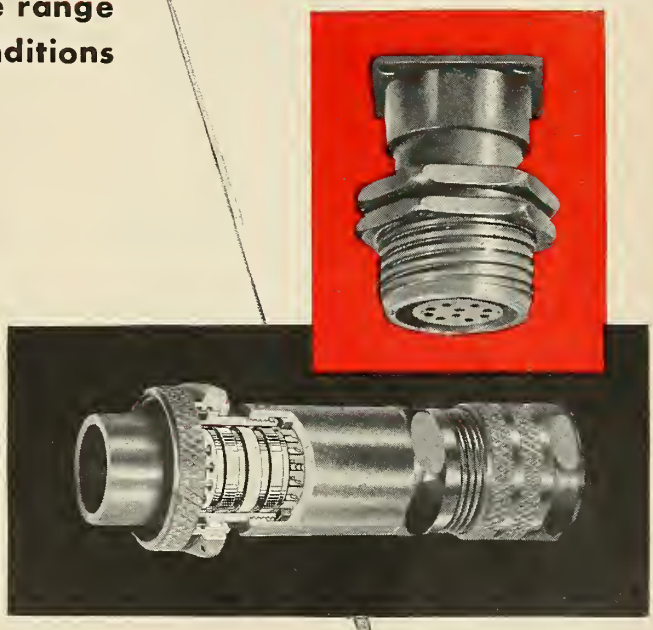

FEATURES

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NATO Budgeteer Holcombe

Points up how quarter billion dollar European missile market operates

John L. Holcombe is Director, Office of Programming and Control, International Security Affairs. Previously he was Deputy Controller for Europe under Lord Ismay and reporting to Assistant Defense Secretary W. J. McNeil. Probably more than anyone else he knows the basics of Europe's defense needs.

Q. *Can you give us a measure of the NATO missile program over the next several years?*

A. It would be misleading to speak of a NATO missile program since each NATO country is responsible for the logistic support of the forces it contributes to the NATO defense effort. Several of the countries are undertaking missile development. While there is concentration on surface-to-air missiles, efforts are also being devoted to surface-to-surface, air-to-air and air-to-surface missiles.

Q. If there is no NATO missile program, have the NATO military authorities taken a position with respect to missiles?

A. The most complete public statement on this followed the Annual Command Post exercise conducted from April 15-18, 1957. Then, Deputy Supreme Allied Commander Europe, Field Marshal Viscount Montgomery, stated that by 1966 we will be in the missile age. NATO strategy, he said, is built on the philosophy of the deterrent. In carrying out their task, the NATO military authorities must be careful not to plan the next war in terms of the last.

Q. How does Field Marshal Montgomery see the next ten years in missiles?

A. I can give you his exact words:

"Strategic missiles fitted with nuclear warheads. The expense and lack of accuracy of ballistic missiles make them unsuitable vehicles for less powerful explosives.

"In some weapons systems, guns will have begun to be replaced by missiles and rockets, e.g., antitank and antiaircraft.

"Short-range guided missiles with ranges up to 500 miles will be available in quantity.

"Intermediate-range ballistic missiles, with ranges up to 2000 miles, will be available and operational from fixed positions from land and ships.

"Man-made satellites will circle the earth.

"Intercontinental ballistic missiles, with ranges up to 5000 miles or more."

Marshal Montgomery considers that while there always will be a need for efficient strategic air forces to provide flexibility and to locate interior targets, the number of aircraft required for interception tasks will be reduced as the effectiveness of air defense by missiles increases. He also considers that piloted aircraft will be needed for limited and cold war activities.

Q. Does Montgomery consider that missiles will solve all the military problems of the Free World?

A. Indeed not. He recognizes that there are many troublesome problems connected with missiles, of which many are technical. Some of the present-day missiles are slow and can be intercepted, and guidance systems can be jammed, which reduces accuracy as the range increases. The ballistic missile is yet to achieve high precision, so that for real accuracy reliance must continue to be placed on piloted aircraft.

Q. What is the United States doing to provide missiles to its NATO allies?

A. Such weapons are included under the Military Assistance Program, including guided and free-flight missiles. Since the United States is the only nation of the Free World producing substantial quantities of missiles at the present time, it is essential that the United States provide missiles to our allies to match the growing strength of Soviet forces, which are being progressively armed with similar weapons. The NATO forces in continental Europe might not long survive a major assault if the United States contingent were the only forces armed with modern weapons, including missiles. Our allies cannot maintain their vital contributions to the common defense if their armed forces are inferior by reason of outmoded weapons.

Q. To what extent is the United States furnishing its allies with advanced weapons?

A. Through Fiscal Year 1957, the United States had programmed $410 million for new weapons, including missiles. Not all of this is grant aid, however. Approximately $136 million represents sales of equipment to Germany and other allied nations. Additional funds will be used in Fiscal Year 1958 to provide new weapons on a grant-aid basis and new weapons will continue to be offered for sale.

Q. What missiles are being made available by the United States?

A. *Nike, Matador* and *Honest John* missile systems are among the advanced weapons being furnished.

Q. Roughly what percentage of the $410 million is for missiles and related equipment?

A. Roughly half.

Q. Are we doing anything to provide them with United States missile production know-how?

A. There is now in the United States a team of Italian military and industrial technicians visiting military production and testing facilities. Similar teams from other countries are expected in the future.

Q. Is this the kind of assistance that Secretary Wilson referred to at the December 1956 meeting of the NATO Council?

A. Yes. At that time the Secretary of Defense announced two important steps being taken by the United States to provide NATO forces with modern weapons. The first, already mentioned, is that the military assistance program now includes deliveries to the other NATO forces of certain new weapons heretofore furnished only to the United States forces. The second is that the United States is prepared to make available certain new weapons system

and equipment, together with appropriate technical data, to those of our allies who are willing and able to utilize them for developing their own modern weapons systems.

Q. Can you break down for us the mechanics of planning and programming missiles capabilities of the NATO powers?

A. The need for modernization of the NATO forces has been studied by SHAPE (Supreme Headquarters Allied Powers in Europe), and SHAPE has stated a list of requirements. These requirements have been reviewed by the United States military authorities, including the Joint Chiefs of Staff, to insure that SHAPE and United States planning are consistent. Because many of the items involved are, or have been, of a classified nature, the security authorities of the Departments of State and Defense have also entered the picture. On the basis of the requirements dveloped by SHAPE and reviewed by the JCS, the Department of Defense has programmed certain advanced weapons to be furnished under the Military Assistance Program. Also, the Department of Defense has indicated its willingness to consider the sale of certain items to those countries which have the economic capability to buy them.

Q. What are some of the ways in which the United States is encouraging European production and development of missiles?

A. Through the Mutual Weapons Development Program, established in 1953, the inventive capability of Western Europe is being added to that of the United States in the race to keep ahead in the development of new weapons. Bilateral agreements have been negotiated with the governments of the participating countries. This means the United States has the benefit of European know-how and vice versa. These technical argreements set forth the details of the projects and the responsibility of the participating country. They also serve as the basis for payment by the United States of specified amounts contributed to the support of the projects which are shared between the United States and the other nation. The results of MWDP projects generally will be made available for the benefit of all NATO countries. Included are projects for guided missiles systems, countermeasures, new and improved radar, etc.

Q. Are there other ways of encouraging European efforts?

A. If a country has a new weapons system that would make a genuine contribution to the NATO defense, it may be considered for inclusion in the Facilities Assistance Program. This is designed to assist the establishment and expansion of overseas facilities for the manufacture and maintenance of essential military equipment, including guided missiles. Projects presently under consideration include several missiles systems and projects for components. The capacity required for missiles propellants has already been established in Europe with the aid of previous projects.

Q. Does the European missile requirement vary materially from that of the United States? If so, how?

A. Yes, the NATO missiles requirements are different from those of the United States—geographical location; distances to potential targets; short warning time. For many tactical applications, however, the requirements will be similar.

Q. Is there any program under way or planned for a simple missile design and development competition in Europe similar to that conducted for the NATO Light Fighter?

A. Missiles are still in their infancy, whereas aircraft have been with us for a long time. It has not yet been possible to establish an environment that would make profitable international competition in missile design. The fact is becoming increasingly clear, however, that the complexities of missiles development and production, and the tremendous costs, will necessitate cooperative and coordinated efforts on the part of the various European NATO countries. This was also expressed by Secretary Wilson in addressing the NATO Council last December. The technical basis for such cooperation appears to be available, in that there are several simple effective systems in Europe. There seems to be an increasing need for coordinated effort, but this has not yet been achieved on a multilateral basis. There have been some bilateral arrangements, however, which are very encouraging.

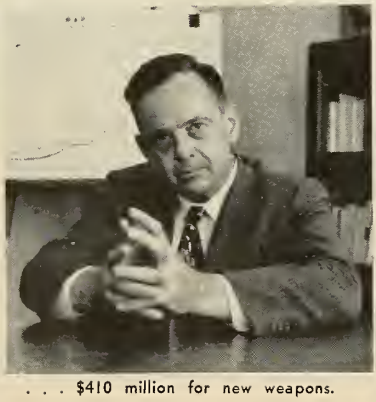
Q. In programming for the integration of missiles in European defense, have you run into any major political troubles such as from Communist minorities or Soviet blackmail?

A. No problems involving Communist minorities have yet been encountered in programming missiles for the European defense effort. You are aware of the threats to Norway, Denmark and other NATO governments by the USSR and especially of the similar threats more recently against Western Germany. Such Soviet propaganda efforts can be anticipated against any efforts to strengthen the NATO defenses.

Q. Can you be specific in saying what the views of NATO planners are toward some of the European missiles as operational weapons, such as French, Swedish and British missiles?

A. Some of the European-developed weapons systems are very good. Since Sweden is not a NATO member, however, there is no knowledge of what may be under development in Sweden. The NATO planners encourage the development and production of missiles in Europe. The United States also encourages such efforts. Any data or information regarding European-developed missiles must be sought from the originating country. ★

For Europe in fiscal 1957 . . .



. . . $410 million for new weapons.

Roughly half for missiles.

Sectional Satellites

. . . a bit-by-bit approach to space flight

By Commander George W. Hoover, U.S.N.
Office of Naval Research

THE LAUNCHING of the first earth satellite during the International Geophysical Year will be only the first step in a very large research program to gather data which will eventually lead to manned space flight. Before man can venture too far beyond the protective blanket of the atmosphere many satellites must be launched and a vast amount of data must be gathered and analyzed to determine the design of a manned space ship.

As more and more information is sought, the satellites will tend to grow larger and larger, putting an increasing strain on the relatively small amount of power to be derived from presently known rocket propellants. The size of the boosters and each successive stage of the satellite vehicles will increase and the number of stages will multiply until we reach a point of diminishing returns.

Since there is a definite limit to the amount of payload that can be placed in an orbit with chemical rocket fuels, it might be in order to look at another possible way of gathering data over long periods. One possible solution might be a sectional satellite.

The paramount requirement for any satellite is to stay within payload limitations compatible with the power capabilities of rocket fuels in a system which remains small enough to guide and control efficiently.

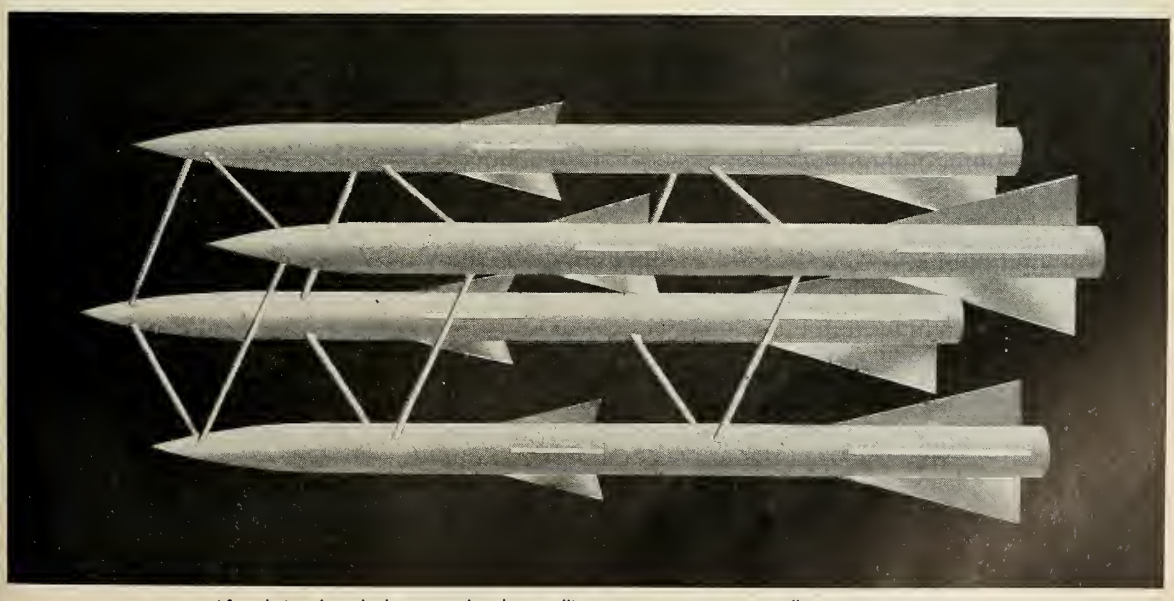
Additional requirements call for sending up sensors which are capable of sensing many kinds of information. such as spectrometers, cosmic ray and aurors counters, gamma ray counters, X-ray counters, meteor dust counters, telescopes and many many others. Some of it must be run through amplifiers and computers. All of it must be recorded.

From the recorder it must then be transformed into a signal which can be transmitted at proper intervals to the receivers back on earth. In addition there is the power requirement to operate these devices for very long periods. When the power source is depleted, the satellite will be of no further value except where ground observation techniques can be used. The satellite must also transmit position information.

In order to meet the above requirements it will be necessary either to build one very large satellite or a great many smaller ones. In the case of the very large one the expense will be monumental and such a satellite must be confined to measuring only the information which it was originally designed to gather.

Even with a large power supply it will eventually run down with no possibility for replenishing the power source. Its greatest weakness, however, is a lack of flexibility.

In the case of a large number of



After being launched separately, the satellite components automatically join up in space.

small satellites, each one must carry the necessary components, sensors, computers, amplifiers, recorders, transmitters and power supply. The greatest weakness here will be redundancy without reliability. Each one will operate until its power supply is gone and then it will again be useless except for ground observation. Each will be able to gather only a little data because most of the payload will be used up in the transmitters, recorders and power supply.

Now let's go back to our requirements. First we need a relatively small payload to keep within economical size. This would indicate a large number of small satellites rather than one large one. Further requirements, however, call for many sensors but only one computer, one recorder, one transmitter and one power supply. Ideal satellites would permit addition of sensors as new data is desired and to replenish the power when the supply is run down.

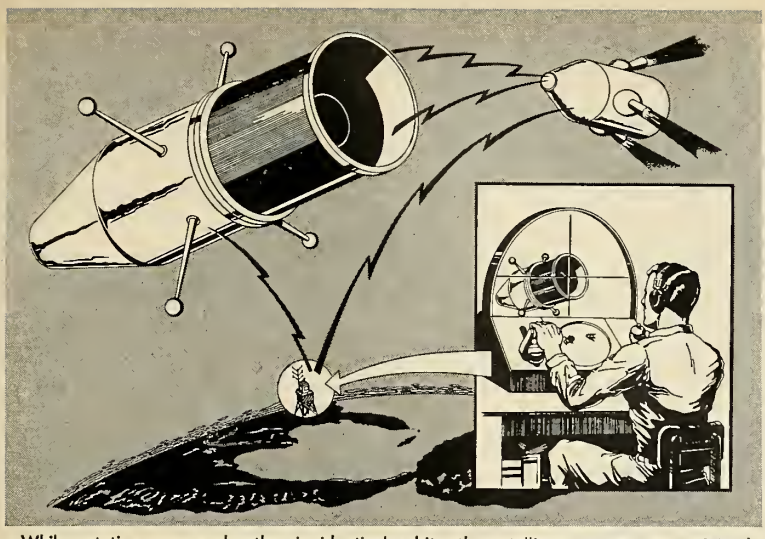
One solution would be to develop a series of small satellites, each as a component in the total system. These components would be placed in the orbit and then connected together. This would permit using relatively small payloads, using the total payload in each unit for the component itself and would eliminate redundancy.

Doubling up on critical components would increase reliability. It would permit replenishing the power supply at any time; and with the proper design of connectors, it would permit flexibility by allowing new sensors to be connected when new data was desired. In addition the basic design of the components as well as the satellite vehicles could be fairly well standardized for large production, thus reducing the overall cost.

The problem of connecting the components could be achieved by one of several possible methods. One way might be to launch the components as a cluster in which each stage would be flexibly connected with other components in that stage. If there were five components to the system, five multistage rockets arranged in a cluster could be used to place the satellite components in the orbit. The flexible connections could be utilized to take care of deviations in trajectory during the firing of the multiple stages.

Such a method would require very good quality control of each of the components in order to insure simultaneous firing of each element in the cluster, but this would be well worth the advantages that could be derived from getting a much more efficient satellite into the orbit.

Many combinations could be used, such as: the elements could be rigidly



While rotating near each other in identical orbits, the satellite components are joined together through the use of ground control stations using television cameras as "eyes."

connected using each component in the cluster as firing stage. The only difference here would be in the fact that the stages were arranged in clusters rather than in tandem.

Another method of establishing the connections of a sectional satellite would be to place each component into the same orbit but slightly to the rear of the preceding one. This would require extremely accurate launching in order that each successive section would arrive in the orbit at the proper time and in the proper position.

Errors in orbit could be corrected by using an infrared or magnetic homer which would also bring about the connection of the components. Each successive unit would require a slightly higher velocity in order to overtake the preceding one and some means would have to be included in the last firing stage of each of the satellites in order to clear the way for the payloads to connect. A small jet using compressed air would be sufficient for this action.

Much must be learned about placing satellites into orbits but with the state of the guidance art improving as it is, such a method is not impossible.

A third method would be to affect the connection of the units by ground control. Here the controller would get his information from the unit itself. Each unit would contain a small television or infrared sensor which would look forward at the tail of the preceding component.

By means of small compressed air jets controlled by a simple radio control from the ground, the approaching unit could be plugged into the orbiting unit in much the same way as aerial refueling is achieved. Upon connecting, the television camera could be set to realign itself in order to be used as an observation sensor.

All power to supply these units would come from the main power unit by means of a carefully designed hook-up circuit.

Each component could be added by the same technique until the entire system was assembled. The best order for assembly of the components would probably be to place the power source into the orbit first, the transmitter, recorder, amplifier and finally the sensors. Additional sensors and power supplies could be added as desired.

The employment of a man-controlled system would obviously be more flexible than any self-contained system and would probably come closer to meeting the overall satellite requirements. Since telemetering will be required in any case it seems much more efficient to make use of this means to control and connect the satellite.

Manned space stations will eventually be constructed but a great deal must be learned before this can become a reality. Sectional satellites can teach us how to construct these space stations while being utilized to gather scientific data. It may even be possible to construct the total space station by remote control by building the sections in a honeycomb arrangement and then placing each section into the orbit either in clusters or individually. Unmanned observatories could be built utilizing a sectional technique.

Thus it appears that a sectional satellite would meet the overall requirements for a sophisticated research satellite, accelerate the gathering of scientific data, teach us orbital construction techniques and bring the day of manned space flight just a little closer.★

missile miscellany

Something else seems to have happened to Vanguard. This page hears reports from people who are privy to the project's secrets that (a) the first stage with the dummy second and third still hasn't been fired, though it's allegedly been "ready" for a few weeks now; (b) that delay may involve alteration of fuel (magnesium or boron-plus-JP4 slurry) or oxidizer (flox) or both. If so, it could mean more delay and expense for the satellite project.

And this page heard and saw demonstrated by one of the World's top solid propellant experts how a dye marker could be landed on the moon within weeks for a total cost of less than $200,000. Heard also from another expert how bombs and rockets will be useless as weapons when launched from manned satellites, skip bombers and other space vehicles.

Then, there was the misdirected telephone call to extension 92658 at the Pentagon which was answered: "Good morning. Unconventional Warfare."

And speaking of changing times and difficult adjustments, let's look at tomorrow today—like *Jupiter*, for example, with the aerodynamic surface of a bullet and an all-welded aluminum skin, and Thor whose toy-tiny fins seem more a concession to habit than a functional necessity. Why fight tomorrow? It's here with more dollars than ever.

And for the day-after-tomorrow, a report, still untraced, of two positrons in a mutually destructive collision and simultaneous, momentary low-energy elimination of the local gravitic field. Whodunit?

Before the Red ICBM we were told that missiles would soon be IT. The airplane had a limited future. Now the Russians have the big bird, and the same people tell us missiles aren't all that good; that airplanes will be the mainstay for many years. Remember, too, how a few weeks ago the anti-ICBM was "years away" and now it's just around the corner? Uh-huh . . .

Now, about that 3000-mile super-radar—it's not all that close, nor necessarily practical. It requires: voltages heretofore achieved only in the laboratory; antennae as big as the Capitol dome; railroad tracks to direct it; a remote location so it won't cook everybody in front of it; and a nuclear power plant. Even then, it's line-of-sight and won't tell the instant an intercontinental ballistic missile is launched.

We're also told "but the Russian ICBM isn't operational." If it will carry a nuclear warhead to within a reasonable distance of a target 5000 miles away, it can be fired from the factory floor! It doesn't need complex mobile logistic back-up like small missiles.

And in case anyone thinks solid-propellant missiles won't get "all that big," this page recently learned of a tooling requirement for a precision lathe with a 140-inch swing and a bed over 45-feet long, center-to-center, needed for finish work on large solid-propellant motor now in design and prototype test stage.

Hawk will be the drone for Hawk. Motorola's revolutionary pulse-light guidance system will keep bird an even 50 feet over any terrain at high supersonic speeds. Hawk, incidentally, is a two-stage vehicle.

Grand Central Rocket Co. has a small rocket-carrying borate solution for fighting brush and forest fires . . . And a sign in a large missile-development laboratory: "We can do it—what is it? We did it—what was it?" . . . 100,000-pound capacity static test stand is going up on one of the islands in the Detroit river . . .

Underwater missile tests are being conducted in Lake Erie . . . Towed models of special hull on West Coast have shown a drag reduction of 80% . . . which makes 60-knot submarines and 600-knot underwater missiles closer to being more than just talk . . . Growing support is noted for very small, high-speed solid-propellant underwater missiles fired in salvo, like 2.75-inch air-to-air rockets; their mission: puncture enemy subs' hulls . . . Navy has turned down small high-speed interceptor-type anti-sub sub as "unnecessary"—eh? . . .

Now a report this page hears of super-hush-hush meeting of nation's top scientists in Old State Department building. The question they ponder: How can this country be defended—from missile-launching subs lurking 15 miles off shore, Red ICBM's, H-bombs, anti-missile-missiles, anti-anti, etc.

Shades of confusion—because of improper liaison between launch-site builders and missile-makers, missiles couldn't be fitted into many of the Nike launch sites. And, antipodally speaking, proof that Japan admires American ways: Japanese Air and Ground Self-Defense forces are raising Nipponese Ned about who should have control of guided missiles. Then, there's the U.S. Vanguard propulsion expert who suggests that if Red ICBM is patterned after Vanguard, it won't work—he probably forgets that the twin-jet Bison bomber couldn't fly either, but does; that the Reds traditionally get a lot more thrust out their engines than we.

And a bitter question: With so much money going for R & D on officers' white dinner jackets, runway vacuum cleaners, etc.—stuff industry should do on its own on competitive basis—why slash basic weapons research?

And out of Redstone Arsenal and ABMA, official insistence that Jupiter be called the Air Force Jupiter and an anticipatory enthusiasm for becoming an AF ballistic missile subcontractor.

At right—wonder what this would do to solid-propellant rocket's specific impulse . . .

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Space Medicine

By Hubertus Strughold, MD., PhD.

The high-altitude balloon flight of Maj. David G. Simons was a great event in space medicine. This record 32-hour flight, Aug 18th to 20th, with altitude peaks up to 102,000 feet, has demonstrated that man can exist in a sealed gondola filled with an artificial atmosphere and surrounded by an environment which is to a very high degree equivalent to free space.

With regard to air pressure and its functional significance for the human body, the altitude reached is almost the same as the near-vacuum of interplanetary space. This flight, with a plastic balloon developed by Otto Winzen Co., is indeed a breakthrough on the vertical frontier. Behind it were several years of meticulous scientific and experimental preparation. It will be remembered as a heroic scientific and major engineering achievement in the history of human flight. Our congratulations to Maj. Simons, to Col. Paul Stapp of the Aeromedical Field Laboratory and Mr. Winzen.

•

The School of Aviation Medicine, under Maj. Gen. Otis O. Benson, will conduct a three-day symposium in San Antonio on Physics and Medicine of the Atmosphere and Space during the first half of November 1958, the end of the International Geophysical Year. About 40 papers will be presented by physicists, astronomers, engineers and medical doctors from the U.S. and abroad.

•

The American Rocket Society's Human Factors Section, headed by Major D. G. Simons, will have a session at the annual meeting of ARS in December in New York. The writer of this column will be chairman of the meeting.

•

The study of the solar-terrestrial relationship, which is high on the list of the IGY program, is of special interest from the space medicine point of view. Solar flares, for instance, lead to an enormous increase in cosmic radiation. In a paper published in the August issue of the JOURNAL OF AVIATION MEDICINE, Dr. Herman Schaefer of the U.S. Naval School of Aviation Medicine, Pensacola, Fla., reports on the Cosmic Ray Dosage During the Giant Solar Flare of February 26, 1956.

His calculations, based on the sea level influx of neutrons, indicate that in the middle latitudes—twenty minutes after the visible flash of light on the sun—cosmic radiation in the estra-atmosphere regions increased suddenly to very high intensities (about 1000 times greater than normal) and then gradually returned to normal within about eighteen hours. A similar strong solar eruption was observed at the beginning of the IGY.

•

Dr. Syrrel S. Wilks of the School of Aviation Medicine has discovered that green plants like algae, proposed as a source of food and oxygen in space flight, give off deadly carbon monoxide gas. The Randolph Air Force Base pysiologist says this might raise a problem for future space-ship occupants.

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INDUSTRY SPOTLIGHT

By Norman L. Baker

Thiokol Scores Major Breakthrough in Solid Motors

MARSHALL, Texas—The development of the *Nike-Hercules* sustainer motor, currently in production at Thiokol Chemical Corp., Longhorn Division, was the result of a major breakthrough in solid motor design.

Propulsion units for *Falcon, Lacrosse, Hawk,* and the *Nike-Hercules* sustainer are currently in production here. Although few details have been released about the latter system, there have been a number of interesting disclosures. A photograph of the sustainer unit shows a bottle-like motor which necks down to a long blast tube. At the end of the blast tube is a conventional nozzle. The reasons for these configurations are twofold: (1) to have the center of gravity as far forward as possible, (2) to give an annular space for controls around the blast tube.

Thus, it appears Thiokol has scored two major breakthroughs: ducting the extremely hot gases for a considerable distance and insulating against these temperatures for long burning times. The thrust level, too, is quite high as evidenced by the long flame emerging from the nozzle mouth during firing tests.

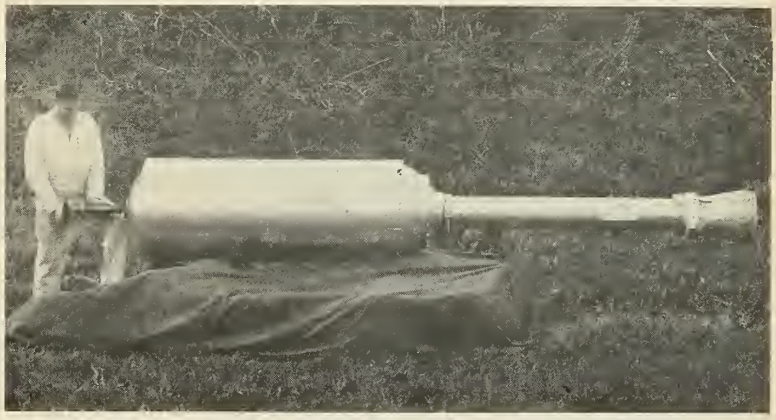
The long-burning-time motor is uncooled and is successful because of insulation techniques. This insulation material is probably furnished by Haveg Industries Inc. Machined parts are supplied by Goodyear and Borg Warner.

The motor, which can be touched with the hand immediately after firing, is so little affected by heat that during development several firings have been made by reloading the same hardware. The booster for the *Nike-Hercules* consists of four standard double-base solid-propellant *Nike-Ajax* booster motors.

Under a $5-million expansion program, the Longhorn Division is being expanded. This contract has recently been extended through 1959 and it is anticipated that the Ordnance Corps will make additional demands on this corporation. Rocket facility was designed by Thiokol in 1953 to produce a large volume of small solid rockets such as the *Loki* and a two-inch air-to-air rocket. The plant was put into operation in 1955. Now, with the trend toward a small volume of large solid rockets, production thinking and techniques have had to be revamped.

In 1956, some 800 persons were employed at the Longhorn Division which is located at Karnack, Texas. In addition to the rocket facility, Thiokol is responsible at Longhorn for maintaining a TNT plant in standby, and a pyrotechnics plant in layaway, ready for use as required by the Department of Defense.

For security reasons Thiokol has not released production figures, but production capacity in 1953 was estimated at about one-half million pounds per month, and it is believed that current capacity is several times that. The primary purpose of this Thiokol-Texas facility is production, although a certain amount of development is carried out. In this regard, The Thiokol Division works closely with Thiokol-Redstone Division and with the two company-owned divisions of Elkton, Md. and Brigham City, Utah.

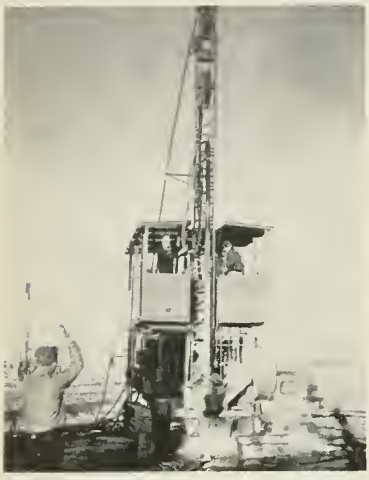


The NIKE-HERCULES sustainer motor is an uncooled and long burning unit. Success of the motor is due to advances in insulation techniques by Thiokol and Haveg Industries.

The long flame produced during a static firing of the NIKE-HERCULES sustainer motor is indication of a high thrust level. Cooling is so effective motor units may be re-used.

Rocket Exhaust Flame Drills Rock

The rocket exhaust flame is now being put to industrial use. On the gigantic St. Lawrence Seaway project, blast holes are being sunk in rock with a rocket flame process known as Jet-Piercing. Developed by Linde Co., Division of Union Carbide Corp., the new process works on the rocket principle and makes it possible to pierce rock at speeds up to ten times faster than conventional drilling methods.

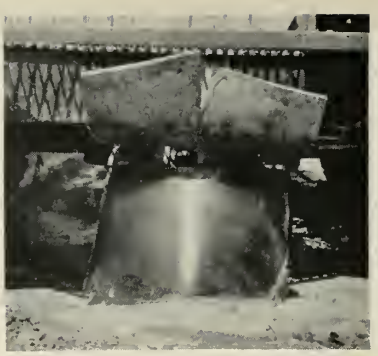


The Jet-Piercing rig is fed 10,000 cu. ft. of oxygen and 40 gal. of fuel oil per hour. Oxygen is supplied from a trailer holding enough for eight to ten hours operation.

Intensely hot, supersonic jets of flame are the key to the new process. Reaching temperatures of 4000°F, the flame spits out of a rocket nozzle and disintegrates or spalls the rock in its path. This is a continuous operation. Disintegrated rock particles are thrown up out of the hole by the combined force of burning gases and steam so that a fresh surface is continually exposed to the jet flame. The only limitation to penetration depths is the length of the hoses (carrying fuel, oxygen, and water) that are lowered into the hole. Deepest penetration obtained to date is 160 feet.

The rocket flame represents one of the highest concentrations of energy available to man. At its highest velocity, flame has a mechanical energy equivalent of about 500 horsepower—yet this energy is contained in a flame not more than 18 inches long and two inches wide.

Low viscosity fuel oil or a liquid hydrocarbon fuel such as kerosene is combined with high-purity oxygen to produce the intensely hot flame. A blowpipe, suspended from a crawler-carrier, controls flame combustion and action.



The 4000° rocket exhaust flame begins to cut.

Linde has found that their new process works fastest on the class of spallable rocks which normal drilling methods find toughest—especially those containing silica—such as granite, syenite, quartzite, sandstone and magnetic taconite. Potsdam sandstone, the rock being pierced on the St. Lawrence Seaway, is a highly abrasive material that would normally cause excessive bit wear. In the past it has taken as long as a week to drill a 100-ft. hole in this

very hard rock using churn drills. But with jet-piercing, a 100-ft. hole can be sunk in a single shift.

In addition to the increased speeds of penetration, Linde's Jet-Piercing process makes it possible to "chamber" blast holes. Chambering consists of enlarging the blast hole at any desired depth so that extra explosive charges can be placed exactly where needed. The operator simply lifts the blow-pipe off the bottom of the hole and lets the jet blast away.

Since Jet-Piercing harnesses thermal energy instead of mechanical energy, the new process also eliminates the maintenance problems associated with churn drills, pneumatic drills, and jackhammers.

AF Seeks More Seattle Space for Boeing

The Air Force is trying to get more space for Boeing's pilotless-aircraft division in Seattle. The Army Engineers' headquarters installation there has been tapped for the space, and a decision on the request should come out of Washington. Air Force has also obtained government warehouses across from the Engineers' HQ for its Boeing-Support program.

AP&C is Sole Producer of Solid Oxidants

The production of the solid propellant oxidants, ammonium and potassium perchlorate, is the sole responsibility of the American Potash and Chemical Corp.'s Henderson, Nev., plant. Production capacity is in excess of present and foreseeable defense requirements. Production will step up on completion of a new plant in Aberdeen, Miss., currently in the planning stage.

Products manufactured at Henderson are sodium chlorate, potassium chlorate, potassium perchlorate, ammonium perchlorate and manganese dioxide.

The chlorate and perchlorate processes start with the electrolysis of salt trucked from a deposit approximately 90 miles away in California. The primary product, sodium chlorate, is sold commercially and used as a raw material in making perchlorates.

The perchlorate process involves electrolysis of sodium chlorate solution at a platinum anode to produce sodium perchlorate. This is in turn reacted with potassium chloride to produce potassium perchlorate in a company-owned facility, or it is reacted with ammonia and hydrochloric acid to produce ammonium perchlorate in a Navy-owned plant.

The company-owned sodium chlorate facilities are capable of producing considerably more than would be required to run the perchlorate plants at maximum capacity. In addition, the Navy owns sufficient cells to produce approximately 600 tons of sodium chlorate per month. Approximately one pound of sodium chlorate is required to make one pound of potassium or ammonium perchlorate.

Currently sodium perchlorate capacity is approximately 1000 tons per month. There is ample space to install additional cells to bring the monthly capacity up to 1500 tons.

The Navy-owned ammonium perchlorate facility is an integrated unit built on land owned by the Navy adjoining the American Potash plant. Sodium perchlorate is piped to it in slurry form. Power, water and other services are provided by American Potash.

The capacity of this plant is 1200 to 1500 tons of ammonium perchlorate per month for a maximum of 18,000 tons per year. Ammonia is brought in by rail from California producers and hydrochloric acid is supplied from an

adjacent plant at Henderson.

The Henderson plant is capable of producing either ammonium or potassium perchlorate or any ratio thereof up to the total capacity of 1200 to 1500 tons per month.

APCC is also engaged in the production of lithium perchlorate. This is only one of the products from their lithium chemical products facilities.

Present price schedule for ammonium perchlorate is in the range of 40¢ to 45¢ per pound, depending on the grade and quantity involved. Increased production would drop these figures substantially.

Current price schedule on ordnance-grade potassium perchlorate, grade suitable for solid-propellant systems, ranges from approximately 25¢ to 30¢ per pound.

In order to further expand their knowledge and technique in the solid-fuel oxidant picture, APCC recently acquired National Northern Corp. of West Hanover, Mass., where large scale facilities are maintained for research, development and production contracts for rocket power development.

Propellex Moves Up In Solid Propellants

EDWARDSVILLE, Ill.—Starting from a basement operation in August 1956, Propellex Chemical Corp., headed by Robert A. Cooley, has moved into its new 100-acre facility located near East Alton, Ill. The security area, comprising about 15 acres, houses an administration and engineering building, plus six other buildings for solid-propellant operation. Buildings house materials storage, mixing, and assembly areas and are well spaced for safety.

Propellex will do research, development and production of solid-propellant devices ranging from gas generators to rockets. The firm is already producing several cartridge-actuated devices. Especially interesting is the Propellex-developed cartridge-actuated landing gear system which takes the place of hydraulics or high-pressure bottles and connecting high-pressure tubing.

Estimated capacity of Propellex is about one-million pounds of solid propellant per year. The facilities will now permit casting solid grains of about 250 pounds. Primary emphasis will be on solid propellants of all types—cast double base, ammonium-perchlorate composite, and ammonium nitrate. Work on fuel binders is underway and a low-energy ammonium-nitrate propellant is "in the works" while a high-energy type—possibly mixed with double base—is also anticipated.

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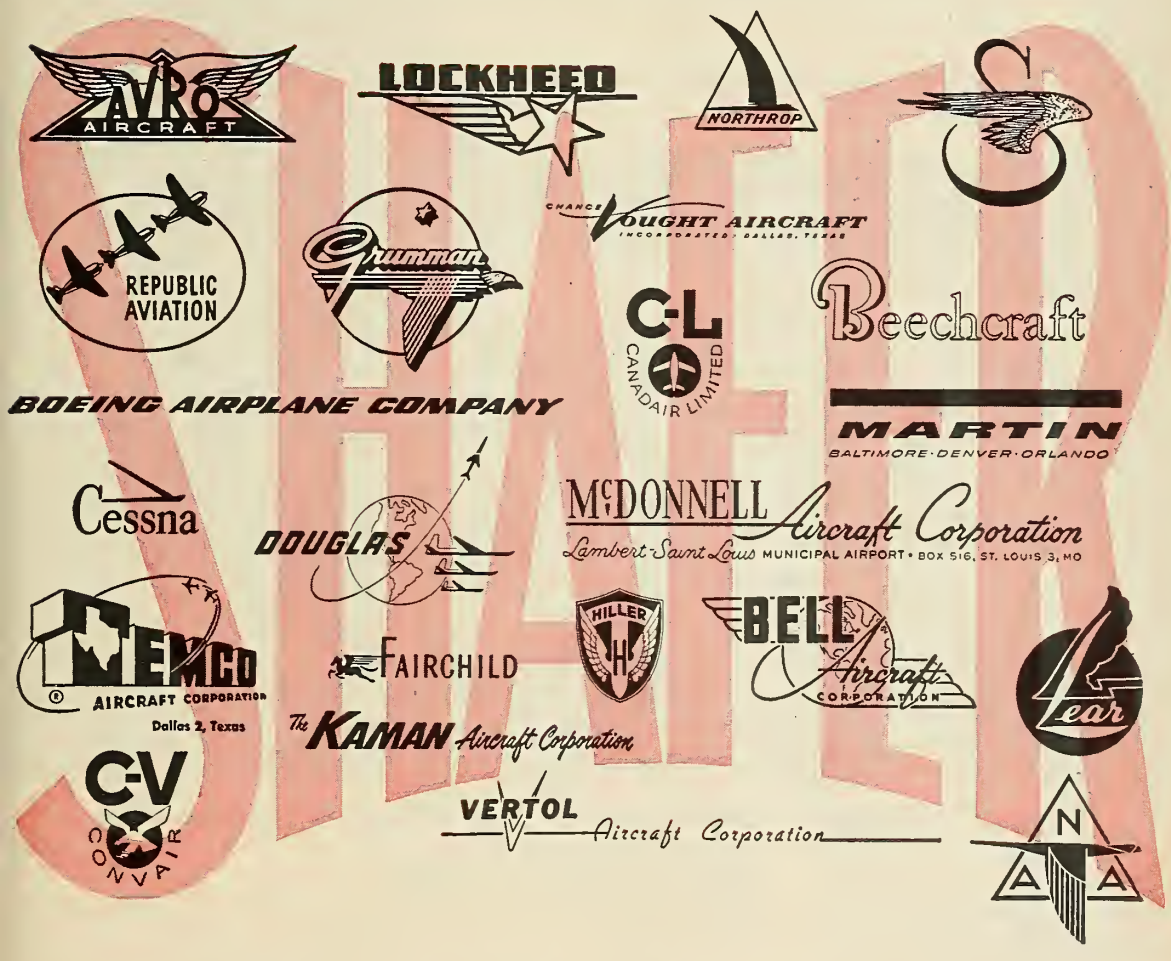

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of new solid-propellant advances and rapidly translate them into hardware.

Other operations of Propellex include: preparation of igniter and delay mixes involving zirconium, novel chemicals for heat sensitivity applications and the nitration of special organic chemicals for use in solid propellants.

NAA to Produce New AF Missile

The Missile Development Division of North American Aviation has been selected by the Air Force to produce a new long-range bombardment ASM. According to NAA, organizational ability was one of the chief factors for its selection by the Air Force for the new project.

The company's proposal was selected for its superiority in technical concept and its proposed managerial plan for carrying out the development on a timely basis. The division has responsibility for the weapons system and will have high-priority support from other NAA divisions during the project.

Aeronca Receives *Atlas* Contract

Aeronca Manufacturing Corp. has signed a contract with Convair-Astronautics for a design study program on the *Atlas* ICB. The contract provides for a study in the application of materials in the design and fabrication of the *Atlas*, now in pilot production at Convair.

The initial Aeronca program will cover several months of research and development work at both the Middleton and Baltimore research divisions, and will include application and environmental testing. Aeronca is in the midst of a transition from conventional airframe production to weapons subsystem production.

Lockheed Investigates Nuclear Power for Missiles

Nuclear power to propel missiles of the future is under serious investigation by Lockheed Missile Systems Division scientists. Dr. Louis N. Ridenour, assistant general manager for research and development, revealed that nuclear propulsion studies will be further advanced with a powerful new atom smasher which went into use this week at the Lockheed nuclear laboratory, one of the facilities of the missile division's research and development center located in Stanford University's Industrial Park at Palo Alto, Calif.

West Coast Industry

By Fred S. Hunter

No secret is Lockheed's great desire to establish itself solidly in the electronics field to round out its missile systems division. Not so well known is the fact that it also has its eye on the propulsion field. Senior Vice President Hall L. Hibbard let this cat out of the bag in addressing a management club meeting in Palo Alto, where he told the MSD supervisors the division must get into propulsion.

Power ties in so closely with missiles that propulsion systems should be tailored for each individual weapon, Hibbard said. He pointed out that there have been no really new inventions in missile power that have amounted to anything since the start of missile developments. Liquid rocket engines are simply refined V-2s, he added.

"We haven't scratched the surface in getting energy," Hibbard stated—a broad hint as to Lockheed's course in its propulsion development efforts.

•

It's likely the Air Force will pick P&W's new J52 turbojet engine for the air-to-surface missile for the B-52 to be developed by North American Aviation. Another possibility is two General Electric J85s, but there's less chance for engine failure with one engine than with two and this is a critical factor for an ASM operation. The J52 is a Navy engine, but the Navy undoubtedly would be only too happy to let the Air Force come in for a share of the development costs.

Interesting sidelight of NAA's planning is the shift of Dale D. Myers from chief engineer of the Missile Development Division to project manager on the ASM. One of the factors which won the ASM competition for NAA was its proposed managerial plan for carrying out the development expeditiously.

•

Radioplane's new XQ-4A supersonic target drone, for which it has an Air Force development contract, is a higher performance vehicle than the XQ-4, incorporating a new engine. The needle-like XQ-4 has made a number of quite successful flights in the test program that should be running just about now at Holloman Air Force Base and has set the stage for the new model. The XQ-4A is not a training drone; it's designed for use in evaluating weapons systems.

•

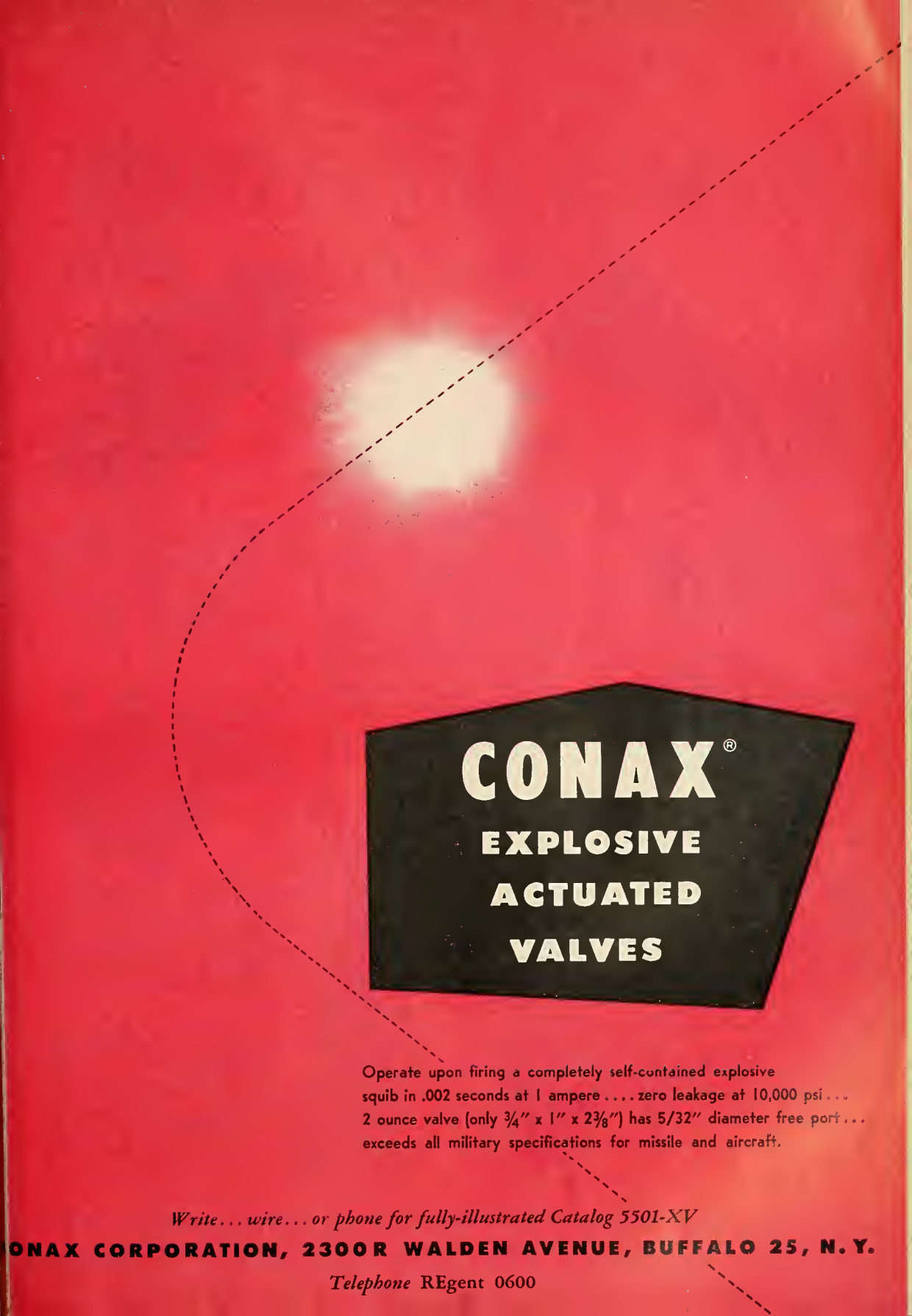
One outward difference between the Rocketdyne test stands at Santa Susanna and Neosho is the sheet metal siding used on the stands in Missouri. That's to permit all-weather operation. The weather in California is, of course, always balmy so the Santa Susanna test crews have no need for this protection . . . This reminds that lately Rocketdyne has been teaching Joplin and Fort Crowder firemen how to handle liquid oxygen. LOX for Neosho's test operations is shipped by rail to Joplin and then to the test area by truck.

•

Hughes Aircraft Co. has been gradually making over its plant at Tucson, where two versions of the *Falcon* rocket are in production—the radar-guided GAR-ID and the infra-red GAR-2A, both used by the Convair F-102A interceptor. Work on the program, estimated to cost $1 million or more, started about a year ago. It is expected to move rapidly toward completion after the new warehouse, being built by the Tucson Airport Authority for lease to Hughes, is ready for occupancy (in the next couple of weeks or so). This will free main building stores space for manufacturing.

•

We wouldn't vouch for the truth of it, but there's a rumor around that it was President Eisenhower himself who ordered the *Navaho* cancelled when he learned the project's cost was $15 million a month.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Typical Characteristics at 25° C

	DT100	2N441	2N442	2N443
Moximum Collector Current	13	13	13	13 amps
Collector Voltoge, Emitter Open	100	40	50	60 volts
Soturation Voltoge (12 omps)	0.7	0.7	0.7	0.7 volts
Power Dissipotion	55	55	55	55 watts
Thermal Gradient from Junction to Mounting Bose	1.2°	1.2°	1.2°	1.2° °C/watt
Nominol Bose Current I_B (V_{EC} = —2 volts, I_C = —1.2 omp.)	-19	-26	-26	-26 ma
Distortion (Class A_1, 10 wotts)	5%	5%	5%	5%

Delco Radio offers four new alloy junction germanium PNP transistors to meet an even wider range of applications. Like all of Delco Radio's High Power transistors, these are characterized by high output power, high gain and low distortion. All, too, are normalized to retain their fine performance characteristics regardless of age. Furthermore—these new types are all in volume production. Other types are available at new, lower prices. Data and application sheets and price lists are available upon request.

DELCO RADIO
Division of General Motors
Kokomo, Indiana

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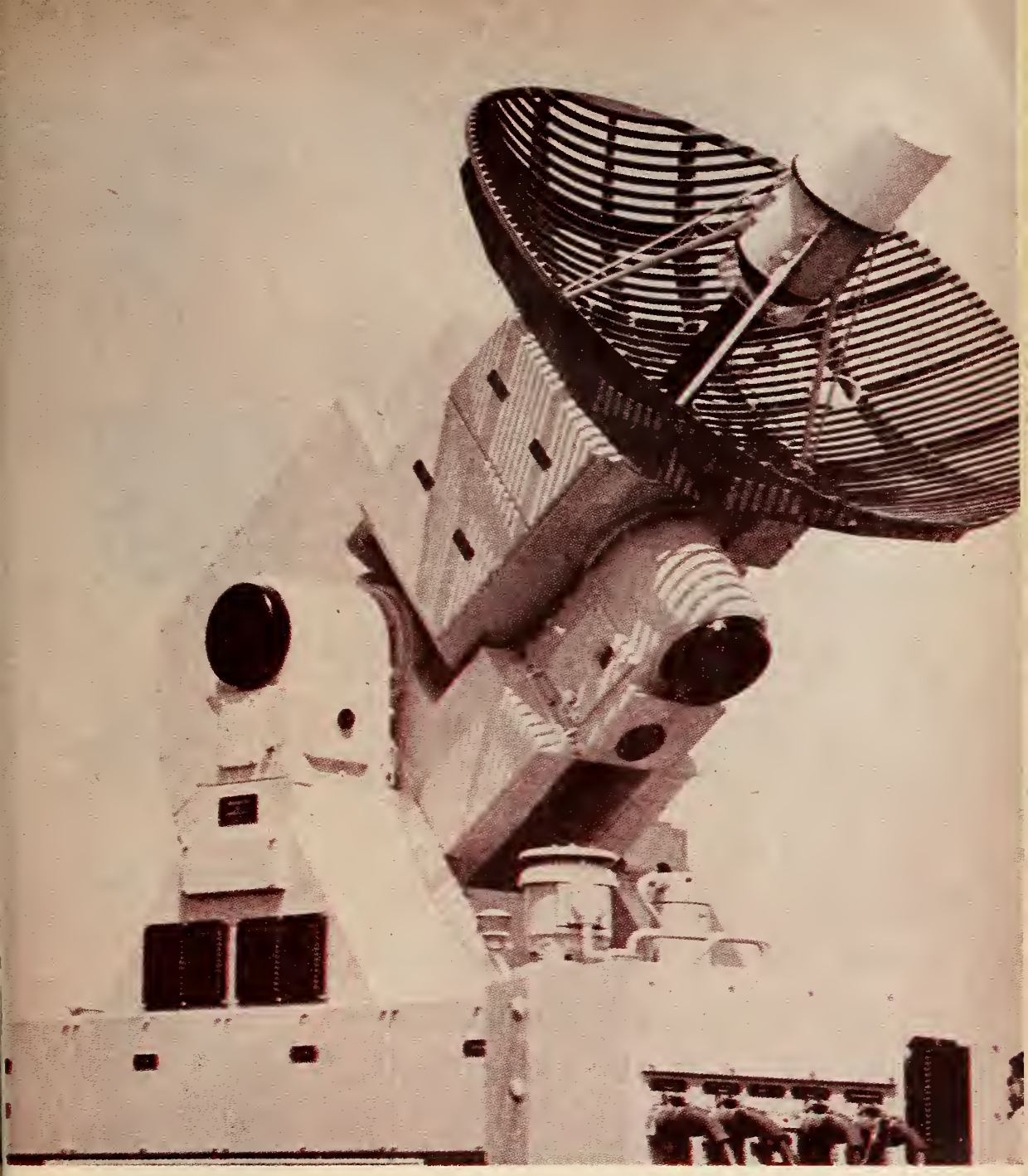

missile electronics

STRIONICS · GUIDANCE · OPTICS · TRACKING · TELEMETRY · COMPUTING

OCTOBER 1957

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Benefit from Exide's experience and facilities—unduplicated by any other battery maker in the world. You are invited to submit your auxiliary power requirements and problems to us for study and evaluation by our engineering staff. Exide Industrial Division, The Electric Storage Battery Company, Philadelphia 2, Pa.

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missiles and rockets

missile electronics vol. 1, no. 1

contents

missile electronics news

special features

cover picture:

Switzerland's achievements in the missile industry can be credited almost exclusively to the Oerlikon Co. of Zurich. The Oerlikon surface-to-air missile (m/r cover) and its associated ground control equipment is a tremendous achievement for a private company. The missile is equipped with a lock-on and track radar. The track radar controls the beam transmitter and the missile launcher. The beam transmitter is equipped with a fine and a coarse beam. The coarse beam locks on the missile after launching and guides it toward the fine beam. The fine beam then directs the missile to the target. Limited by a computer, which controls speed and accelerations of the beams, the transmitter moves at a rate the missile is able to follow.

departments

photo credits: *Oerlikon, Cover; Army, pp. 170, 179, 180, 181, 182, 187; Ford Instrument Co., pp. 183, 184; Navy, p. 173.*

calendar

OCTOBER

National Electronics Conference and Forum on electrical research, development and application, Hotel Sherman, Chicago, Ill., Oct. 7-9.

Lewis Flight Propulsion Laboratory, Triennial Inspection, Cleveland, Ohio, Oct. 7-10.

International Astronautical Federation, Eighth Annual Congress, Barcelona, Spain, Oct. 7-12.

National Noise Abatement Symposium, Sherman Hotel, Chicago, Ill., Oct. 10-11.

Computers in Control Conference, American Institute of Electrical Engineers, Chalfonte-Haddon Hall Hotel, Atlantic City, N. J., Oct. 16-18.

IRE Canadian Convention, Automotive Building, Exhibition Park, Toronto, Canada, Oct. 16-18.

Canadian Aeronautical Institute of the Aeronautical Sciences Meeting, Montreal, Canada, Oct. 21-22.

Aircraft Electrical Equipment, Fourteenth Annual Display, Aircraft Electrical Society, Pan Pacific Auditorium, Los Angeles, Calif., Oct. 24-25.

Computer Applications Symposium, sponsored by Armour Res. Foundation, Morrison Hotel, Chicago, Ill., Oct. 24-25.

Aeronautical and Navigational Electronics, Annual East Coast Conference, Fifth Regiment Armory, Baltimore, Md., Oct. 28-30.

Aviation Electrical Equipment Display, U.S. Grant Hotel, San Diego, Calif., Oct. 30.

IRE, Electron Devices 1957 Meeting, Shoreham Hotel, Washington, D. C., Oct. 30-Nov. 1.

NOVEMBER

Joint Military-Industry Guided Missile Reliability Symposium (limited to those with Secret security clearance), Nov. 5-7.

Aeronautical Communications, Third Annual Symposium, Hotel Utica, Utica, N. Y., Nov. 6-8.

IRE, RETNA, Radio Fall Meeting, King Edward Hotel, Toronto, Canada, Nov. 11-13.

IRE, 3rd Instrumentation Conference and Exhibit, Biltmore Hotel, Atlanta, Ga., Nov. 11-13.

IRE, Mid-America Electronics Convention, Municipal Audit., Kansas City, Nov. 13-14.

National Aviation Trades Assn. Annual Convention; meetings with National Air Taxi Conference, Maintenance Council and Aerial Applicators, Hotel Adolphus, Dallas, Texas, Nov. 13-15.

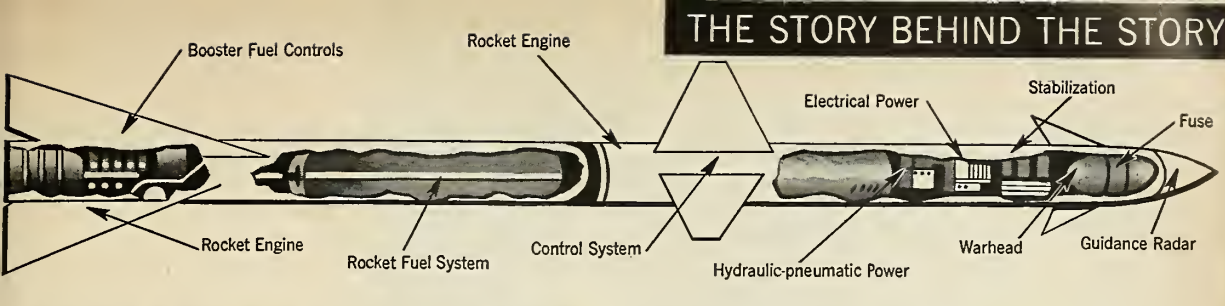
IRE, New England Radio and Electronics Meeting, Mechanics Hall, Boston, Mass., Nov. 15-16.

AIEE Magnetism and Magnetic Materials Conference, Sheraton-Park Hotel, Washington, D. C., Nov. 18-21.

Aviation Distributors and Manufacturers Assn., 30th Meeting, Sheraton Cadillac Hotel, Detroit, Mich., Nov. 21-22.

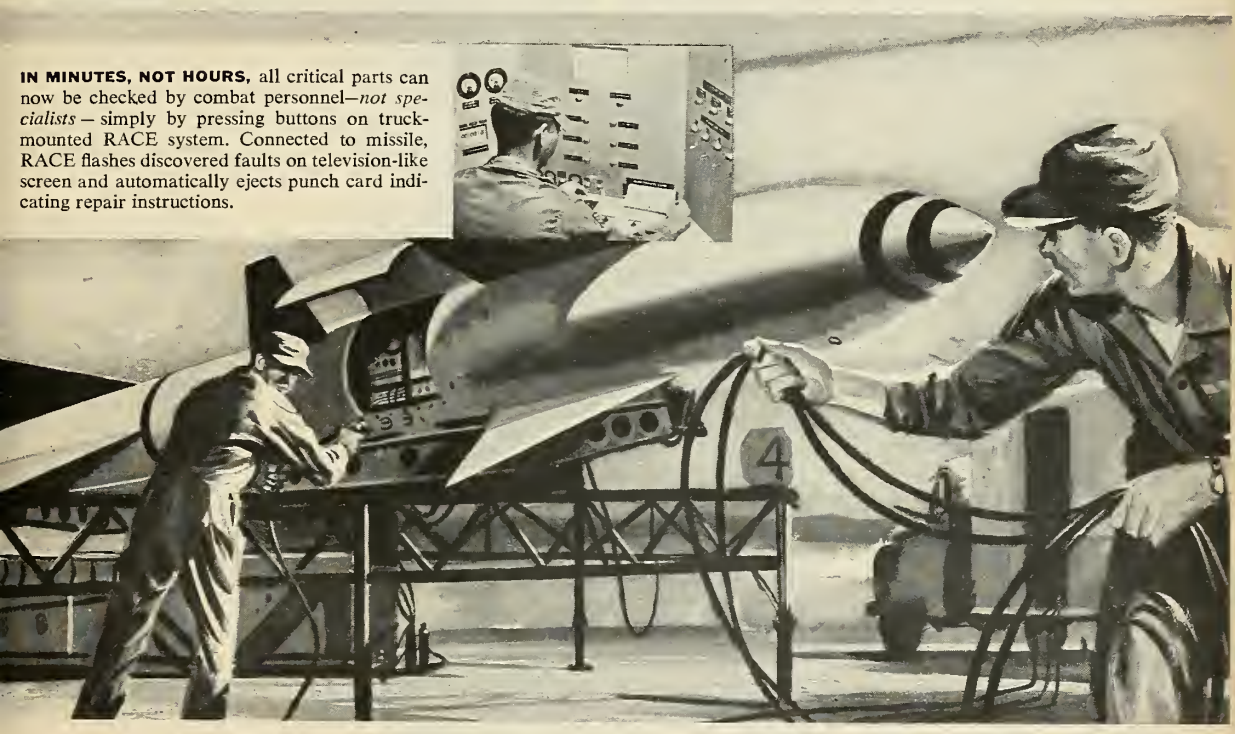
DECEMBER

IRE, AIEE, ACM, Eastern Joint Computer Conference, Sheraton-Park Hotel, Washington, D. C., Dec. 8-11.



THOUSANDS OF "FAULTS" can develop in a guided missile, each capable of causing it to misfire or swerve off-course. Pre-launching check-out takes specialized technicians many hours. Under stress of enemy attack, a small but fatal defect might be missed.

IN MINUTES, NOT HOURS, all critical parts can now be checked by combat personnel—*not specialists* – simply by pressing buttons on truck-mounted RACE system. Connected to missile, RACE flashes discovered faults on television-like screen and automatically ejects punch card indicating repair instructions.



IN FLIGHT, RACE-checked guided missile flashes toward target, performing at the peak capacity engineered into it, with all components functioning to give missile best possible opportunity to reach and destroy objective.

"RACE" TO BOOST MISSILE STRIKING POWER

Electronic System Cuts Launching Time, Ups Dependability

When a rifle bullet misfires you simply fire another. Guided missiles, however, are costly and complex, packed with precision parts in hair-line adjustment. When these "birds" take off, they've got to fly right the first time!

At present, making sure missiles perform properly takes hours, even days, of careful testing by highly trained crews. And under the stress of actual combat, the best-trained crew might neglect an important check-point—and there are thousands of potential trouble-spots in a typical missile.

Sperry's new missile testing system called RACE does the job in only minutes —with little chance for error. RACE (for Rapid Automatic Check-out Equipment) tests all missile components at the launching platform, warns of the tiniest fault. even tells the operator how to fix it. And RACE doesn't make a mistake because it checks itself while it checks the missile. Result is, missiles are ready to launch far quicker and are more likely to perform with full effectiveness.

Designed to test supersonic aircraft as well as missiles, RACE will strengthen our national defense by keeping key weapons fit to fight.

SPERRY GYROSCOPE COMPANY
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DIVISION OF SPERRY RAND CORPORATION

washington briefs

THE PENTAGON IS INTRIGUED by Maj. David Simons' suggestion that we place "platforms" at altitudes in the neighborhood of 100,000 feet. Simons has commented that the platforms would be permanently fixed installations from which scientists could study cosmic radiation and other phenomena indefinitely. A new need for electronics gear?

NAVAL ORDNANCE LAB IN WASHINGTON has developed an electrochemical device which replaces vacuum tubes or transistors in many electronic systems. Known as solion (ions in solution), the device is sensitive to sound, temperature, pressure and acceleration and is expected to be particularly useful in sensing course errors in inertial-navigation systems.

RELIABILITY, RELIABILITY, RELIABILITY is the echo that follows the word "electronics" in Washington's military circles. Most recent and significant echo came from AMC's commander, Gen. Edwin Rawlings, who warned that contracts would be withheld from industry unless reliability greatly improves. "We must," he said, "accept the fact that where we do not have reliability, we do not have the ability to fight."

DEPARTMENT OF THE NAVY has cancelled the *Triton* ramjet missile program, but will support the program long enough to incorporate the missile's best features, namely its "extremely accurate" guidance system, into other missiles.

LITTON INDUSTRIES WILL BUY Maryland Electronic Manufacturing Corp., located outside Washington, for an undisclosed amount of stock. Maryland Electronic has current sales figures over $3 million, and will become the twelfth Litton plant.

PENTAGON CONTRACTS FOR ELECTRONICS: Two contracts for closed-circuit TV have been awarded to Hallamore Electronics Co. division of the Siegler Corp. The TV systems will be used for monitoring rocket engine tests at Huntsville, Ala. and the Martin Co.'s facility for *Titan* at Denver. Contracts total about $300,000. Cook Electric Co. will design and construct a missile range instrumentation system at Point Mugu, Calif., under a Navy contract valued at $2¼ million. Gilfillan Bros., Inc. has received a $404,745 contract to cover field-engineering services connected with *Corporal* ground guidance equipment.

THE TELEMETRY GAP between the West Indies and Ascension Island has had Pentagon officials worried. It is now being filled by six Army cargo ships (AGSs) converted to carry telemetry gear.

ARMY SIGNAL ENGINEERING LABORATORY nearby has developed a special type solar cell for possible use in satellite power packages. The device has previously been used in research rocket telemetry.

WASHINGTON HAS RECEIVED more evidence of industrial cooperation among NATO members. Compagnie Francaise Thomson-Houston, a French electronics firm, and Decca Radar, Ltd., of Britain, have signed a contract to share equally in providing surveillance radar antennas for NATO air defense.

ASTRONAUTICS CIRCLES IN WASHINGTON are pleased at the news that Lockheed has produced laboratory speeds of 100,000 miles per hour. Shock waves are produced in the company's Palo Alto R&D center by a hydromagnetic shock tube using high-voltage discharges which are boosted to tremendous speeds by magnetic fields. The device's shock waves produce temperatures in excess of 100,000°C, and better shock tubes are in the design stage. Much of the data obtained from the devices are expected to be valuable in the study of space travel.

TO MAKE THINGS BETTER FOR AMERICA—

Avco Manufacturing Corporation is a builder of quality products for the commercial economy and high-performance military systems for national defense. Aircraft engines, electronics systems, farm implements, kitchen components and the nose cone for the Air Force Titan intercontinental ballistic missile are being produced by Avco *today*.

The foundation for Avco tomorrow is being laid at our Research and Advanced Development Division. We know that the technology of the future will be built on scientific research being done now. Amazing new materials and new means for creating useful power hold out the promise of great advances in transportation, in agriculture, in consumer products, in nearly every aspect of our future economy. New scientific knowledge and its imaginative application can turn these promises into reality. Work at the Research and Advanced Development Division has already shown what rapid strides can be taken in a short time.

The division is composed of outstanding scientists and engineers who work in an environment that fosters creative investigation. It is the "breakthrough" division of a progressive manufacturing organization. Avco management recognizes the role of the scientist in modern technology. Avco's determination to make things better for America places the resources of a large, diversified, aggressive company firmly behind the Research and Advanced Development Division.

– Raymond A. Rich
President, Avco Manufacturing Corporation

Raymond A. Rich, President, Avco Manufacturing Corp.

Pictured above is our new Research and Development Center now unc construction in Wilmington, Massachusetts. Scheduled for completion early 1958, this ultramodern laboratory will house the scientific and tec nical staff of the Avco Research and Advanced Development Divisic

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Write to Dr. R. W. Johnston, Scientific and Technical Relations, Avco Research and Advanced Development Division, 20 South Union Street, Lawrence, Massachusetts.

3000-Mile Anti-ICBM Radar Claimed

Line-of-Sight Radar Being Developed in Conjunction with Anti-Missile Missile

A radar capable of detecting intercontinental ballistic missiles (ICBMs) 3000 miles away is under development by the U.S. Though still in the development stage, Gen. Thomas D. White, AF Chief of Staff, announced that the radar will be available for operational use very soon.

The radar would warn civilian and military centers shortly after the enemy ICBMs were launched. Thus, appropriate defensive action could be taken almost immediately. Gen. White predicted that fear of such action would probably deter aggression, and marks an important victory in the military era of electronics.

It would also be an important "breakthrough" in the state of the art. No details as to the nature of the "breakthrough" were disclosed by the general or Air Force spokesmen, since the project is still highly shrouded in secrecy. However, it is logical to assume that the "breakthrough" occurred in the field of line-of-sight applications. Informed sources conjectured that the achievement was the one referred to in a recent Columbia University news conference. At the conference, according to one of the sources, the recent "breakthrough" was hailed as "probably the greatest single advance in radar" since 1939.

Development of the 3000-mile radar nevertheless raises many implications for tactical and strategic operations.

Prime contractors in the development of the radar are the Lincoln Laboratory, Radio Corporation of America, Sylvania Products, and General Electric. No information is available as to who contributed what to the radar.

Operating presumably on the line-of-sight principle, the new radar will be able to see only objects in or above a straight line tangent to the earth. Thus, though it will be able to detect ICBMs at long ranges (because of their relatively high, loping trajectory in the initial phase), it will be unable to detect short-range missiles and low-flying aircraft.

When employed against ICBMs, the radar will enable computers to determine not only trajectory and speed but also size and shape. As a result, it would be possible to determine the specific target in advance, the type of missile used and the location of the launcher. The amount of warning time that would be given for the average missile launched from the Soviet Union would range, it has been estimated by authorities, from 10 to 15 minutes.

Given that much time and knowledge of the trajectory and speed, the most immediate objective of course, would be destruction of the missile. This would imply the availability of an effective anti-missile missile. However, as far as is publicly known today, no such missile exists, although Gen. White in his announcement explicitly stated that one was being developed with utmost "urgency." He was probably referring to the Army *Nike-Zeus* and the more recent Air Force *Wizard* project.

Lacking an effective anti-missile missile, there is a possibility that the military might accept full-effort retaliation as the only recourse. Thus the new radar might signal a total offense.

A missile battle, or even a missile war, might be fought without sufficient time to inform political leaders. Given an equally effective ICBM-detection radar in the hands of the enemy and effective anti-missiles in the hands of both enemy and friendly forces, both sides could conceivably detect and destroy each other's missiles in a matter of seconds or minutes. It would not particularly matter which side fired first. And, of course, if the action took place in the Arctic wastelands, it is quite possible that the civilian population might not know about it.

Telemetry Use For Manned Space Vehicle

Whenever electronic engineers gather to discuss their profession, the question inevitably arises about the future of telemetry when manned space ships come into use. In view of the continuing and increasing interest in the question, we feel it would be helpful to quote from the statement of Mr. Martin V. Kiebert, Jr., director of electronic development at Miami Shipbuilding Corp. Writing in SIGNAL for the eleventh convention of the Armed Forces Communications and Electronics Association, Mr. Kiebert said:

> Manned space craft will probably employ telemetering and remote-control functions (as aided by both carried and ground-based computer facilities) for the following functions:
>
> 1) Telemetry can be used to fix a landing position provided previous facilities have been so established.
> 2) Ground-based radar and computers will be available for landing on the earth; however, the lack of these facilities on the celestial bodies now makes it appear essential that the space craft carry its own radar and high - frequency - response computer system.
> 3) Telemetering may be required on the earth as an advisory means as to when and where landings may be

made, and re-orientation of inertial references to the earth's coordinates.

4) The role of telemetering in the landing of extra-atmosphere space craft on celestial bodies. It appears that telemetry will serve as an extremely important element in the landing of space craft on previously unexplored celestial bodies as indicated. Knowledge of both the physical and chemical environment on a proposed celestial body will be essential for survival of both the craft and the crew.

Radioactive Cobalt Aids Missile Recovery

The Era Engineering Corp., Santa Monica, Calif., has announced a radioactive recovery technique to insure post-flight recovery of missile and rocket test vehicles.

Originated by Harold Hutchinson, company vice president and radiation expert, the simple and relatively inexpensive technique has been used successfully on Aerophysics Development Corp.'s Hypersonic Test Vehicle.

In a typical operation, the one-to-two-ounce radioactive source, contained in a one-inch long, 3/8-inch O. D. Allen screw, is removed from its lead shield ten minutes before launching, and placed in the test vehicle by means of a six-foot aluminum rod fitted with a magnetized Allen wrench at one end.

Although the impact point of a vehicle is seldom observed visually or by radar, it is usually known to be within a square of approximately ten miles to a side. This area is searched by flying parallel grid lines about 3000 feet apart in light aircraft or helicopters equipped with scintillometers until the vehicle's radioactive source is detected.

It normally requires three hours to search an area of this size using such a flight pattern, but the results of 40 tests using the radioactive technique produced an average location time of just 30 minutes.

Once the site is located and marked with flares a specially trained recovery crew transports the trailer-mounted lead shield to the impact point, removes the radioactive source with the aluminum rod and places it in the lead shield. The source may be removed from its shield and placed in the test vehicle, or vice versa, in from 30 seconds to one minute.

Under normal conditions, the crew receives negligible and often unmeasurable amounts of radiation. Even in cases where the vehicle broke up in flight, the dosage was not in excess of the daily allowable maximum.

Radioactive intensity is not affected by high shocks or G forces encountered in flight nor will the source itself affect

electronic equipment and for short periods has no affect on ordinary film.

The original radioactive source consisted of two Curies of Cobalt 60 with a half life of 5.2 years and an effective lifetime of 20 years. A new source has been recently introduced—four curies of Antimony 124 with a half life of 60 days and an effective lifetime of eight months. The latter was introduced to reduce the hazard if a vehicle impacted in a stable condition, buried itself and was never found.

The company points out that there are many other uses of this recovery technique such as camera pods, instrument packages, propulsion units and material specimens ejected from test vehicles during upper atmosphere studies.

Bomb casings that "dig in" after drop tests may be located by two modifications to the technique: the attenuation effect of the ground can be accommodated by using a more intense source and an isotope which emits high energy gamma rays can be used.

Era can also supply millicurie (1/1000 curie) sources for aircraft flight testing which may be used to locate valuable individual components in the event of pilot bailout or destruction of the aircraft. These small sources require little or no shielding to protect aircraft operating personnel.

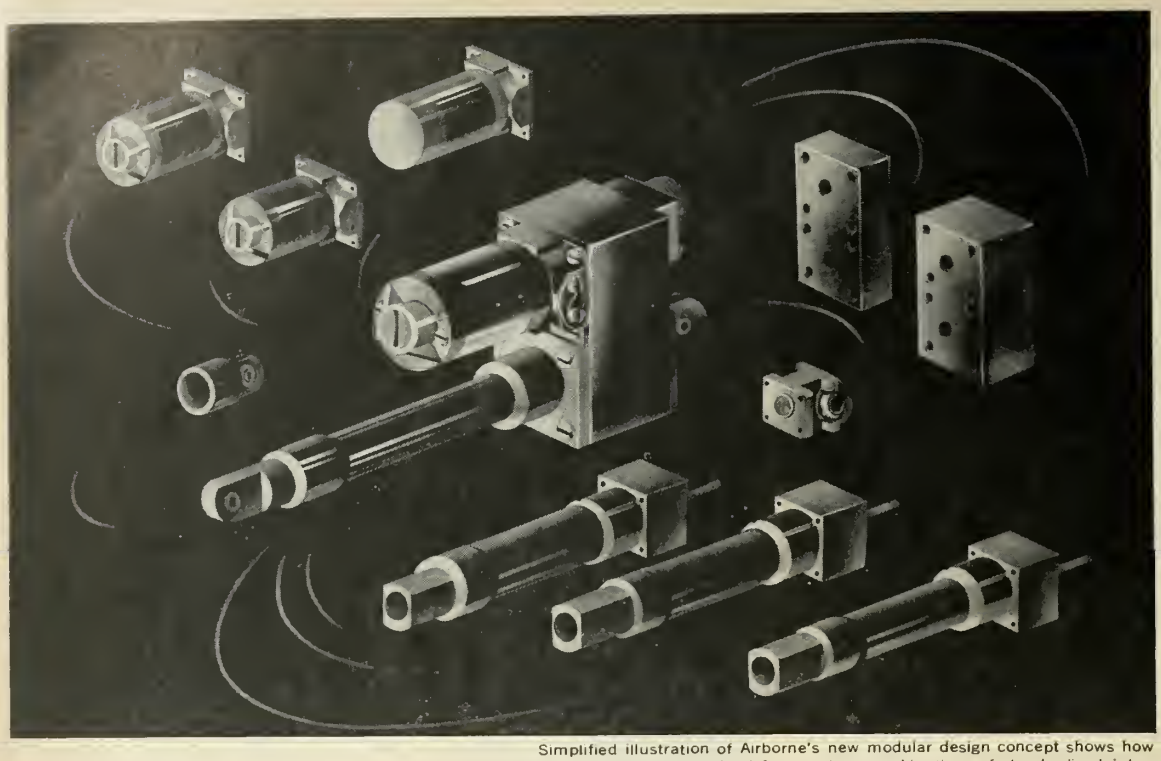
The recovery system may be supplied either as a contract service, in which Era provides trained personnel and equipment, including the design and fabrication of source capsules to fit the user's needs, the procurement and storage of the source pellets and the installation and subsequent search and location.

If a user wishes to purchase the equipment and conduct his own operations, Era will furnish all necessary equipment, provide initial training to fit the user's applications, arrange for the supervisor's training course and assist in the application for Atomic Energy Commission authorization.

Sperry's Super Radar To Guide *Talos* SAM

Sperry Gyroscope Co. has developed a "super radar" which the Navy plans to use in the *Talos* surface-to-air missile. The radar unit is said to include many automatic functions and the ability to pick up targets many miles beyond the horizon.

Included in a long-secret class of super-radars developed for the Navy, the SPG-49 *Talos* uses an antenna that resembles a gigantic searchlight. The system is reported to be providing "exceptionally high performance for tenacious, stable guidance of supersonic missiles, whether fired singly or in



Simplified illustration of Airborne's new modular design concept shows how actuator can be assembled from various combinations of standardized, interchangeable parts. Components actually available appear in the diagram below.

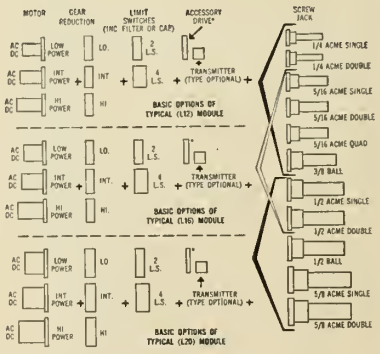
New Airborne modular actuators give you greater design freedom, help eliminate specials

Airborne's new modular concept of linear actuator design is based on a system of standardized components. These components—motors, switches, jacks—are grouped in three broad operating capacity classifications: L12—up to 350 lb.; L16—up to 2500 lb.; and L20—up to 3500 lb. All components within each classification are interchangeable.

As a result, you are no longer limited to a line of, say, a dozen standard actuators whose design is relatively fixed. Instead, you can now select any one of several hundred possible combinations from over 40 standard Airborne actuator components. In 90% of cases, this will give you a linear actuator meeting your capacity and configuration requirements exactly. Thus you have greater design freedom without becoming involved in the extra costs and delays associated with specials.

In addition, while redesigning under the modular system, we have reduced the bulk and increased the capacity of many Airborne actuator components. You get more power in a smaller package, saving valuable weight and airframe space.

Write today for further information on Airborne's new modular actuator line.



Above, the complete line of Airborne modular actuator components.

LINEATOR® • ROTORAC® • TRIM TROL® • ROTORETTE® • ANGLgear® ROTOLOK

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NEW MODULAR ACTUATOR CATALOG 57A

Discusses modular design; gives operating capacity curves for the new Airborne actuator classifications; contains complete dimensional data. Write for a copy today

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salvos at individual or multiple targets."

Development of the system was the responsibility of Sperry's surface armament division and the company says that production contracts for the SPG-49 system currently total more than $47 million.

Autonetics Components Tested at 90,000 Feet

Autonetics, a division of North American Aviation, Inc., has successfully carried out functional and environmental testing of components at an altitude of 90,000 feet. The tests, conducted on electromechanical components for guidance and control systems, were performed in a metal-framed gondola carried aloft by a General Mills balloon from New Brighton, Minn.

The gondola was designed by Autonetics engineers, while General Mills provided the balloon and handled launching operations.

Two Advanced Transistors Developed by RCA

A germanium p-n-p alloy-type transistor embodying the "drift" principle and a junction transistor of the germanium p-n-p type have been developed by RCA's semiconductor division.

The compact design of the former opens new applications in military and commercial equipment where space is limited. It operates at frequencies extending from the standard AM band well up into the short-wave bands. It may also be used as a mixer-oscillator and has a high input circuit efficiency, excellent operating stability, good automatic-gain-control capabilities and a good signal-to-noise ratio.

The junction transistor is designed for use in switching circuits of compact, medium-speed military and industrial electronic computers. It has characteristics permitting the design of electronic computers having exceptional stability over wide temperature ranges.

Transistorized System to Measure Liquid Levels

A transistorized electronic system for measuring the level of liquid in any of 100 remotely located storage tanks, with accuracy of performance, reliability and self-checking features has been developed by Texas Instruments Incorporated.

Called the DATA-GAGE, the system was designed and developed to control liquid materials stored in large tanks.

Du Mont Establishes Forward Scatter Link

The successful operation of a complete "forward scatter" communications link in frequencies above 2000 megacycles has been established by Du Mont. According to the company, the path length of the new link is 124 miles, and transmission and reception are at 2180 megacycles. The transmitter is located at Cedar Grove, N. J., the receiver at Somers, Conn., near the Massachusetts state line.

The equipment has been developed and designed for high reliability, ease of maintenance and operation. The design and systems concept allows application of the equipment to both line of sight and scatter communication multichannel links.

The transmitter dish of the system has an 18-foot diameter and is mounted on a 24-foot tower. It is connected by wave guides to a one-kilowatt transmitter utilizing an air-cooled Eimac klystron tube. The transmitter is capable of 72 voice channels with a band-width of 2.5mc.

A unique feature of the transmitter is a magnetic-amplifier-regulated power supply for the klystron, which requires no tubes.

Reception at Somers utilizes two 10-foot dishes on 25-foot towers. The specially designed, highly sensitive 52-tube dual diversity receiver operates reliably on a signal strength of eight microvolts.

Manufacturers Favor Two Annual Trade Shows

The average electronics manufacturer received almost a 50 per cent increase in the number of requests to exhibit his products at trade shows during 1956, according to a survey just made by the Electronic Industries Association.

Cost per show increased from $1712 in 1955 to $1916 in 1956 for the average manufacturer. For parts, tube and semiconductor manufacturers, however, the cost was below the industry average for both years.

Regarding industry attitude toward the increasing number of shows, replies indicated only 13 per cent favor more than four shows a year, and more members favor two shows per year than any other number.

Magnetohydrodynamics: Latest Combined Science

The recent outstanding research work of 11 top U.S. and British physicists and astronomers in the new field of magnetohydrodynamics—combining the sciences of fluid flow and electromagnets—has now been compiled in a volume edited by Dr. Rolf K. M. Landshoff, consulting scientist of the Lockheed Missile Systems Division.

The book, MAGNETOHYDRODYNAMICS, just published by Stanford University Press, grew out of the talks and discussions at a year-end Lockheed-sponsored symposium attended by 200 leading scientists at the company's missile division laboratories in Palo Alto, Calif.

Magnetohydrodynamics, a new branch of physical science, is a study of how magnetic fields influence and are influenced by ionized gases which are brought about at extremely high temperatures.

The foreword to the new book is by Dr. Louis N. Ridenour, assistant general manager for research and development, Lockheed Missile Systems Division. He also presented the welcoming address at the symposium.

This Army Signal Corps DIANA moon radar has been used recently to bounce signals off the moon in efforts to develop a technique for the testing of VANGUARD and other satellite tracking stations. The unit may be used in calibration of MARK II stations.

astrionics

By Henry P. Steier

THERE IS SPECULATION THAT SUPER-RADARS located in the Near East might be spotting flights of Russian IRBMs and ICBMs! Be that as it may, there *has* been a flurry of news on new radar techniques tried by the military. One of these was use of the moon as a reflector for 151-megacycle signals from Army Signal Corp's giant DIANA radar to test satellite tracking stations. Then came Columbia University's announcement of Omnirange Digital Radar for long-range missile detection. ORDIR is said to have a 2500-mile capability for measuring range and velocity with great accuracy. Another report told of Naval Research Laboratory's moon radar antenna made by scooping out earth to form a parabolic reflector over 200 feet in diameter and lining the hole with iron mesh. Navy says it has used the moon as relay station for voice signals.

AIR FORCE IS TRYING ITS OWN APPROACH to calibration of satellite tracking antennas. Cambridge Research Center, ARDC has designed a receiver with time-integrating circuits that allow very low levels of satellite signals to be detected. This in turn should add accuracy to angle information at the instant of satellite transit. It might also allow the antenna to be calibrated by means of radio stars and also be suitable for navigation by radio astronomy.

MOST SENSITIVE SHORT WAVE RECEIVER and farthest reaching transmitter is the new 250-foot diameter steerable radio telescope of the University of Manchester in Great Britain. Beam angle of the telescope will be about one degree at a wavelength of one meter and power gain will be over 16,000. At the wavelength of the spectral line at 21 centimeters, beam angle will be only a few minutes of arc. New detailed maps of radio sources in the sky plotted with the new instrument will add significant new data for use in radio celestial navigation as well as aid studies of the moon, radio echos from meteors and solar-terrestrial relationships.

DURING HIS RECENT TALK AT WESCON on the AF ballistic missile program, Maj. Gen. Bernard A. Schriever put the accent on accelerometer technology to illustrate fields where enterprising electronics firms can make their mark. He said, "Since the interest in mouse traps has begun to wane, the world would probably beat a path to the door of someone who built a really outstanding accelerometer. Most particularly if he could do it for a reasonable price." This column previously noted price of accelerometers as $5000-$10,000 per pound (m/r July 1957).

WORK ON MOVEMENT OF IONS IN SOLUTION UNDERTAKEN BY U.S. Navy researchers may pave the way to devices that replace vacuum tubes and transistors when high sensitivity and low power consumption are vital. The new electrochemical control devices generate current by movement of ions between electrodes in an iodine solution. Current is varied or sustained by stimulation caused by temperature, pressure, light, sound or acceleration. A promising use would be as an integrator in inertial systems. Several hundred pounds of electronics might be replaced by an electrochemical integrator weighing a few ounces.

ARMY IS PLACING MOUNTING EMPHASIS ON ITS RECONNAISSANCE needs for nuclear-age war. Missiles and drones, heavily equipped with new electronic surveillance gear, will probably appear in increasing numbers to form a whole new family of vehicles suiting new Army concepts. These are controllability over greater depth and breadth of area, utilization by higher echelons, increased transportability of input and output systems. Army needs for the new airborne vehicles ought to kick off many electronics-airframe company tie-ins during 1958.

electronics reliability

A sticky art becomes a sensible science as first tools of the trade are developed

By G. G. Brown and R. J. Dennis

Inland Testing Laboratories
Cook Technological Center

THE RELIABILITY PROBLEM has been stated and restated many times. Most engineers concerned with missiles or military electronics have devoted some time to pondering a solution. However, one encouraging sign in the swirl of component reliability confusion is that engineers today are aware that a problem exists, and the terms and phrases of reliability and statistics, failure rate, mean-time-to-failure, confidence limits, etc., are a necessary part of their vernacular. This in itself is progress.

Even though familiarity of the concepts exists, there are still shortcomings. Important aspects of the art are relatively unknown or are being neglected. The tools of the trade are at hand, but who should be using them and how are they to be used? The true value of any tool is in its application and utilization.

To achieve the extreme reliability of complex electronic systems under obtuse environmental conditions, comprehensive component criteria must be established and put to day-to-day use. These criteria (Table I) are the basic tools of the reliability art. It then remains to exemplify how and by whom they should be utilized.

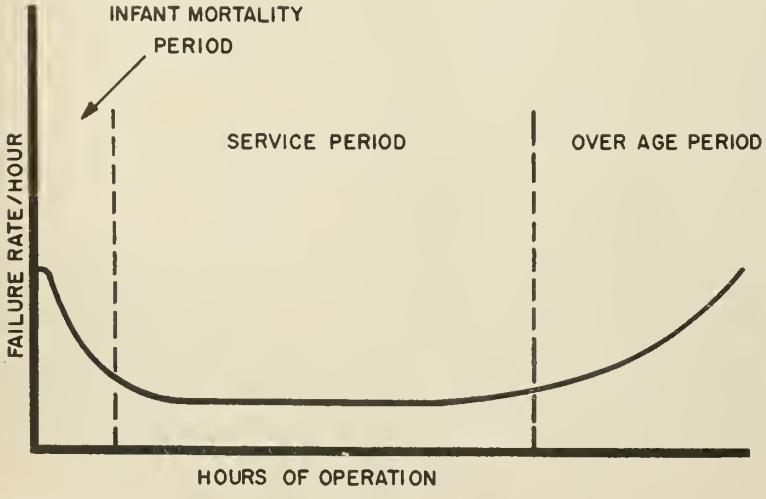


Figure 1. Component failure rate vs. operating time.

Failure Rate Curves

An example of the familiar three-part failure rate curve showing early, random and wearout failures is depicted in Fig. 1. Failure rate per hour is the ordinate and time the abscissa, with the three intervals being defined as the infant mortality screening period, service period and over-age period.

For simplicity, only catastrophic failures are shown. A more useful presentation would include a family of curves as shown in Fig. 2. The catastrophic failure curve is repeated and others added, showing cumulative catastrophic and out-of-tolerance failures for progressively decreasing tolerance limits. These curves take into account the fact that malfunction may occur under conditions that are less stringent than absolute component destruction.

Environmental stress as well as primary circuit stress has a considerable effect on failure rate curves. Failure rate as a function of circuit stress can be combined with the failure rate as a function of environmental stress. This serves to define a surface in a three-dimensional system. An example of such a three-dimensional presentation is illustrated in Fig. 3 where temperature has been added as a third parameter. The infant mortality period is shortened, the useful service period is reduced and failure rate in general becomes progressively higher as temperature increases to extremes.

Parameter Drift Curves

There are many ways by which

component drift may be graphically portrayed. To name a few: the change from the nominal or initial value could be plotted vs. time, circuit stress or environmental stress; the number of components drifting beyond given tolerance limits could be plotted against time; or the percentage of a total component population vs. per cent change in the measured parameter at a particular time.

Fig. 4 illustrates the per cent change in the resistance of two different nominal values of composition resistors during their operational life. A plus or minus 10 per cent design tolerance has been superimposed on the graph and shows that the resistance of the highest nominal value has drifted above this design limit after 8000 hours of operating time. The curves also indicate that the resistance change is relatively independent of nominal value.

The resistors as received were all within plus or minus 5 per cent of their nominal values. Consequently, they could have been ordered as a nominal value at least five per cent lower and still have been within the design specification limits. This would have permitted considerably longer equipment operation before the components drifted above the upper specification limit as shown by curves R_{2a} and R_{2b}.

Fig. 5 incorporates the results of parameter drift measurements over a period of 10,000 hours and compares the findings for two test groups of components, each of which is subjected to a different condition of electrical loading (other environmental conditions being the same). The two degrees of electrical loading, one group at 100 per cent of rated and the other at 50 per cent, illustrate the effect of derating on component life.

An initial distribution, derived from measurements made on individual components as received from the manufacturer and prior to environmental exposure, is shown in the first position on the left in the series of histograms in Fig. 5. This distribution shows the per cent deviation of the measured parameter from the nominal component value.

Succeeding histograms, shown for 2000 hour intervals, depict subsequent changes in the component parameter based on the actual initial value of each component. A mean value is computed for each of the aforementioned frequency distributions. Its position is indicated by the point of intersection between the interconnecting dashed line and the ordinate scale for individual histograms.

The path described by the dashed line progressively defines the mean change in parameter as it varies with the period of component exposure to a specific environment. This method of data presentation for parameter measurements enables the user to exercise his preference in considering the performance of the components as individual units or as a group.

Comparison of the two series of curves exemplifies the advantages to be gained by 50 per cent derating of this particular type of component. As an example, consider a circuit in which a change greater than 10 per cent in the component parameter is critical and would cause malfunction of the equipment. At 6000 hours, eight per cent of the units operating at 100 per cent of rated capacity could be expected to be outside this limit (shaded area), whereas all of the derated components are satisfactory.

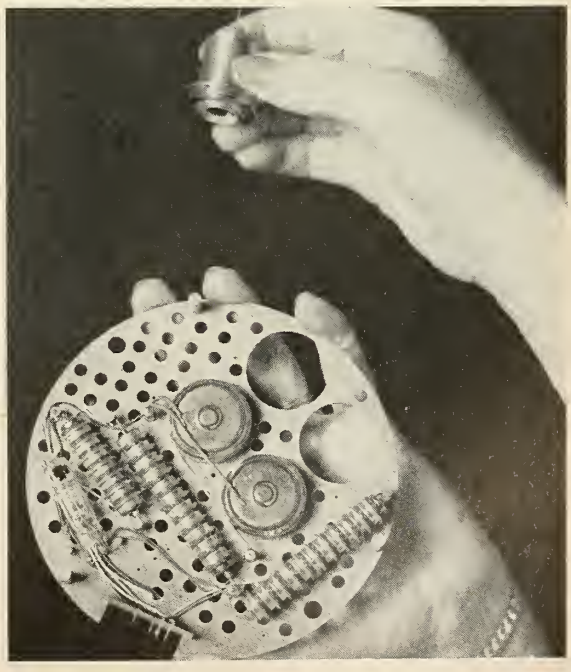
A critical change in the derated units occurred between 8000 and 10,000 hours of operation when two per cent of the units experienced an 11 per cent change in parameter. Thus, it is readily discernible that a gain in operational life of at least 2000 hours has been realized by derating the components.

Failure Analysis Data

One of the most valuable items at our disposal is the component which fails under known conditions. This is our third basic tool toward the attainment of improved reliability. A study of the basic molecular properties of failing components can be used to determine the mechanics of failure.

Initial studies of component failure indicate that it is possible to get information on the physical structure of a component that could then be applied to 100 per cent incoming inspection of this type of unit. Based on this knowledge, X-ray, electron microscope, spectrographic, or X-ray defraction tech-

Examples of some of the circuitry and electronic components with which missile telemetry and guidance engineers are concerned: Below shows a multi-channel telemetry wafer from the instrument package that will be placed in an orbit in the VANGUARD satellite. To the right is the "eye" and circuitry for measuring ultra-violet light.



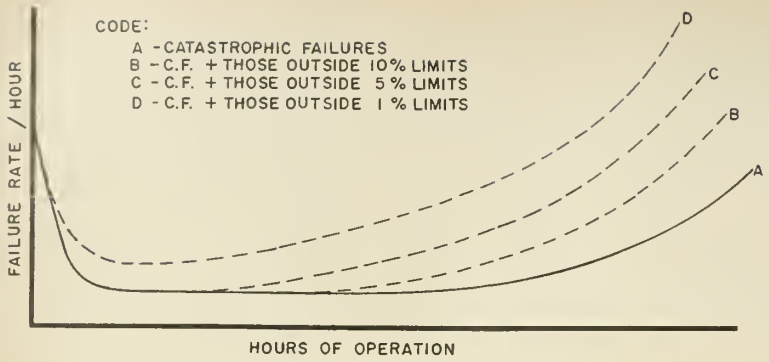


Figure 2. Component failure rate per hour.

niques could be used to screen components which would be potential failures from the total production lot.

Component Screening

Screening of component parts may be done on either a partial or 100 per cent sampling basis. An example of partial sampling is the application of destructive accelerated test techniques to a portion of incoming components. Of much greater value, however, are nondestructive techniques that may be applied to all components that are to be used in the equipment.

Two good examples of 100 per cent sampling are physical inspection and marginal testing techniques. If it is to be used to improve reliability, physical inspection presupposes knowledge of a property or properties of a particular component type which would serve as an indicator of potential failure. For this reason, it cannot be universally applied to all components until extensive studies of the failure mechanism of each individual type have been made. On the other hand, marginal testing techniques are currently used in the computer field for almost all electronic components and have met with great success in this area.

Marginal testing can be defined as operation under more severe conditions than are normally present, but that are still within the individual component's rating. An example of such a test would be operation of diodes with −50 volts reverse voltage applied and 20 milliamperes forward current, where normal operation is at −2 volts reverse voltage and 1 milliampere forward current. The −50 volts and 20 milliamperes are within the diode ratings, so the components should not be overstressed.

What benefits are to be gained by the use of component screening in actual practice? The information presented in Table II demonstrates how component reliability could be substantially improved by screening 90 per cent of the potential failures that would otherwise have been used in the equipment. It is based on the exponential failure law:

$$P_s = e^{-N\lambda T}$$

where

P_s = Probability of survival
λ = Failure rate per unit of time
N = Number of components of a specific style
T = Desired period of failure-free operation

This law is applicable to equipment which has a constant failure rate and where the probability of survival, computed during the life span of the device, remains unchanged. Under these conditions, the probability of survival (P_s) will vary exponentially when evaluated for different periods of failure-free operation (T).

Table I

Tools of the Trade

1) Failure Rate Curves or Reliability Indices
2) Characteristic or Parameter Drift Curves
3) Failure Analysis Data
4) Component Screening Techniques
5) Trade-off or Compensation Techniques

The benefits of screening can best be demonstrated by considering a piece of electronic equipment composed of five different types of components, each type having one of the failure rates that are shown in Table II. The probability of survival for this equipment would then be equal to the product of the probabilities of survival for the several different styles of components which make up the unit.

$$P_s \text{ (group)} = P_{s1} \times P_{s2} \times P_{s3} \times \cdots\cdots \times P_{sn}$$

From this relationship, the calculated probability of the equipment surviving for 10 hours, if initial component screening was not employed, would be 0.51, and approximately 50 per cent of the units could be expected to fail during any 10-hour operating period. On the other hand, if preproduction component part screening was conducted, the probability of equipment survival would be 0.935, thus obtaining an increase of more than 40 per cent in survival probability by utilizing screening techniques.

Trade-Off Techniques

The word *trade-off* usually brings to mind the idea that something irreplaceable is lost, and therefore some doubt is cast on the benefits which can be derived by utilizing this technique. But the gain may outweigh the loss. A good example is the use of negative feedback in amplifier design. It is true that negative feedback has one basic disadvantage—it reduces the over-all voltage gain, but its many advantages such as improved frequency response, increased signal-to-noise ratio, improved stability and reduced distortion more than compensate for this loss.

Some examples of trade-off or compensation techniques which may be applied to reliability are: (1) Derating or load compensation, where the component is operated at a reduced load condition to increase service life; (2) environmental compensation, where

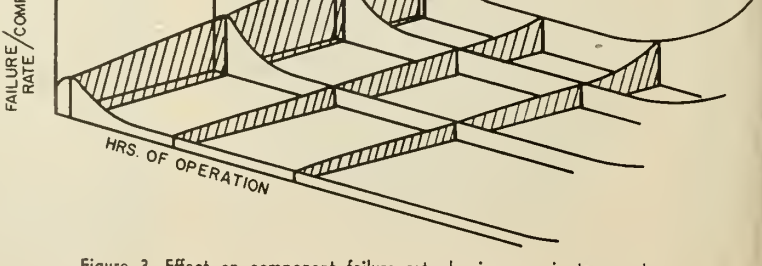


Figure 3. Effect on component failure rate by increase in temperature.

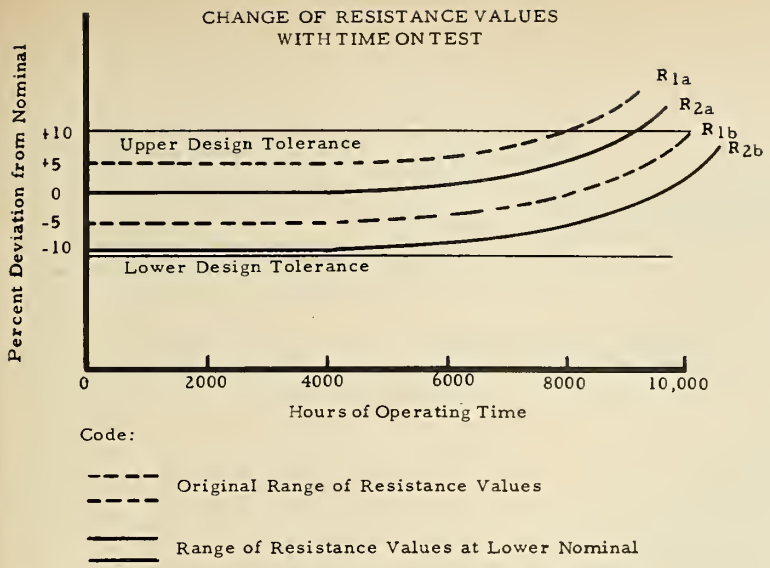


Figure 4. Change of resistance values with time on test.

weight and size are sacrificed to provide insulation or cooling to reduce the components' operating temperature; (3) redundancy, where substitute or parallel parts come into use upon failure of the primary circuits; and (4) compensation for drift characteristics in which components are chosen with opposite drift characteristics. Judicious use of these techniques can greatly improve the over-all system reliability.

After exploring the use of tools and techniques, consider again the question raised at the beginning: "Who should be using them and how are they to be used?" The obvious answer is the design engineers, component application engineers, and quality control engineers. However, the techniques which have been presented can also be utilized by purchasing department personnel, test engineers and field service engineers. Each of these individuals or groups can gain invaluable information from the reliability data and curves that have been brought up, and thus contribute to an increase in equipment reliability.

Use by Design Engineers

During the equipment design stage, many decisions must be made by the design engineer that would be substantiated by component capability data. Component reliability indices or failure rate curves provide information in the initial design stages to establish the feasibility of the preliminary design; environmental stress failure rate curves pinpoint the critical areas where trade-off techniques would be effective; and component derating and characteristic drift curves provide guidance for the application of these techniques. For example, if the circuit designer has knowledge of parameter drift with time

Table II

Improvement of Reliability by Screening

Per Cent Failure Rate/1000 Hours	Probability of Component Group Survival for 10 Hours* No Screening	With Screening
0.1	0.99	0.999
0.5	0.95	0.995
1.0	0.90	0.99
2.0	0.82	0.98

*Figures based on a quantity of 1000 components and 90% screening of potential failures.

for component types under various conditions, it is possible to select two or more components with compensating drift. An example of such an application to the design of an RC timing circuit is shown in Fig. 6.

A composition resistor used in the circuit increases in value with operating time. A capacitor could therefore be chosen which had a negative drift characteristic, thereby providing little or no change in the circuit-time constant during the operational life.

Parts-Application Engineers

Parts-application engineers are responsible for determining a component's suitability for a particular application and serve in a consultant capacity to the design engineers. They should have at their disposal component failure rate, derating, and characteristic drift information. Many uses will not require the most reliable components available, and these engineers select the most economical components for a particular application based on failure rate data.

Characteristic drift curves will assure optimum selection of nominal values; if a component characteristic drifts in an upward direction during its operational life, as previously illustrated in Fig. 4, then one would want to select a nominal value somewhat

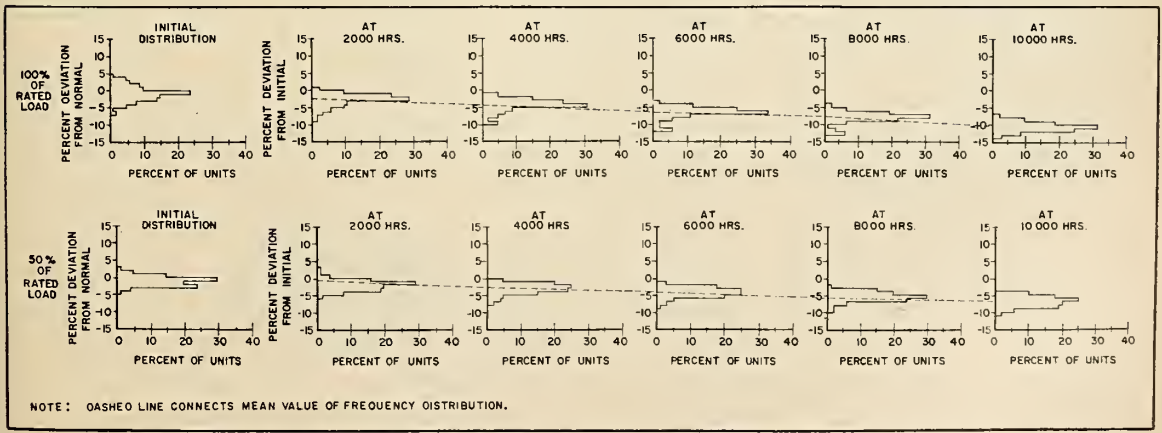
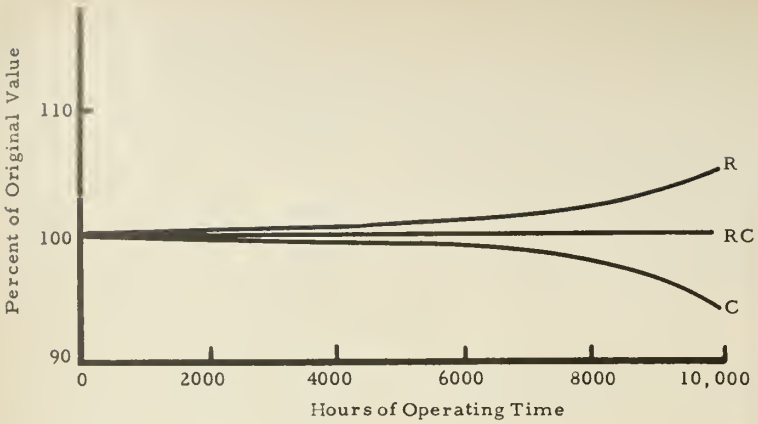


Figure 5. Per cent deviation in component characteristic for operation at 100 per cent and 50 per cent of rated load.



Code:

R - Resistance

C - Capacitance

Figure 6. Drift trade-off in R-C circuit.

lower than when relatively little drift is anticipated.

Control and Test Engineers

Quality control and test engineers can utilize the wealth of information in failure rate and characteristic drift curves, failure analysis data and screening techniques for design of test procedures and to substantiate test results. This information would indicate which tests are likely to be most effective for a particular component type and provide confidence in the test results from a small sample when correlated with the accumulated reliability data. The shape and duration of the infant mortality period of the failure rate curves are important factors in the selection of production tests, for it is quite conceivable that these tests could decrease rather than increase the equipment reliability if the components were inadvertently overstressed.

In conjunction with the purchasing department and application engineers, quality control and test personnel could apply their combined knowledge to the design of procurement and acceptance specifications to assure that the components which are ordered and received for production use meet the required standard of reliability.

Field Service Engineers

Preventive maintenance is a necessary adjunct to the present complexity of electronic systems, and requires a vast pool of highly trained personnel to assure continued equipment operation. Many of these maintenance programs consist of a systematic removal and replacement of equipment components before their useful life has been achieved.

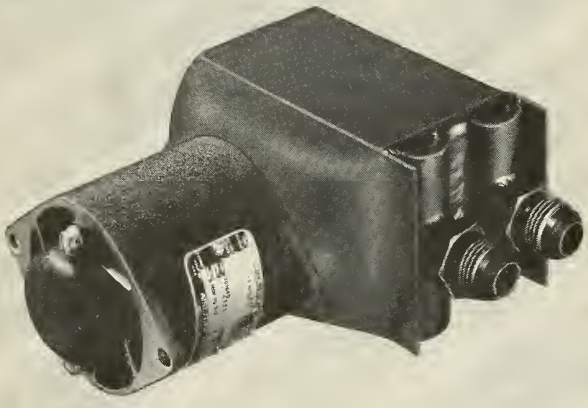
This may not be good practice for two reasons: the first and most obvious is the expense involved for labor and materials; and the second and more important is the danger that the replacement part is not as reliable as the original, or that the replacement technique, such as soldering, has introduced another factor of unreliability.

By applying the knowledge that can be obtained from failure rate curves, preventive maintenance programs could be streamlined or realistically redesigned. Utilization of marginal testing techniques could also be an important factor in these programs to determine when a component needs to be replaced.

The road to reliability lies in the proper engineering application of component parts. These are the basic building blocks of our electronic systems; but before they can be intelligently applied, we must know their strong points and weaknesses, their failure and shortcomings.

Where can reliability information be obtained? Valid, but limited, component capability data is available in reports such as those prepared by ARINC, Vitro, BuShips, etc., and in some cases in component manufacturers' literature. But the scope of this endeavor must be greatly broadened if the degree of reliability necessary for today's complex systems is to be achieved. A concerted attack must be made on the "reliability barrier" by exchange of information among manufacturers and by systematic preparation of handbooks such as those available in the mechanical and structural engineering fields.

The task ahead is formidable, but by no means insurmountable. To attain our goal—elimination of the reliability barrier—industry and government agencies must sponsor the preparation of electronic component handbooks. Furthermore, the entire team, from designer to field service engineer, must become well-versed in the proper utilization of component capability data. ★



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Fan Pressure Rise	1.2 inches water
Heat Exchanger Pressure Drop	1.0 inches water
Liquid	Water Methanol (70% Methanol)
Liquid Flow	0.4 GPM
Heat Rejection*	300 Watts
Fan Power	30 Watts, 110 V., single phase, 400 cycle
Package envelope dimensions	7 x 6 x 3 inches
Package wet weight	2.5 lbs.

*Assumes Class A (85°C.) electronic components, liquid inlet temperature to heat exchanger, 55°C. Includes heat from fan motor.

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ICBM and anti-missile missiles force reassessment of measurement technique

new missiles strain test art

by Henry P. Steier

PERFORMANCE REQUIRED of present-day missiles has begun to strain the capabilities of available astrionics instrumentation to check performance. This condition will be aggravated when flight tests on ICBMs and anti-missile missiles get under way in the near future.

Much of the success of future missile programs depends on more rapid strides in the field of electronic trajectory-measurement systems for missile tests, according to a paper delivered at the Western Electronic Show and Convention by Vernon L. Miller, White Sands Proving Ground, N. M.

"The task of instrumenting the present and planned missiles presents some nearly insurmountable problems. The expense involved in missile tests and the shortage of range time precludes the firing of large numbers of missiles with a hit-or-miss evaluation technique. The least expensive and most expeditious course is to fully instrument a limited number of missiles. Some of the problems placed on the present systems are quite severe. It is these more severe requirements that present today's problems, and these are the problems which must be solved if missile development programs are to attain success while remaining within reasonable development times."

Typical Future Requirements

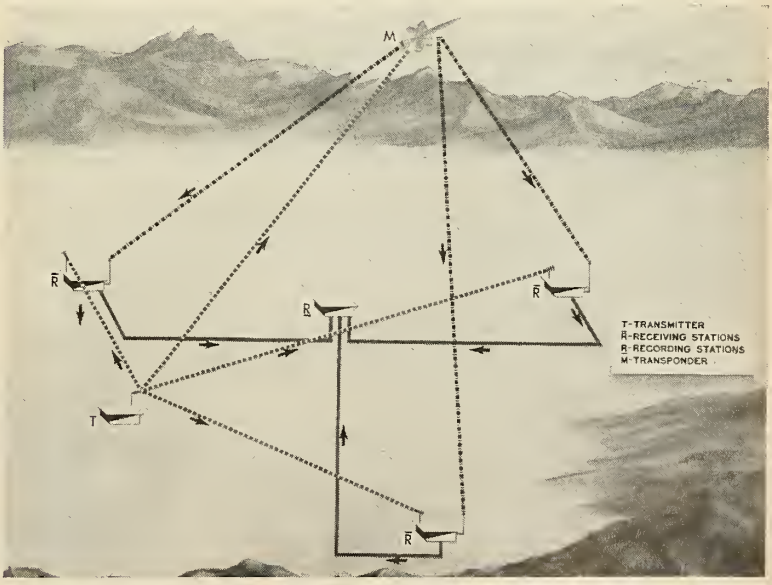
The precision with which the burnout conditions of an ICBM ballistic missile must be measured typifies measurement conditions facing designers.

If the missile has a 5000-mile range with a circular error probability (CEP) of one mile, a velocity measurement error of one meter per second or an angular measurement error of 0.01 degree is excessive to the performance design tolerance of the missile.

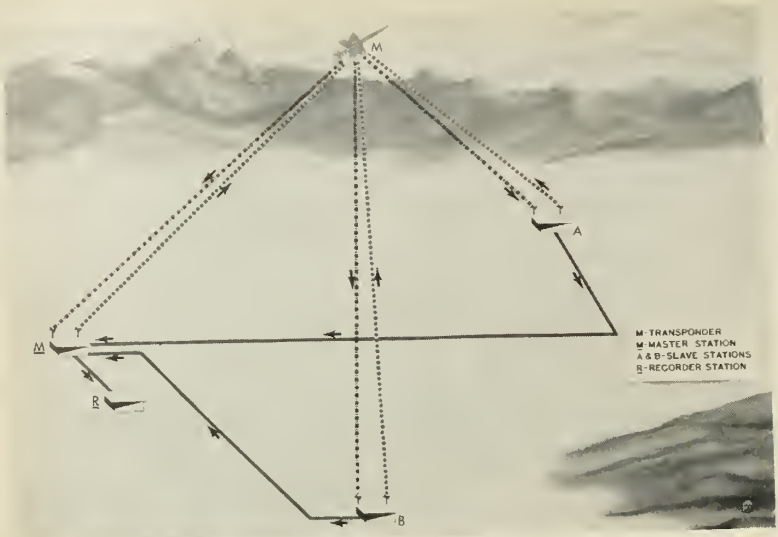
Such tolerances would give a measurement error greater than the specified CEP of the ICBM. Added to the close measurement required is the handicap of making the measurement hundreds of miles from the nearest instrumentation facility. Even with short-range missiles, the difficulty is present since these may have smaller specified CEPs.

Instrumentation of the anti-missile missile goes beyond ICBM requirements. Measurement of needed miss-distance data will be strained by the high closure rates. Miller says these will be in excess of Mach 10, and it will be "next to impossible to predict within 25 miles or more where the encounter will occur."

Add to this the safety problem. High maneuverability is needed in ad-



Electronic trajectory measuring system using Doppler effect. In missile, signal is doubled in frequency and sent to receiving stations for analysis at different positions.



Phase measuring system. Stations send and receive a signal in sequence. Phase shift is proportional to change in path length. Station gets independent readings.

dition to high speed. Position data required during an anti-missile missile test flight must be not only highly precise but instantaneously available to prevent the anti-missile missile from going hundreds of miles off course and doing damage in event of guidance-system failure.

The high-altitude research rocket presents its own stringent problems. Necessary accuracy for position might be within one meter, and velocity within 0.1 meter per second while the vehicle is at 200 miles altitude.

Such measurements mean obtaining accurate data within three parts per million. On an angular basis it amounts to measurements within 0.6 seconds of arc.

Basic Techniques

At this time there are about 30 electronic trajectory systems in use or in development. A basic similarity between the systems is measurement of radio-signal propagation time. The measurement is done in different ways. These form different geometrical configurations of data-acquiring equipment stations.

Combinations of measurement methods are selected for applicability to different tests depending upon parameter accuracy, degree of automation and logistic needs.

What the trajectory systems provide is a time history of the missile flight path. This is in the form of space-position data with velocity and acceleration derivatives.

These data are used for post-flight analysis of missile performance, or for control of missile while in flight. Latter applications might be for real-time trajectory measurement for flight-safety control, miss-distance measurement, navigation when missile data sites are shipborne or airborne, or real-time systems that are part of a control loop.

Measurement of propagation time is done in three ways: pulse time, frequency measurement, phase measurement. Systems in the vehicle may be passive or active-passive requiring no transponder, or active requiring a transponder. Another (hybrid) system requires no transponder but uses an rf signal generated in the missile to operate a telemetry transmitter.

Ground systems may be of multi-station type where stations are distributed over a test range to give the required geometry, or a single-station which yields all measurements to obtain trajectory data.

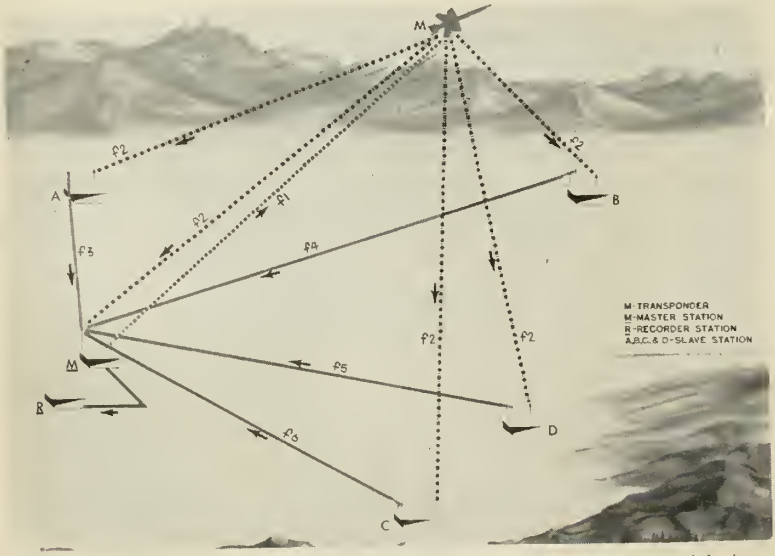
Although categories of trajectory systems based either on geometry or measurement techniques are not distinctive, they may be arbitrarily divided in four groups: Doppler phase measurement; pulse time measurement; interferometer.

Present Systems

Some factors to be considered before a trajectory measurement system is selected are:

- Can the missile accommodate a transponder and antennas?
- What is the trajectory? Accuracy and resolution of systems are different for different trajectories.
- What is stability and accuracy of data derivatives? A system may produce medium-accuracy position data and high-accuracy velocity data or the reverse of this.
- Cost balance between expensive single-station systems and lower cost available multistation systems.
- Data transmission costs for multistation systems.
- Is real-time data needed or will rapid data-reduction techniques suit the need?
- What are the frequency requirements? Spectrum availability, interference and propagation problems must be met.

Two of the most common Doppler systems are DOVAP and TRIDOP. Known as "elliptical" systems, they use the principle of detection and integration of Doppler frequency shift resulting from missile velocity.



Radar triangulation pulse time system. Pulse-modulated carrier is frequency shifted in missile. This signal is again shifted by slave stations and sent to master station.

A high-stability rf signal is sent to the missile from a ground reference transmitter. The signal is received by a transponder in the missile and a number of ground based receivers.

In the missile the signal is doubled in frequency and retransmitted to the ground receivers. Comparison of the original and doubled signal gives a Doppler "beat." By integrating this signal a loop range representing distance from transmitter to vehicle and back to the receivers is obtained.

The loop range is a non-directional quantity and describes ellipsoids of revolution with the transmitter and receivers as foci of the ellipsoids. By solving for the intersection of three or more ellipsoids, space position of the missile is determined. By successively differentiating the position data, velocities and acceleration at different points are obtained.

There are other Doppler systems such as PARHOP, which uses no transponder but depends on reflection of a continuous wave signal. SPHEREHOP eliminates the transmitter-to-missile link by using a very stable oscillator in the missile. Reflection Doppler uses a single station to derive velocity data only.

Among the phase measurement systems are ROMOTAR, SECOR, and DORAN. Station configuration for these can be similar to DOVAP's. Geometry of the system may be elliptical or spheroidal. With these a group of ranging frequencies modulate an rf carrier sent from a master station. The signal is received in the missile and at ground receivers. In the missile, the rf carrier is offset in frequency and retransmitted. The frequencies received from the missile by the ground receivers are different in phase from those received by the master station.

Phase shift is proportional to changes in path length throughout the trajectory. Using four or five modulating frequencies, high precision, non-ambiguous readings may be obtained over long ranges.

Another of the phase-measurement systems uses a transmitter and receiver at each ground station. Controlled sequencing of transmissions is used and each transmitter interrogates the missile in turn. Each station obtains a range measurement and missile position is determined from the system of spheroidal loop range data obtained.

Pulse time systems are basically applications of radar technique. They are based on transit time of a pulse from a ground transmitter and return. One of these is the radar triangulation MIRAN system.

With MIRAN a pulse-modulated carrier is sent to a missile. The missile receives it, shifts the frequency and retransmits the signal to slave receiving stations on the ground.

The slave stations offset the received frequency and beam the signal back to a master station. At the master station the times for transit of the pulse from the missile to each of the slave stations is measured. Missile position is obtained by solutions similar to previously mentioned systems.

Some of the electronic interferometer systems are MINITRACK, COTAR and EMA. MINITRACK will be used to track the satellite launched from the Project *Vanguard* vehicle. Such systems perform angular measurements by comparing phase of a signal received from a missile at two antennas mounted on a short baseline.

The phase difference is related to the direction cosine of the angle. To obtain high precision and ambiguity resolution, multiple antennas are used on short and long baselines. Also, by crossing baselines two direction cosines are found from which azimuth and elevation angles can be obtained.

If such a facility is combined with a means of range measurement of the Doppler or phase measurement type, the system becomes a single-station system. Sometimes two or more angle measurement stations are set up on a long baseline to permit triangulation for obtaining position, velocity and acceleration data.

The EMA system is not a trajectory measurements system but gives

low-precision information so optical instruments may receive the vehicle being tested.

Future Systems

There are other systems available which, because of security, cannot be discussed. Others are under development. However, to get the utmost out of any system and to select one that will do a particular job, considerable system analysis is required before it goes into use.

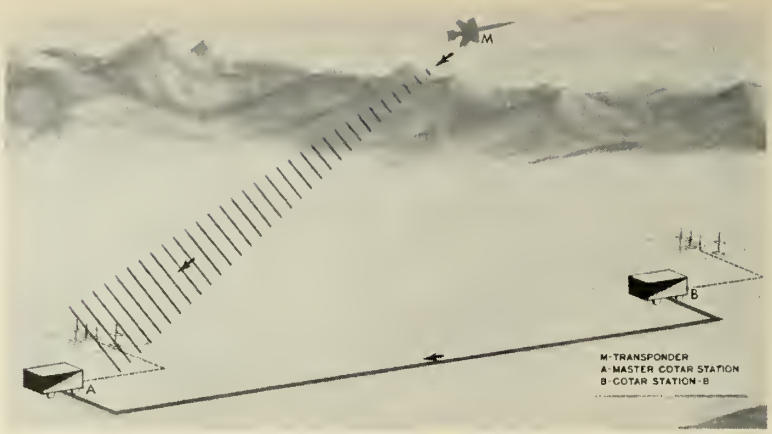
According to Miller the trend in the past few years has been to specialization in error analysis of trajectory systems. This work is aimed at verifying measurement precision. These tests must often be dynamic, involving actual missile flights.

At this time the study of errors is directed to simplification of analysis by obtaining a mathematical method for describing the geometry of various systems. A mathematical approach will show which systems of geometry are best for exploitation.

After that, precision figures could be obtained for every conceivable technique. This would result in a tabulation of statistical figures for application to system selection.

This information would enable rapid selection of a particular geometric configuration to satisfy a given set of parameters established by the missile in question and reveal what must be learned about it.

Other problem areas that must be included in the new analytic tool that will become available are effects of ionospheric refraction, flame attenuation of electromagnetic radiation, ionization shields around high speed missiles and effects of atmospheric noise.



Interferometer system similar to MINITRACK, using two stations to measure phase difference at multiple antennas. Two-station system gives position, velocity, acceleration.

Another trend in this field is consideration of measurement system requirements at the time a missile is conceived. Specific provisions are being made in designs to include necessary instrumentation as part of the system design.

Miller predicts that we will ultimately have measurement systems in which trajectory, telemetry and real-time control are a single integrated system. ★

Special dust-free labs required in the development of air-bearing gyros

air-lubricated gyros

By Norman L. Baker

THE DEVELOPMENT of the guided missile has opened many new fields of engineering. New approaches to the engineering field have led to the rapid growth of new techniques. This applies particularly to the technology associated with ballistic-missile guidance, which is spearheaded by the Missile Development Division of Ford Instrument Co.

This group is currently engaged in work on two missile programs for the Army Ballistic Missile Agency at Redstone Arsenal. The first of these programs involves the *Redstone* missile and the other, the *Jupiter* missile.

In nearly five years of engineering and manufacturing effort, a highly successful product-improvement program on missile guidance and control components has been achieved, in particular on the Redstone Arsenal-developed air-bearing stabilizing gyros and air-bearing gyro accelerometers. These air-bearing devices are major components of the stabilized platform used as the nucleus of the navigation system of the *Redstone* missile.

The air-bearing gyro and air-bearing gyro accelerometer were developed by Redstone Arsenal and adapted for production by the FICo, the only company in the U. S. that manufactures such a gyro.

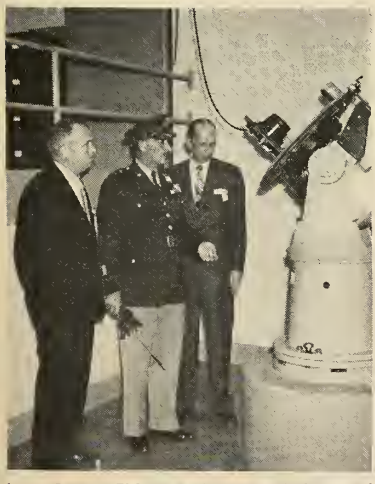
At the present time, work on the *Redstone* missile program includes an evaluation and improvement program aimed at determining the extent to which the guidance and control system components will withstand the rigors of military storage, handling and firing. Components are subjected to the most severe climatic and environmental conditions they will face during storage, handling and firing by the Army's own personnel. Invariably, these environmental tests demonstrate weaknesses in design which can only be detected by semidestructive environmental testing.

Early in 1956 FICo launched the second of its ballistic missile programs. The character of the *Jupiter* engineering effort now in progress differs markedly from the current *Redstone* missile work. While the *Redstone* project has progressed to the point where existing designs are continually improved and reimproved, the *Jupiter* work involves the formulation of the first designs of experimental missile hardware. However, much of the theory underlying *Redstone* guidance, and much of the experience gained in developing guidance and control equipment for the *Redstone*, is directly applicable to the *Jupiter* missile work

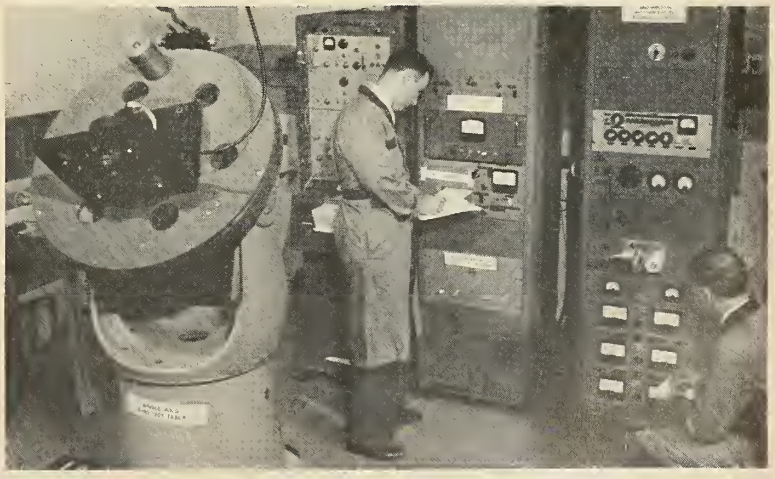
A modern gyro-test lab was set up to evaluate and measure the accuracy of the ultrasensitive air-bearing gyroscopes used in the *Redstone* and *Jupiter* guidance systems. Experience has shown that even the smallest dust particle could create an unbelievable amount of friction torque in the presence of ultraprecision gyroscopes. With this uppermost in the minds of the planners, the lab was designed to be one of the cleanest and most dustproof in existence.

The completely enclosed laboratory is windowless and has a minimum of horizontal surfaces. Extra plaster was applied to areas between ceiling and walls to round off what normally would have become right-angled dust-collecting spaces. All wires are hidden within the walls and receptacles and fixtures are flush with the walls. Floors, ceiling and walls are smooth and clean. A specially-treated dust-absorbent mat covers the area between the vestibule and the outside door.

In the vestibule are lockers for changing clothes. Employes working in the gyro lab must remove their shoes before entering through the heavy, win-



Larry Brown, FICo, ABM9 Gen. Medaris and Raymond Jahn, Pres. FICo, visit gyro lab.



Engineers examine air-bearing gyro drift data that has been recorded by drift-rate measurement apparatus. Equipment will measure angular drift rates of one revolution in 40 years.

Engineer installs an air-bearing gyro on sensitive equatorial test stand in FICo test lab.

dowless double doors opening into the main work area. They must wear special, lint-free white coats.

Sheet linoleum was selected for floor covering, since tile and many other materials would have been broken up by dust-collecting crevices. A dustproof public-address system is housed in the ceiling for convenient interlab communication. This eliminates any unnecessary traffic through the lab.

Eating, drinking and smoking in the work area are taboo. No "unnecessary" tools or equipment may be brought into the lab, mainly to keep out additional potential dust carriers. Consideration is being given to the drilling of a periscope-type device through the outside wall so the night watchman can inspect the area without danger of carrying dust inside the lab.

Daily all surfaces, such as desk and bench tops, are vacuum-cleaned, using a brush attachment. Plastic waste baskets of the dustproof, washable type are used and are emptied outside. Glass surfaces are cleaned with a moistened cellulose sponge rather than with a dust cloth or broom. All floors are cleaned with cellulose mops.

All walls and ceiling areas of both main laboratory and vestibule are vacuum-cleaned. They are also cleaned with a cellulose sponge using warm water and a mild detergent. Every effort is made to prevent the water from dripping. The floor is waxed with a cellulose-sponge attachment using a special dust-resistant mixture.

Porters wear white coats, white gloves and moccasins over their shoes when working in this area. But no gloves are worn during any washing procedure. Equipment belonging to the lab porters is thoroughly cleaned after use before re-storing in special lockers. Periodically the inside of the duct work for the air conditioning and heating systems are vacuum-cleaned.

Outside experts were called in to further insure that the area be free of dust. The finest available separately controlled air conditioning and heating plants were installed in a room directly below the lab. The air conditioning features a special-type filter often used in Atomic Energy Commission work. It is believed to be the most completely dust-free filter yet made.

An air compressor was purchased to provide the gyro lab with clean, dry, filtered air free of contamination and oil vapors. This is the same type of air compressor used to supply air for hospitals. A special air dryer has also been installed.

Temperature and humidity controls were built into the walls to provide complete control of temperature and humidity for the extremely sensitive gyroscopes being tested.

The lab was located in an area of the plant where building vibrations from any cause were minimized. Simple tests with a pool of mercury and a vibration meter helped determine the most vibration-free site. The area also had to be soundproofed to reduce the noise coming from high-speed rotating machinery used to test the gyros.

The Coast and Geodetic Survey, which specializes in precision mapping of the U. S., was called in to establish a line between two bench marks. From that line the engineers were able to orient a rotating test stand so its axis was parallel to the earth's axis.

FICo expects this lab to play an increasingly vital role in the current era of guided missiles and the not-too-far-off era of space travel. ★

Measurement of drift rate of the air-bearing gyros in the REDSTONE's guidance system.

thermocouple application for ballistic missiles

Temperature measurements are accomplished by thermocouples in Redstone and in Jupiter

By Charles T. N. Paludan
Army Ballistic Missile Agency

THE MOST RELIABLE temperature measurements that can be made on a ballistic missile, from a mechanical standpoint, involve the use of thermocouples. A thermocouple measuring junction can easily be located at practically any point within or on the missile. This is not always true in the case of resistance thermometers, thermistors, gas, vapor pressure or bimetallic thermometers.

In many cases a thermocouple installation may be exceedingly rugged. At the present state of the art the insulation resistance problem gives the thermocouple a decided advantage over resistance-type measurements at high temperatures.

Three primary problems are associated with thermocouple measurements: (1) low output, (2) lead resistance and resistance change, and (3) the reference junction temperature.

The low output problem can be solved by means of a stable, high-gain DC amplifier of the magnetic, chopper, or transistor type. As most thermocouple materials have a high resistivity and a high temperature coefficient of resistance, large errors are possible if long leads and severe environmental temperatures are involved.

This error could be minimized by avoiding long leads of thermocouple material, changing over to low-resistance copper wires for the major portion of the distance. This could be done by placing the reference junction near the measuring junction.

The reference junction temperature must be determined in order to evaluate the output of a thermocouple system in terms of measuring junction temperature. This is commonly done in the laboratory by immersing the reference junction in an ice bath or, for less precise work, by determining the reference junction temperature by means of a mercury-in-glass thermometer.

Industrial and missile applications, involving the use of meters or recorders, make an automatic or semiautomatic correction for ambient temperature changes by means of a bimetallic device, a thermistor, a resistance thermometer, or a moving vane. Slide-wire potentiometers are often equipped with similar devices.

Another method is to maintain a fixed, higher-than-ambient temperature within a small oven. A much simplified but far less elegant method would be to imbed the reference junction in some material of high heat capacity, measure the temperature with a mercury-in-glass thermometer, and assume no change for a given length of time.

Oven devices have been used extensively and are available commercially from a number of manufacturers. One such device, developed for the Army Ordnance Corps by members of the Chrysler Corporation's missile branch, has been used for a number of temperature measurements in the *Redstone* missile (Fig. 4).

This device, although successful, did not eliminate the problems of long thermocouple leads, the need for thermocouple material connectors, and the inability to read temperatures below the oven's set temperature. Furthermore, the oven acted as a heat source which was sometimes troublesome when it was operated near temperature-sensitive equipment.

In order to prove that all temperature-measuring equipment was func-

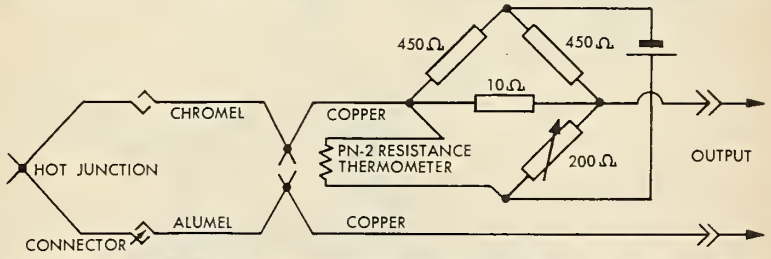


Fig. 1—Circuit diagram of first reference junction system for the REDSTONE missile. The ambient-temperature-sensing thermometer dictates proper correction into the system.

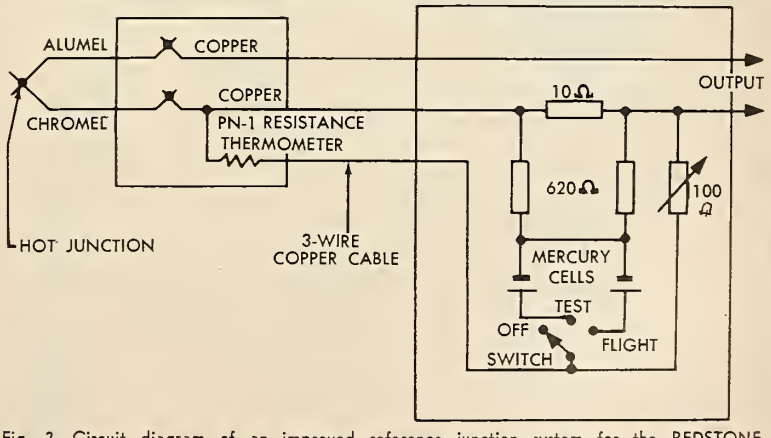


Fig. 2—Circuit diagram of an improved reference junction system for the REDSTONE. Dependability of the system is largely a function of the stability of the mercury cell.

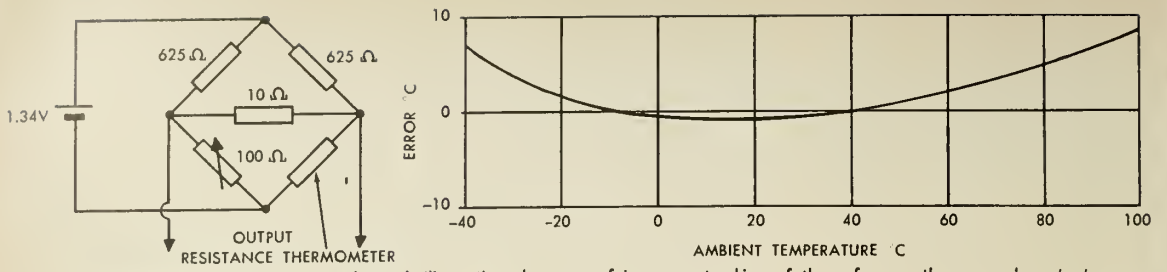


Fig. 3—Circuit diagram of "zone box" and graph illustrating the error of improper tracking of the reference thermocouple output.

tioning properly before a missile launching, it was necessary to read the ambient temperature which was usually on the order of 25°C. Many of the measuring points were inaccessible for external heating.

An actual ice bath reference would be impractical for missile use because of the difficulty in servicing it. Furthermore, it would not eliminate the extension lead problem of the scattered measuring points. A series thermistor compensator would be difficult to devise because the impedance of the amplifier system would vary for different ranges of measurement. A series thermistor device would still give zero output at ambient temperature, an undesirable condition.

Basically, the reference junction problem is one of knowing the reference junction temperature. As this knowledge is useful only as a correction, it would be sufficient if the correction were made directly in the measuring system.

If the reference junction is to be at ambient temperature with no resort to ice or oven, and is to be located near the measuring junction, the ambient temperature must be sensed at that point. The ambient-temperature-sensing organ would then dictate the proper correction into the system. As the required correction is electrical, a resistance-changing sensing organ is needed. Inexpensive resistance thermometers are available which will serve the purpose.

Figs. 1 and 2 are circuit diagrams and essential parts of a system meeting the requirements just outlined. Fig 1 depicts a system which has been used for several hundred measurements in the *Redstone* missile. Fig. 2 is an improved version for use in the *Redstone*.

As can be seen in the circuit diagrams, the resistance thermometer senses the reference junction temperature, operates into a deflection-type wheatstone bridge which draws power from a mercury cell, and applies a correction across a ten-ohm load resistor which is in series with the overall thermocouple circuit. The error introduced by the series ten-ohm resistor will be negligible if the impedance of the amplifier system is sufficiently high. At any rate, it can be calibrated out.

The dependability of the system is largely a function of the stability of the mercury cell. It is desirable to use a fresh cell for the missile's flight, because check-out procedures at the launching site may have exhausted the energy of the original cell.

In most cases the measuring junction is in direct contact with some metallic part of the missile. This makes the junctions electrically common. For this reason a separate compensating system and mercury cell are required for each measurement.

The original equipment shown in Fig. 5 required mercury cell servicing at each installation point. In some cases this would be an advantage; however, the complexity of a large missile system such as *Redstone* or *Jupiter* makes the task of battery replacement rather formidable. For that reason the new system (Fig. 2), with its centralized batteries was evolved. In either case the individual cell lifetime would be several weeks.

Utilizing an adjustment potentiometer, the reference setting may be varied so as to give artificial reference temperatures at levels other than 0° C. In that way it is possible to make thermocouple temperature measurements with elevated or depressed temperature levels of zero electrical output. For example, a measurement might have a span from −50°C to +500°C, in which case the thermocouple com-

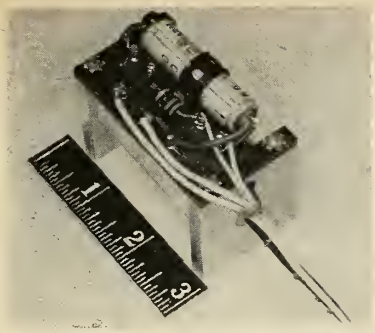


Fig. 4—Oven device for temperature check.

Fig. 5—REDSTONE reference junction system.

pensator system would have zero millivolts output at −50°C.

The accuracy of the system presented here depends on the ability of the resistance thermometer-bridge system output to track the output of the actual reference junction thermocouple. As the load resistor of the bridge is in series with the output of the system, it must be kept small—about ten ohms.

The voltage supply to the bridge is fixed by the potential of a single mercury cell. Series cells are ruled out for reasons of reliability. In order to obtain sufficient output from the bridge, the ratio of the high to low resistance arms of the bridge is somewhat small with the result that the bridge output is unlinear. Therefore, the compensator circuit does not track the reference thermocouple output perfectly. However, the tracking is sufficiently close for most practical purposes over a considerable span of ambient temperature. Fig. 3 illustrates the error resulting from improper tracking.

The system described has been given the name "zone box." The name was suggested by the fact that the unit includes a zone of equal temperature for the reference junction thermocouple and the resistance thermometer.

Development work on the zone box was done in the RF, Telemetering and Measuring Section of the Guidance and Control Laboratory, Army Ballistic Missile Agency, Redstone Arsenal. ★

Long Range Telemetering Transmitter

The demand for extra radiating power near the terminal phase of missile flights has led to the development of a small transistorized 200-watt transmitter with an extended range.

It is in the terminal phase of flight that many unpredictable problems occur, and until now this has been the very region in which background noise has blacked out the weakening telemetered signal. Stepping up transmission power will override background noise and extend transmission range considerably beyond line-of-sight limits imposed by present transmission equipment.

Transistorized to the practical limits of the state of the art, the new 200-watt PM transmitter was developed by the apparatus division of Texas Instruments Inc. It increases substantially the effective range of FM FM telemetering. The new equipment is complete in a single unit and requires no amplification of the output. It is small and lighter than currently available 50-watt transmitters for similar duty, occupying only 67 cubic inches.

The new units transmit in the 215-235 mc range with frequency stability of plus or minus 0.01 per cent up to 71°C. Higher frequencies are possible with only minor modifications. The basic unit can also be modified to operate at power outputs as low as 25 watts. Operation at 200 watts requires 12 cfm external cooling air.

Thermal control

Integral "heat sink" provisions are ideally suited to missile requirements, stretching out the transmitter's operation during periods of rapid build-up—for example, during re-entry into the atmosphere. High-temperature silicon transistors are used in the oscillator, phase modulator, video amplifier, and frequency doubler circuits. The output stage utilizes a stacked ceramic tetrode with considerable excess capacity, and tubes are also used as drivers and multipliers.

Texas Instruments is also supplying components for the instrumentation package of the *Far Side* high-altitude test program now underway.

Plug-in Telemetry Units Explored by Seeburg

Telemetry systems with removable circuits that may be used in varying combinations to provide telemetering equipment for any missile test program are being developed by J. P. Seeburg division of Fort Pitt Industries, Inc.

Seeburg, developing the basic "building-block" components with its own funds, feels that the advantages of such a flexible telemetry system are almost unlimited. The individual plug-in circuits would also allow changing of functions within a missile's telemetry.

Radio Spectrum Study Approved by EIA Board

A cooperative long-range study of the radio spectrum, covering both military and civilian uses of frequencies, was approved in principle by the board of directors of the Electronic Industries Association at the conclusion of a three-day EIA conference in Los Angeles.

The proposal for the study emphasized that the radio spectrum is one of the most valuable national resources and that its full value can be realized only by means of frequency allocations based on comprehensive technical information.

Big Antennas Replaceable With Smaller Units

Two scientists of Bendix Aviation Corp.'s systems division have announced a technique whereby extremely large and complicated antenna structures can be replaced by much smaller and simpler structures.

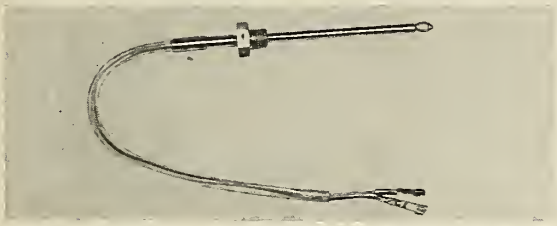
The scientists, Dr. Winston E. Kock and Dr. Jack L. Stone, described an example where the beam of a parabolic dish 10 feet in diameter was duplicated by three small wide-band receivers arranged in an equilateral triangle, six feet on a side.

The technique is applicable to sonar underwater sound systems, radio astronomy and other forms of radio and radar.

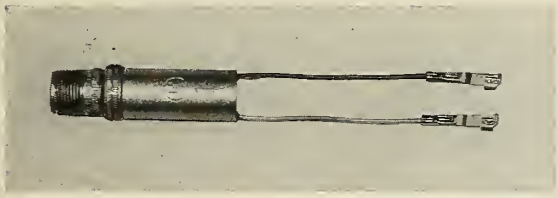
New Universal Temperature Measuring System

Rugged and reliable – extends use of thermocouples, eliminates icebath and oven references

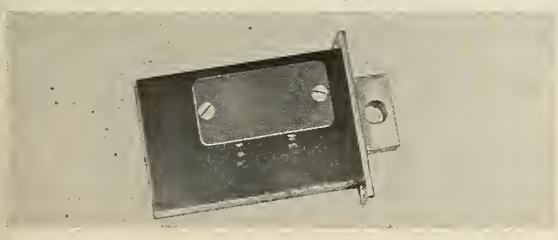
Simplified system accommodates all three gauge types. Magnetic-amplifier "heart" makes possible low-span thermocouple measurements up to 2000°C. Developed for a major missile program, system is fully flight-tested. Offers industrial uses, too.



Use of thermocouples as sensing elements boosts measurement level from 900°C to a new maximum of 2000°C. Characteristic ruggedness of thermocouples also increases system reliability. Thermistors or resistance thermometers may also be used as system requires.



Compact, inexpensive "zone box" (part no. 91-101-0) does away with icebaths and ovens by simulating exact reference temperatures electrically. Box mounts near thermocouple, thus eliminating long leads. It withstands extreme environments without losing accuracy. Since each thermocouple feeds into its own zone box, referencing is decentralized, system reliability and flexibility are further increased.



Zone box adapter (part no. 91-102-0) permits easy, precise adjustment of thermocouple reference to point desired. Adapter suitable for operation into low- or high-impedance instrumentation. Both adapter and zone box are manufactured by Magnetic Research Corporation to ABMA specifications.

Micromag MM 423 low-level dc magnetic amplifier is the virtually indestructible heart of the system. It is the stability of this unit that makes possible the use of thermocouples under severe operating conditions. Amplifier drift is less than .1% over 2000 hours. Voltage gain of 500 simplifies small-span measurements with any of the three gauge types. Unit is temperature compensated for high gain stability. Used with or without zone box and adapter, the Micromag ups reliability of temperature and strain measuring systems.

SPECIFICATIONS OF MICROMAG* MM 423 LOW-LEVEL MAGNETIC DC AMPLIFIER

Voltage Gain:	500
Input Resistance:	200 ohms
Drift:	Less than .1% over 2000 hours
Output:	0-5 VDC into 100 kilo-ohm load
Response Time:	80 milliseconds
Compensated Temp. Range:	0 to 60°C (can be extended to 85° upon request)
Environment:	−55° to 105°C
Power Source:	105-125 VAC, 400 CPS
Vibration, etc.:	Designed to meet MIL-E-5272 specs.
Volume:	Less than 7 cubic inches
Weight:	11 ounces

MM 424 Micromag Low-Level Magnetic DC Ampifier Same model as above. In addition, it provides its own DC voltage regulated to .1% to replace mercury batteries in Zone Box system or power bridge type measuring devices.

MMO 528 Micromag Low-Level Magnetic DC Amplifier Same as Model MM 423 above, but powered from unregulated 28 VDC system.

Write or telephone for technical information on MRC temperature-measuring systems and components. Our Engineering Department will be glad to discuss your special needs.

MAGNETIC RESEARCH CORP.
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ONLY 2.0 WATTS AT NOMINAL VOLTAGE FOR 12 MILLISECONDS EFFECTS ARMATURE TRANSFE

NEW
POTTER & BRUMFIELD
KG SERIES RELAY

The new KG magnetic latch relay was designed by P&B engineers at the insistence of leading aircraft and missile manufacturers and their suppliers of control systems. A permanent magnet which locks the armature into position is the secret of the KG's dramatically high resistance to shock and vibration.

In addition to withstanding 30g vibration from 6 to 2000 cps, tests show the contacts will open for no more than 80 microseconds during 100g shock.

Armature transfer from one set of tl 6PDT contacts to another can be made i approximately 12 milliseconds with only 2 watts at nominal voltage. The KG is rat for ambient temperatures from −65°C t +125°C.

The KG, together with other relays in tl P&B "Star Series", has vastly increased tl realm of relay reliability for critical applic tions demanding positive action of all cor ponents. Write or wire today for comple technical data.

POTTER & BRUMFIELD, INC., PRINCETON, INDIANA—SUBSIDIARY OF AMERICAN MACHINE & FOUNDRY COMPAN

industry briefs

Northrop Creates Nortronics Division

Northrop Aircraft, Inc., has created a new division, to be called Nortronics, which will handle the company's operations in the design, development and manufacture of electronic, electro-mechanical and opto-mechanical products and components.

The establishment of the new line operating division will enable the company to collect its work in these fields under a central detailed management. In creating Nortronics, the company elected Dr. William F. Balhaus a vice president of Northrop Aircraft, Inc., and assigned him duties as general manager of the Nortronics Division.

Babcock Opens Facility To Consolidate Plants

Babcock Radio Engineering, Inc., has opened a new facility at Costa Mesa, Calif. The 25,000-sq. ft. in plant area will allow consolidation of all the company's divisions in a central location.

Babcock is producing drone guidance and electronic ground support equipment for Beech and Radioplane drones and also for several leading missile programs.

Micronics Gets R&D Contracts

Three research and development contracts covering guided missile components have been awarded to the Micronics division of Elgin National Watch Co. The new contracts total approximately $500,000 and have been assigned to the division's West Coast R&D laboratories at Burbank.

Atomichron Contract Awarded to National

National Co., Inc., communications equipment and atomic clock manufacturer, has received a $609,525 contract from the Army Signal Supply Agency for development of military-type atomichrons. The device is used for super-accurate timing involving missile guidance.

Era Engineering Gets Development Contract

Era Engineering, Inc. has signed a contract with Douglas Aircraft Co. for development of an in-flight instrument to measure thickness of a material sample. The material erosion rate instrument is transistorized and withstands high acceleration loads.

glossarifery

As in other arts and sciences, the field of instrumentation and automation, in growing, has developed its own vocabulary. As a public service, and in an effort to promote communication with the outside world, we set forth below definitions of the most commonly used terms.

AIRFRAME: Ambiguous terminology. May mean either a frame constructed around a body of air, or a body of air surrounding something.

ALCLAD: Entirely clothed.

BASE METAL: A term used by makers of aluminum products in referring to stainless steel and vice versa.

BLUEPRINT: A melancholy reproduction.

BREEDER REACTOR: Two rabbits of opposite sex.

BINDING ENERGY: Energy required to tie up a package.

CHAIN REACTION: Longitudinal waves in a light chain when one end is vibrated.

CHAPERONE: Force action on a couple to maintain it in a state of equilibrium.

CHARACTERISTIC CURVES: Easiest way to distinguish between a steward and a stewardess.

CHIEF ENGINEER: A person totally devoid of all engineering knowledge who married the boss' daughter.

CLOUD CHAMBER: A bedroom with clouds.

COSMIC RAY: A ray of powder, rouge and lipstick.

CYCLOTRON: Electron on a bicycle.

ELECTRON: A man up for election.

ENGINEER: One who is educated in the art of developing new and different ways of making the same mistakes.

FAHRENHEIT: A system of measuring vertical height above the earth's surface. One Fahren equals 0.53959 nautical miles.

FISSION: Drowning worms on the end of a stick.

FITTING FACTOR: A process used in structural analysis whereby a factor is manipulated so as to fit a particular requirement.

FRESHMAN ENGINEER: A young man who knows why a strapless gown is held up but doesn't yet know how.

HYDROGEN: An alcoholic beverage consisting of water and gin.

ISOTOPE: Ski area covered with ice.

K-ELECTRON CAPTURE: Russian electron in captivity.

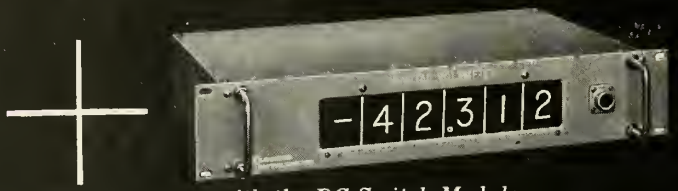
MESON: My son (colloquial).
NUCLEI: A recent lie.
OHMETER: One who eats ohms.
OXIDE: The hide of an ox.
PILE: Big heap.
PHOTON: A man who takes pictures.
PLANCK'S CONSTANT: The amount lumber is reduced from given dimensions when purchased at a sawmill.
POSITION: A man who is always right.
QUANTUM: A large sum of Wamptum.
RADIATION: Johnnie Ray's cousin.
REACTOR: An actor who takes part when an old play is produced.
REYNOLD'S NUMBER: 92-71941.
RADIOACTIVITY: A function with the use of a radio.
ROENTGEN UNIT: Unit price of a gun when rented.
SLIDE RULE: A baseball regulation.
TELEVISION: An improvement over radio. Now you cannot only hear static, you can see it, too.
THEORY OF RELATIVITY: A scheme for getting rid of your mother-in-law.
WOMEN'S TEARS: The first successful fluid drive.

Reprinted from ISA (Cleveland Section) Bulletin, Vol. 8, No. 1, Sept. 57.

Precision instruments for automatically measuring DC, AC-DC, Ohms and DC-AC ratios constructed from basic modules.

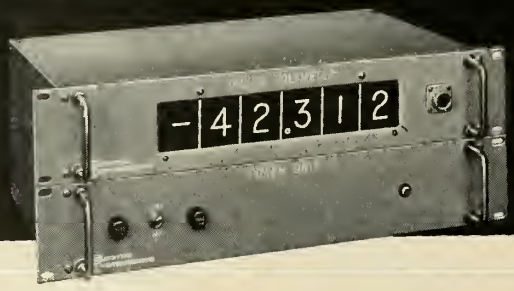
For example:

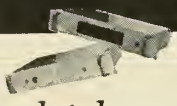
Combine the Universal Power Module



with the DC Switch Module

to get an 0.01% Digital Voltmeter





a completely new idea in digital instrumentation!

Now from five basic E-I modules, almost any combination of instruments can be assembled for precision, digital measurement of DC, AC-DC, Ohms and AC-DC Ratios. The basic E-I modules never become obsolete. As needs change, simply regroup or add new modules. This new modular concept provides maximum versatility and enables equipment to be kept current at minimum cost and engineering.

New engineering specification and other features have been incorporated into the basic modules from the experience of over 2,500 digital instruments in the field. Where applicable, all circuits have been fully transistorized to provide increased reliability, low power consumption, low heat dissipation and to eliminate radio noise and line transients.

New catalog sheets *give the complete story of this newest advance in digital instrumentation and complete specifications on all modules. Write for your set today.*

ELECTRO INSTRUMENTS INC. 3794 Rosecrans, San Diego, California

Circle No. 96 on Subscriber Service Card.

NEW MISSILE PRODUCTS

MINIATURE PUMP CARTRIDGE

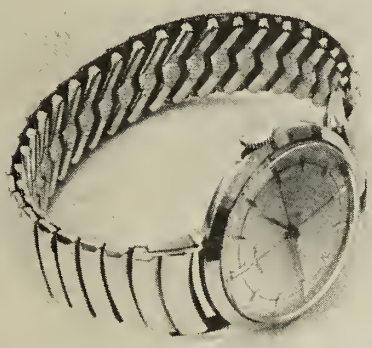
Miniature vane pump cartridges with a delivery capacity of 1.04 gpm at 1000 psi and 10,000 rpm are in production at Vickers, Inc. The unit weighs 2.5 oz. and has an output of 0.6 hp. Overall diameter is slightly less than 1 1/8".

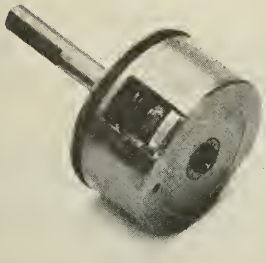
The pump may be supplied separately for incorporation into the user's housing either singly or stacked on a common shaft, or the manufacturer will furnish suitable housings. It can be manifolded with servo valves, miniature piston hydraulic motors and FHP electric motors.

The cartridge features hydraulic balance to eliminate pressure-induced bearing loads and the company feels that the performance figures currently cited will be extended. Shown with the cartridge is a standard wrist watch for comparison of size.

A minimum change in performance during the pump's life is expected by the company because optimum running clearances are automatically maintained by vanes and pressure plates that are self-compensating for wear. The cartridge incorporates many desirable features of the firm's larger models and overall construction is somewhat similar.

The unit is applicable for such operations as small radar or computer drives, electronic cooling, fuel pumps, missile skin cooling, flow dividers or pressure lubrication.





Circle No. 212 on Subscriber Service Card.

SILICON POWER TRANSISTOR

General Electric Co. has produced an 85-watt silicon power transistor said to have the highest power rating of any high-temperature transistor in the industry. The device will dissipate 85-watts at 25°C mounting base temperature and has a nominal collector saturation resistance of 2 ohms.

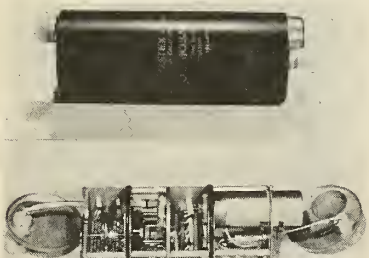
The component, designated the 2N-451, is produced by the vapor-diffusion process and is hermetically sealed in an all-welded case designed for mounting on an external heat sink.

Circle No. 210 on Subscriber Service Card.

BINARY TIME CODE GENERATOR

Giannini DATEX Model DC-103 produces a serial output of one synchronizing pulse followed by eight bits of binary coded DC timing signals per second. Total number of signals is 128.

Shock mounted, the unit withstands temperatures from —65°F to 170°F; linear acceleration of 75g along major axis; shock of 30g on any axis and vibration of 15g. It is completely enclosed in a hermetically sealed container and electrical connections are made through hermetically sealed plugs.



Circle No. 205 on Subscriber Service Card.

MIRROR GALVANOMETER

Hilger & Watts Ltd., of England, is producing a self-contained mirror galvanometer offering sensitivity as high as 2000 millimeters per microampere. The Hilger "Galvoscale," being handled in this country by Jarrell-Ash Co., features a brightly lit, built-in scale, fully legible under ordinary room illumination.

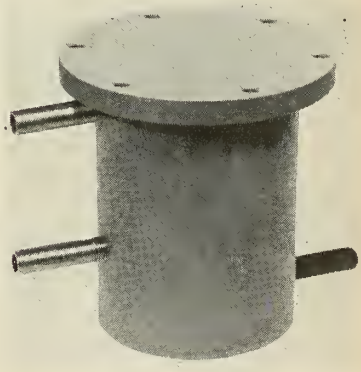
The magnified scale image moves below a stationary index line within a viewing hood and eliminates the visual effort, as well as the darkened room, required by other types of mirror galvanometer employing a traveling light spot and a stationary scale.

The instrument occupies table space of 12" x 21", but its scale length is equivalent to an optical lever nearly seven feet long. Both linear and logarithmic scales are available. Built-in shockproofing eliminates the need for special mountings.

Circle No. 209 on Subscriber Service Card.

ULTRASONIC TRANSDUCER

A high-efficiency ultrasonic transducer incorporating the most recent developments in magnetostriction transducer design has been developed by Massa Laboratories. The new device is said to be virtually indestructible and can operate continuously with 400 watts of power input with a conversion efficiency of 40%.



A sound pressure of 1 million dynes/cm² results in the vicinity of the transducer when radiating into open water with 100 electrical watts input to the structure. Cavitation is evident at this power level throughout about 80° total angle.

The polished stainless steel diaphragm has a radiating face 2 3/4" in diameter. Specifications: operating frequency—26 kc; impedance—150+j100 ohms; over-all dimensions—4 3/8" dia. x 4 7/8" long (6-ft. waterproof cable attached); water cooled, 5 gph for 30°F rise at 400 watts continuous input power; weight 6 lbs.

Circle No. 206 on Subscriber Service Card.

TELEMETERING SWITCH

A multichannel sampling switch designed for telemetering at altitudes up to 200,000 feet and at temperature from 125°C to —65°C has been developed by Applied Science Corp. of Princeton. It is available with from one to five

poles and with up to 60 contacts per pole at sampling speeds ranging from 0.5 to 30 RPS.

Various motor drives are offered and the speed regulation is ±3%. The switch withstands shocks of 150G bi-directional, 100G continuous acceleration bi-directional and a vibration of from 20 to 2000 cycles at 20G for ½ hour.

Circle No. 208 on Subscriber Service Card.

SUBMINIATURE COMPONENTS

New subminiature fixed glass capacitors are currently being produced by Corning Glass Works. Termed Corning WL capacitors, the radial lead units are being designed for printed circuit boards. Production is expected to begin in the near future.

No clamps are required because the high temperature soldered leads allow the capacitor to be connected directly to the breadboard. Both types of the component measure less than 0.1" thick, making them well suited for vertical mounting in small, high-rated circuits.

The units have a fixed temperature coefficient, high insulation resistance, low dielectric absorption and ability to operate under high humidity and temperature conditions. The capacitors are rated at full voltage at 85°C, and withstand temperatures up to 250°C for short time loads of low voltage applications.

Circle No. 200 on Subscriber Service Card

PRECISION RESISTORS

Epoxy-encapsulated wire-wound precision resistors, vacuum impregnated and vacuum cast to eliminate hot spots have been developed by Kelvin Electric Co. The series EP resistors utilize tension-free winding techniques which reduce resistance drift with age, and shorts or opens due to thermal shock. The operating range is from —65° to 125°C and temperature coefficient is ±.000020°C.

Two types are produced in the series. 3/16" in diameter x 3/8" long and 1/4" diameter x ½" long. Other types are available to handle up to two watts dissipation.

Circle No. 203 on Subscriber Service Card.

ATOMIC FREQUENCY STANDARD

The development of the Atomichron by National Co. has produced a frequency-producing instrument providing frequency stability of 5 parts on 10^{10} and frequency accuracy of 1 part on 10^9.

The instrument uses the atomic principle of frequency control by comparing the precise resonance of the atoms of cesium with the output of a crystal oscillator to obtain stability said to surpass any frequency generator in existence. The unit is also self-monitoring and requires minimum adjustment and maintenance.

Circle No. .218 on Subscriber Service Card.

PLUG VALVES

Circle Seal Products Co. has announced new sizes available in their line of plug valves. The valves feature dead-tight shut-off and external leakage prevention through the use of "O" rings. In the open position, the valve is full-ported and allows straight-flow passage. Valves are available in pipe sizes ¼", ½", and ¾" in brass. The ¼" size is also available in stainless steel with an aluminum handle.

Circle No. 216 on Subscriber Service Card.

PORTABLE FORCE CALIBRATOR

This portable unit is designed for calibrating existing weight, force and thrust measuring systems and has direct reading, automatic balance and digital servo indicator features. Produced by Gilmore Industries, Inc., the model 170 is said to provide 0.1% accuracy of reading or 0.1% of lowest range, whichever is greater. National Bureau of Standards calibration can be supplied by the manufacturer.

The model 170 uses a continuous balance servo system in a portable case and the indicator is calibrated with a precision strain gage load cell for tension or compression measurements. The instrument requires no batteries or standardization circuit. Provision is made for range suppression to increase the resolution and accuracy of the system. The complete unit is 6 9/16" wide x 13½" high x 16" deep.

Circle No. 211 on Subscriber Service Card.

PACKING GLAND

Conax Corp. is introducing its micro packing gland measuring 21/32" long and 11/32" hex. The new gland may be used to seal tubes of any material because the soft sealant makes it indifferent to tube composition. Increased fatigue strength and resistance to vibration are assured by reduction of stress concentration at the point of seal.

Temperature ranges of the gland with teflon sealant are —90°F to 500°F and seal pressures from 0.005 microns up to 1000 psi. Using lava sealant, temperatures range from —300°F to 1850°F with pressures from 0.005 microns up to 3000 psi. Standard bore sizes of the glands are 1/16" and 3/32" with 1/16" IPS thread and non-standard bore sizes ranging from .030" to .096" available on request.

Circle No. 214 on Subscriber Service Card.

ALL-ELECTRONIC CHOPPER

An all-electronic chopper containing no moving parts and having a minimum operating life of 5000 hours is available from the Kearfott Co. The unit converts usable DC into AC and vice versa.

Primary features include a zero phase shift, 180° dwell time, frequency range of 60 cps to 20 kc and an unlimited life when properly applied. Reference power is 6.3 V at 2 ma; load resistance is 1000 ohms to 1 megohm; load current 5 ma maximum; balance is —0°; and the ambient temperature range is —55°C to 125°C with no measurable output drift.

Circle No. 204 on Subscriber Service Card.

HIGH-TEMPERATURE ADHESIVE

The first successful adhesive system for stainless steel metal-to-metal bonds and honeycomb sandwich constructions capable of withstanding continuous exposure to temperatures up to 500°F have been developed by the Rubber and Asbestos Corp.

For stainless steel metal-to-metal bonds, the company produces Plymaster 1020, a tape of nominal 20-mil thickness. Testing the adhesive on type 302 stainless, 1" x 4" with a ½" overlap (steel thickness 0.050"), R & A Corp. established the following values: lap shear strengths of 1750 psi at room temperature; 1500 psi at 455°F after ten-minute soak; 1400 psi after conditioning 200 hours at 455°F and tested at that temperature; 800 psi after conditioning 400 hours at 455°F and

tested at that temperature; and proportionate ranges after testing at 500°F.

The new adhesives for stainless steel honeycomb sandwich construction are a one-part primer, trade-named Bondmaster M605, and Plymaster 2040, a tape of nominal 40-mil thickness which is used with the primer.

Test data on the latter adhesives on 0.003" type 321 stainless steel honeycomb core, ¼" cell size, with facing skins of type 302 stainless steel, 0.025" thick, show beam flexural strengths up to 1500 lbs. on unconditioned sandwiches tested at 455° F. 10 minute soak; up to 1400 lbs. after conditioning 200 hours at 455°F and tested at the same temperature; and up to 1400 lbs., unconditioned, tested at 500°F, 10 minute soak.

All three of the new products are based on modified epoxide resins.

Circle No. 207 on Subscriber Service Cord.

INTEGRATING RATE GYRO

A light-weight integrating rate gyro with self-contained temperature control has been designed by General Electric. The gyro's temperature control operates on the heat-of-fusion principle and is designed to maintain a temperature of 80°C with a tolerance of 1/3 degree or it can be altered to maintain other temperatures with the same low tolerance.

The complete unit, designated the KR-8, is 3" long, 2" in diameter and weighs only 1¼ lbs. It has shown a maximum wander of 6/10 degree for a period of more than four hours. The device's minimum life is 1000 hours.

Circle No. 202 on Subscriber Service Cord.

SERVO-AMPLIFIER

A miniaturized, transistorized servo-amplifier for missiles application has been designed and is in production by Kearfott Co. The small, lightweight unit delivers a maximum power of 6 watts, is shock and vibration resistant and is a plug-in type component. Signal frequency is 400 CPS ± 20 CPS and the maximum signal input voltage is 30 volts. The unit's gain stability is rated at ±3db (—55°C to 71°C) and the entire device is completely potted.

Circle No. 215 on Subscriber Service Cord.

MOTOR-TACH GENERATOR

A high temperature miniature motor-tach generator with low output to null ratio has been developed by John Oster Manufacturing Co. Type 10-MTG-6229-15 operates continuously in an ambient temperature range from —55°C to 125°C. Length is 2.131", null voltage .012, linearity 5% to 4,000 rpm, output voltage .3 per 1,000 rpm and excitation 18 v 400 cycles. Variations of voltage and shaft can be furnished to specification.

Circle No. 219 on Subscriber Service Cord.

SILICON RECTIFIER STACKS

A new series of 170°C silicon rectifier stacks has been added to GE's line of semiconductor rectifiers. The units are rated up to 18 amperes per stack, and stacks may be paralleled for even higher currents. The standard stack is available with RMS input voltage ratings up to 3360 volts, and this may be increased by connecting in series. Operating temperatures range from —65°C to 170°C, with a maximum storage rating of 175°C.

Circle No. 217 on Subscriber Service Cord.

people

Dean A. Harvey has been named director of contracts administration for the Associated Missile Products Corp.

Arthur H. Jones has joined Avco Mfg. Corp. as vice president, defense planning. He formerly was gen. mgr. of Motorola's military electronics center.

Norman L. Winter has been named manager of Sperry's Countermeasures group.

Dr. Charles H. Lutz has joined Hamilton Standard electronics department as chief of advanced design. **Dr. Lutz** was formerly with Arma Division of American Bosch Arma Corp.

Roy E. Wendahl, Hughes Aircraft Co. vice president and gen. mgr. of Tucson operations, has been named to the newly created post of vice president of sales. He will make his offices at the company's Culver City executive offices.

Wallace G. Wade has been appointed head of the Janco laboratory. He was previously with the standards laboratory of the Los Angeles department of Water and Power.

Dr. Raymond L. Garman has been elected to the post of chairman of the board of General Precision Laboratory, Inc. He will continue as technical director in charge of research and development. **James W. Murray** was elected president and chief executive officer, continuing as general manager.

Chester C. Utz has been named executive engineer of Chrysler Corp.'s defense operations division.

Lieut. Gen. Patrick W. Timberlake, (USAF, Ret'd) has been elected corporate vice president of Northrop Aircraft, Inc. He previously was commander of allied air forces in southern Europe.

Gladyn H. Putt has been named executive assistant to **L. Eugene Root,** vice president of Lockheed Aircraft Corp. and general manager of its missile systems division.

Philip D. Terry has joined Western Gear Corp. as regional marketing mgr. of aircraft & missile products for the eastern states.

G. J. Rauschenbach has been named director of sales for the Martin Co., moving from the company's Baltimore division to the Denver Division. He formerly was assigned sales management duties on all advanced design missile projects at the Baltimore facility.

HARVEY

JONES

Geoffrey Parsons, Jr., former director of information for NATO, has been elected vice president for Europe of Northrop International.

Dexter Rosen has been appointed administration department manager for Bell Aircraft Corp.'s guided missiles div.

James W. Walker has been named to handle Rocketdyne's export programs, formerly handled by North American Aviation's corporate export office.

Martin Boe, of North American Aviation, Inc., has been appointed to the post of air-to-surface missile engineering manager and **Sanford Falbaum** has been named ASM asst. engineering manager for the company. North American has also appointed **Dale D. Myers** project manager on the AF long range bombardment ASM development program.

Dr. Ernst A. Steinhoff will direct the Air Force missiles department at Aerophysics Development Corp. Since 1950, he has been technical director of Holloman air development center.

Dr. Thomas H. Johnson, Atomic Energy Commission research director, has been appointed manager of Raytheon Mfg. Co. research division. He resigned from the AEC, effective October 1.

Cornell Aeronautical Laboratory, Inc. has been reorganized into six new divisions. Division heads are: **William F. Milliken,** full scale division; **Dr. Franklin K. Moore,** aerodynamic division; **Harold A. Cheilek,** engineering sciences division; **Robert H. Shatz,** systems research division; **Robert S. Kelso,** experimental facilities division; and **Dr. Seville Chapman,** physics division.

Brig. Gen. Robert E. Galer (USMC, Ret'd), former director of the guided missiles division of the Navy's Bureau of Aeronautics, has joined Temco Aircraft Corp. as mgr. of engineering programs.

John P. Broderick has joined the applications engineering department of Yardney Electric Corp.

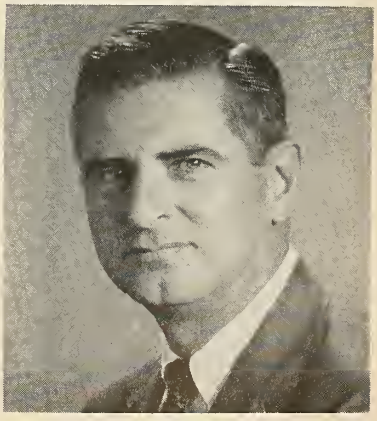
Capt. Otis R. Hill has been appointed USAF Development Field Representative for a new San Francisco Bay area ARDC office.

Richard Driskell has been named engineering production manager of Humphrey Inc., directing control of the company's production of rate and free gyros, linear and angular accelerometers and other control instruments.

Four research managers have been named by the Government and Industrial division of Philco Corp. New managers and their phase of work are: **J. Forrest Bigelow,** radar and radio systems; **F. J. Bingely,** audio-video data systems; **C. P. Woodward,** missiles and advanced tactical systems, and **Ralph Deutsch,** fundamental

WINTER

LUTZ



WENDAHL

techniques. All previously with Philco.

Bernard B. Daien has been appointed chief engineer at Transistor Devices, Inc.

Josiah E. Smith, aerodynamicist, has joined the guided missile research division of Ramo-Woolridge Corp. in Los Angeles.

Dr. J. Howard Brown, Morton S. Kircher, and **Dr. Jack S. Newcomer** have been named as research managers in Hooker Electrochemical Co.'s realignment of its R & D staff.

Dr. James T. Grey, Jr. has been named scientific advisor to the Air Force's Directorate of Research and Development. Grey is head of the chemistry section of Cornell Aeronautical Laboratory, Inc., and will be on leave of absence while carrying out the new assignment.

Col. Arnold T. Johnson has been designated deputy commander of the ARDC's Arnold Engineering Development Center at Tullahoma, Tenn. Prior to assignment to AEDC, Johnson was chief of the USAF section, Military Assistance Advisory Group, Saigon, Viet-Nam. The AEDC is the wind tunnel test center for the Air Force.

Robert G. Schmidt has been appointed project manager for the new $4-million plant of Callery Chemical Co. at Lawrence, Kansas. **Stanley J. Demski** is newly appointed construction manager for the plant, which will produce boron specialty chemicals.

Arthur J. Warner of Harlow, Essex, England, has been named director of research for Mycalex Corp. and associated companies. He will assume responsibility for materials and product development in the field of electronic components, glass-bonded mica, ceramoplastic insulation and synthetic mica.

Edward Rubin has been appointed assistant to the president of Wyle Laboratories, El Segundo, Calif., qualification and testing organization. He was previously manager of powerplant administration at Marquardt Aircraft Co.

Abraham Fuchs has been named head of the analytical department of CDC Control Services, Inc., producers of high-performance servo-mechanisms.

Richard W. Griffiths has been appointed director of sales for the components division of Litton Industries.

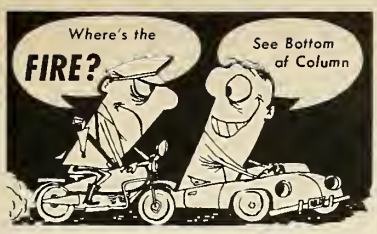
Dr. Arthur C. Ruge has been named director of research development of the electronics and instrumentation division, Baldwin-Lima-Hamilton Corp. Working under Ruge will be **Robert P. Lathrop,** newly-appointed manager of research and development for the division.

Harry McPherson has been chosen to head Temco Aircraft Corp.'s testing program for its missile weapons system. McPherson was previously technical design test coordinator for Convair in Fort Worth.

Sterling C. Spielman has been appointed director of engineering for Philco's Government and Industrial division, assuming full responsibility for all design and development activities. He will be assisted by **Frank D. Peltier,** named director for engineering planning.

Leonard Brewer has been assigned as project director for rocket engines in the solid propellant R & D department. Brewer was formerly with Thiokol Chemical Corp. in Huntsville, Ala.

Col. Carl W. Armbrust has been named executive officer in the Directorate of Procurement and Production, Air Materiel Command. Armbrust formerly served as chief of the airframe, missiles and engine section of AMC's Industrial Resources division.



Dr. Bernard Greifer has joined Atlantic Research Corp. as a member of the kinetics and combustion group. He was formerly with the U. S. Bureau of Mines. At Atlantic, he will conduct research in gaseous and solid combustion processes.

Col. Paul F. Nay, former director of aeronautics at ARDC headquarters, has been assigned to ARDC's field office in Los Angeles.

Lionel H. Orpin has been named director of plans and programs of Stromberg-Carlson division of General Dynamics Corp. He was formerly with the Convair division.

Dr. Oskar Mattiat has joined the Aerophysics Development Corp.'s engineering staff. He formerly was head of the special devices group at the Clevity Research Center in Cleveland, and also directed the electric wave filter section. Aerophysics also appointed **Dr. Robert B. Costello** as assistant manager of the materials department. He previously served as project engineer for Corning Glass Works.

J. F. Harrigan has been named manager of the Dayton liaison office jointly maintained by Reaction Motors, Inc. and Olin Mathieson Chemical Corp. He will be responsible for representing the two companies with the Air Force and area contractors. Before his appointment, he was with Lear, Inc. as contracts manager.

Dr. Lloyd H. Wilson has been appointed manager of the reentry body department of the Missile Systems Division of Lockheed Aircraft Corp. Also named as a manager was **Dr. Wayland C. Griffith**, of the flight sciences division in the research and development branch.

Advertisers Index

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Your requests for information will be forwarded promptly to the companies concerned.

NEW PRODUCT BRIEFS

OXY ADHESIVES. When cooled to 0°F, epoxy synthetic glue holds some ht metals together with enough ength to withstand a force of 8000 . psi. The synthetic adhesive does not come brittle with sudden and ex- me changes in temperature and in- eases in strength as the temperature ops. National Bureau of Standards.
cle No. 251 on Subscriber Service Card.

OXY-SATURATED INSULATION. Two w types of epoxy-saturated electrical ulation for class B applications are ailable. The asbestos-base products i said to have unique electrical and rmal properties. The material is avail- le in rolls, tape or sheet form. Johns- nville Corp.
cle No. 252 on Subscriber Service Card.

XIDE SCALE REMOVER. A process r removing oxide scale from titanium s been developed by Temco Aircraft rp. The electrolytic process removes scale without the use of acids or nd labor.
cle No. 253 on Subscriber Service Card.

LICONE RESIN. This material for nding low-pressure structural laminates parts to glass cloth the qualities us- lly associated with polyesters. It was veloped for the vacuum-molding of mplex structural parts, provides high ength at elevated temperatures, has r dielectric losses and is available in mmercial quantities. Dow Corning rp.
cle No. 254 on Subscriber Service Card.

ANSISTORIZED CONVERTER. A nsistorized 30 amp constant conver- featuring current stabilization, selec- n of current levels in 50 ma steps m ½ to 30 amps, and numerous test- applications and other features have en developed by North Hills Electric ., Inc.
le No. 255 on Subscriber Service Card.

ULTI-FUNCTIONAL INSTRUMENT. med "Voca," this instrument com- es a precision differential null type entiometric voltmeter and calibrator AC, DC and VTVM. Used for pro- tion line testing, calibration of mul- eters, vacuum tube voltmeters and illoscopes, circuit test and design l other applications. Demolab Corp.
e No. 256 on Subscriber Service Card.

ECISION TRIANGLES. Layout trian- s of consistent precision, designed to lace metal triangles in many appli- ons, have been produced by the gorukov Mfg. Co.
e No. 260 on Subscriber Service Card.

TUBE CLAMPS. A line of "Kool Klamps" designed to provide adequate cooling and easy tube changing as well as to retain miniature tubes under extreme vibration and shock is available. The new clamp features an ejector pin to facilitate removing tubes in restricted chassis areas.
Circle No. 257 on Subscriber Service Card.

COAXIAL TERMINATORS. Stoddart Aircraft Radio Co. is producing a coaxial terminator of 9/16" diameter with precise resistance values from DC to 1000 mc. VSWR on the unit is less than 1.20 to 1000 mc, characteristic impedance is 50 ohms and the peak voltage is 100 volts. The component is available with either type BNC or TNC male or female connectors.
Circle No. 258 on Subscriber Service Card.

CONSUMABLE WELD INSERTS. Use of EB weld inserts permits welding from one side of metal and eliminates need for back-up rings in welding of tanks for missiles. Tensile strength of 200,000 psi is developed in the weld metal by heat treatment. Arcos Corp.
Circle No. 259 on Subscriber Service Card.

COAXIAL PUSH-BUTTON DISCONNECT. RF coaxial connectors with a built-in push button disconnect switch eliminate the necessity of removing the cable from an assembly. Available with type "N" and "HN" hermetically sealed receptacles. Don-Lan Electronics Co.
Circle No. 261 on Subscriber Service Card.

RESOLVER. High-accuracy and impedance size 15 resolver features tuned impedance of 10,000 ohms and accuracy of ±0.1% from —55°C to 85°C with amplifier. Norden-Ketay Corp.
Circle No. 262 on Subscriber Service Cord.

PROXIMITY SWITCH. Manufactured to detect ferro-magnetic objects without coming in contact with the object. The unit has no moving parts and may be mounted on a surface extending only 3¼" from the material which operates it. Excitation is 100-125 V, 60 cps, 2 watts (nominal). Minneapolis-Honeywell.
Circle No. 263 on Subscriber Service Card.

RATIOMETER. Servonics, Inc., has introduced a new Unity Ratiometer featuring fast accurate readout, continuous balance, automatic polarity indicator and complete self-containment.

The device has unlimited application with DC analog computers and is equipped with an output shaft extension.
Circle No. 264 on Subscriber Service Card.

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MISSILE LITERATURE

TRANSISTOR MANUAL. The second edition of a transistor manual containing basic information on transistors and their use in electronic circuits has been published by GE. Included in the 112-page manual are data on semiconductor theory, construction techniques, explanation of symbols, specifications (with drawings) of all transistors currently registered with the Electronic Industries Association, and other pertinent data. General Electric Co.
Circle No. 150 on Subscriber Service Card.

AERODYNAMICS RESEARCH. Three reports of aerodynamics research for USAF, two of them on wind tunnel tests and the third on ignition and combustion, have been released to industry. OTS, Dept. of Commerce.
Circle No. 151 on Subscriber Service Card.

TRANSITOR SERVO AMPLIFIER. Four-page brochure giving performance characteristics of miniaturized units. Covers models of the 60 and 400 cps TRAMPS. M. Ten Bosch, Inc.
Circle No. 152 on Subscriber Service Card.

TIME-RATE INDICATOR. Applications of a 10 mc time-rate indicator for measuring frequency, counting pulses per unit time, measuring interval between pulses, and other similar operations are discussed in bulletin 501A-B, published by Laboratory for Electronics, Inc.
Circle No. 153 on Subscriber Service Card.

COMPANY INFORMATION. Information on the various aviation divisions of Kelsey-Hayes Co. is listed in a 32-page booklet just released. Products and services available are listed in the free booklet. Kelsey-Hayes Co.
Circle No. 154 on Subscriber Service Card.

PIEZOELECTRIC CRYSTALS. A revised edition of the Air Force's "Handbook of Piezoelectric Crystals for Radio Equipment Designers" has been released. Prepared as a guide for designers of military electronic devices, the manual contains a comprehensive examination of piezoelectric control of radio frequencies. It includes background material, circuit theory, components data and other information. The 702-page manual is sold for $7.00 through OTS, Dept. of Commerce.
Circle No. 155 on Subscriber Service Card.

OPTICAL TOOLING. The basic principles of optical tooling are described in a 56-page manual which includes photographs and drawings. Major instruments and accessories used in optical tooling are covered, and drawings show the optical principles used in applying the equipment. The application of optical principles permits tolerances as close as thousandths of an inch to be held at distances from a few inches to as much as a mile. Keuffel & Esser Co.
Circle No. 156 on Subscriber Service Card.

HYDRAULIC SYSTEM TESTER. A universal hydraulic accessories test machine is the subject of this brochure, which describes the machine's operations on valves, actuators, regulators, plumbing, tube and hose lines, manifolds, and other accessories. The machine simulates actual flight conditions and is said to test hydraulic components to the most rigid specifications. Greer Hydraulics, Inc.
Circle No. 157 on Subscriber Service Card.

CLOSED CIRCUIT TELEVISION. Industrial closed circuit television systems and accessories are described in a catalog recently published. It contains data on remotely controlled pan-tilt, iris-focus and other camera accessories, special "ruggedized" equipment for operation under adverse environmental conditions of noise, heat, shock, and temperature and humidity extremes. KIN TEL Division, Cohu Electronics, Inc.
Circle No. 159 on Subscriber Service Card

MAGNETIC AMPLIFIERS. Two reports of research for the Armed Forces on standard and two-core magnetic amplifiers are available through OTS, Department of Commerce.
Circle No. 160 on Subscriber Service Card

METALLURGY STUDIES. The impact properties of boron-treated steels can be disrupted by titanium introduced in boron addition agents, according to one of two new reports now available to industry. The other deals with a review of work on development of a substitute material for a cobalt-based alloy. OTS Department of Commerce.
Circle No. 161 on Subscriber Service Car

TRANSISTOR ANALYZER. Four-pa bulletin describes model BCT-300 transistor curve tracer and includes block diagram showing the variety and functions of the unit, as well as specifications. Norden-Ketay.
Circle No. 162 on Subscriber Service Car

NEUTRON SHIELDING. A folder on boral for neutron shielding, showing the material's composition, uses and shielding properties, is available from Brooks & Perkins, Inc.
Circle No. 163 on Subscriber Service Car

ROCKET DESIGN. Discussion of theory and practical application of rocket engine design are among subjects covered in a new issue of "Thiokol Facts," house organ. Other articles include se lant applications and test equipmen Thiokol Chemical Corp.
Circle No. 164 on Subscriber Service Car

METAL FASTENERS. An eight-pag guide for design and assembly socket-head cap screws has been pu lished, giving physical characteristic thread lengths, torque tension data an other information useful in efficient a plication of the fasteners. Strong, Ca lisle and Hammond.
Circle No. 165 on Subscriber Service Ca

PLASTIC TUBULAR CAPACITOR. E gineering bulletin describing type B plastic tubular capacitor for printed c cuits has been published and is ava able from Pyramid Electric Co.
Circle No. 166 on Subsribor Service Ca

RUBBER PRODUCTS. Illustrated catal showing facilities for manufacturing ru ber parts to customer order. Empha is placed on special molded rubb parts, silicone rubber parts, rubb bonded-to-metal parts and other da on rubber synthetics. Williams-Bowm Rubber Co.
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CERAMIC RESEARCH. A 20-page b chure picturing and describing their cilities for exploratory and developm tal work in industrial ceramic techn ogy has been published by Gladdi McBean & Co.
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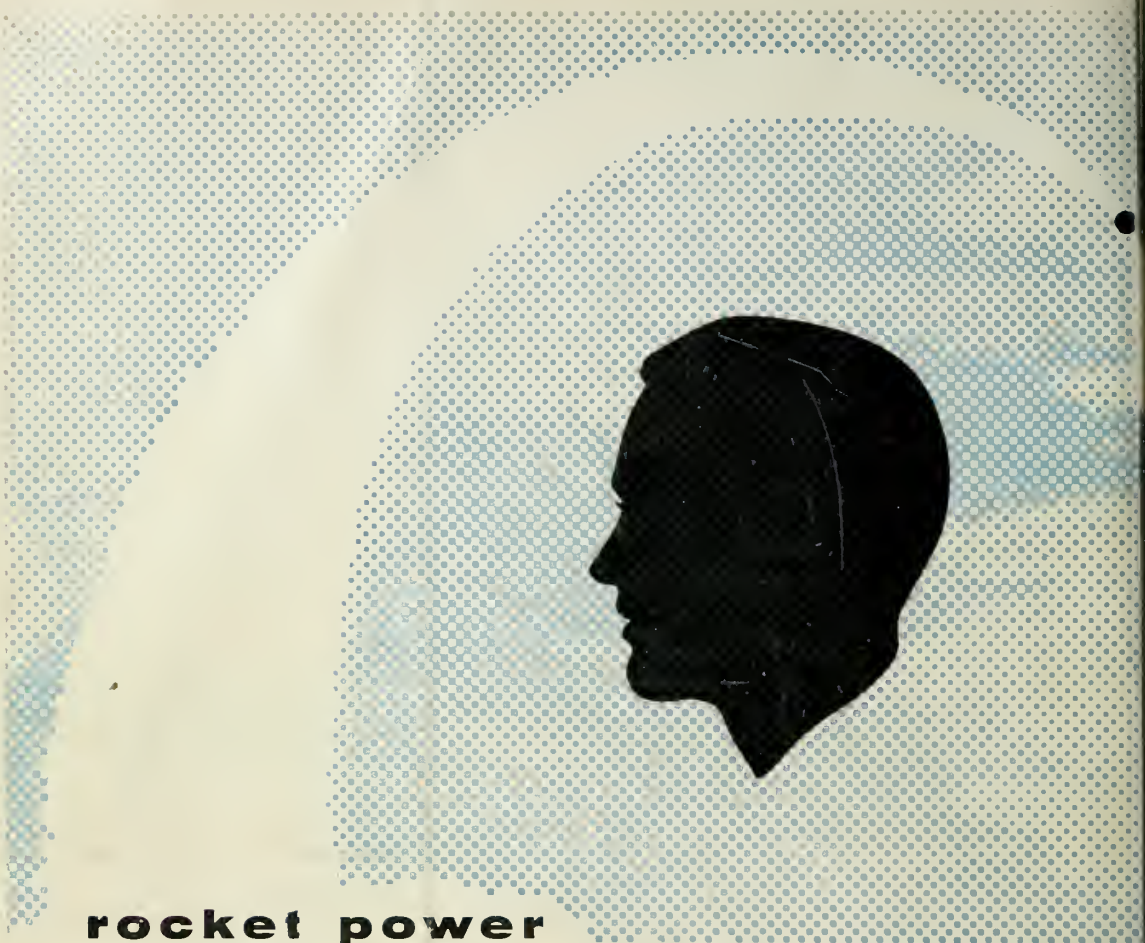

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