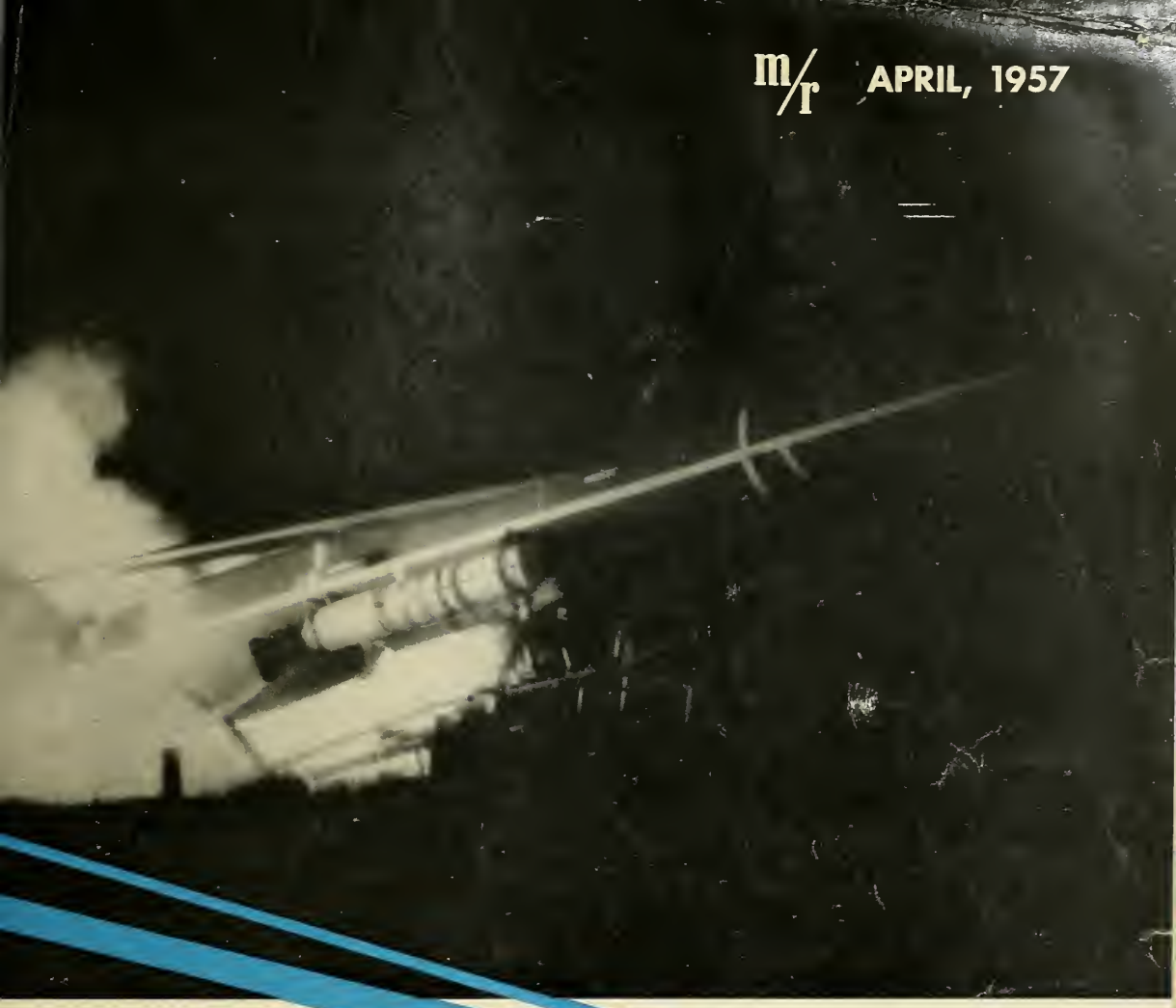
m/r APRIL, 1957



missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS

AMERICAN AVIATION PUBLICATION

This Issue:

US AIR FORCE LONG-RANGE MISSILE DEVELOPMENT

"MIL SPECS"

The industry has long established the Mil Spec as a measuring stick of performance and quality. At Narmco, we too feel at home with Mil Specs.

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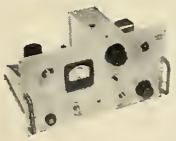
TECHNIQUES and DEVELOPMENTS in oscillographic recording

PHASE SENSITIVE DEMODULATOR PREAMPLIFIER PROVIDES A DC VOLTAGE PROPORTIONAL TO AN INPHASE COMPONENT OF AN AC VOLTAGE WITH RESPECT TO A REFERENCE.

THE measurement of the amplitude of an AC voltage component is often necessary in performance studies of servo systems or of suppressed carrier signals over the carrier frequency range from 60 to 10,000 cps. In such cases the demodulator responds to inphase signals and rejects quadrature signals.



A circuit with these characteristics for use in an oscillographic recording system can be seen in the Model 150-1200 Servo Monitor (Demodulator) Preamplifier. It was developed by Sanborn as one of twelve interchangeable, plug-in front ends for "150" Series equipment, to be used with the appropriate Driver Amplifier-Power unit in any channel of a "150" system. Elements comprising the circuit from input to output, include: compensated stepped attenuator and cathode follower input circuit, phase inverter, push-pull mixer and demodulator stages, differential DC output amplifier and low pass filter. In addition, the chassis contains a VTVM to facilitate accurate adjustment of the reference voltage, and an overload indicator which lights a warning lamp when excessive quadrature voltages exist.

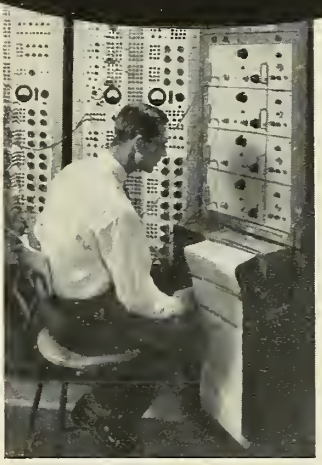
Adaptability to a fairly wide variety of applications is accomplished through broad input voltage, reference voltage and frequency ranges. In order, these are 50 mv to 50 v (for full scale 5 cm deflection), 10 v to 125 v; 60 cps to 10kc. Rise time with low frequency plug-in demodulation filter is 0.1 seconds; with high frequency filter, 0.01 seconds. Quadrature rejection is better than 100.1; for carrier frequencies up to 5000 cycles.

Two representative uses of the Servo Monitor Preamplifier are in the design and adjustment of servo systems, and with instruments used in the design, development or adjustment of other apparatus. The first is illustrated by use of the Preamplifier and associated equipment in the recording of the output shaft amplitude and driving frequency of an AC positional servo; the second by recordings made with a similar setup of the difference between output signals from a gyroscopically-controlled stabilizing device and the "pitch" and "roll" signals generated by a "Scorsby Table" used for testing the device under dynamic conditions.

For a detailed discussion of the principles and design considerations involved in the Servo Monitor Preamplifier, refer to the February, 1955 issue of the Sanborn RIGHT ANGLE, for Dr. Arthur Miller's article on "Measurements with the Servo Monitor Preamplifier."

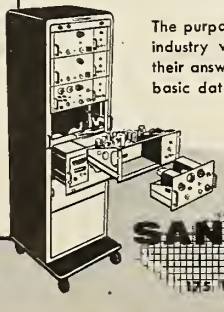
Technical literature and engineering assistance on specific problems are always available from our engineering department.

FROM SANBORN



BASIC FACTORS IN SELECTING OSCILLOGRAPHIC RECORDING EQUIPMENT

WHEN considering any oscillographic system or equipment for your application, three useful "yardsticks" to apply are (1) the recording method, (2) equipment adaptability, and (3) variety of equipment available. Here are the answers to the three, as they apply to Sanborn systems. In the record, rectangular coordinates accurately correlate multiple traces, simplify interpretation and eliminate errors. Permanent traces, produced by a hot ribbon stylus without ink, provide sharp peaks and notches, and clearly reveal all signal changes. One percent linearity results from current feedback driver amplifiers and high torque galvanometers of new design; maximum error is ¼ mm in middle 4 cm of chart, ½ mm across entire chart. From the standpoints of "adaptability" and "variety", Sanborn "150" equipment offers the versatility of 13 different plug-in front ends for any basic system . . . the choice of one- to eight-channel systems . . . the variety of nine chart speeds, timing and coding controls, console or individual unit packaging . . . availability of equipment as either complete systems or individual amplifier or recorder units.



The purpose of the foregoing information is to better acquaint industry with typical oscillographic recording problems and their answers, design considerations in Sanborn equipment, and basic data on what Sanborn makes and how it is being used.

SANBORN COMPANY
INDUSTRIAL DIVISION
175 WYMAN STREET, WALTHAM 54, MASS.

missiles and rockets

Magazine of World Astronautics

April, 1957 Volume II, No. 4

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missiles and rockets

Magazine of World Astronautics

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The Weapon Comes First

America's long-range ballistic missile effort is not an academic exercise in a vacuum. It is not a casual endeavor that can long endure the deprivations and distractions of roles and missions disputes, political jockeying or ulterior bickering of any kind. Who intones the countdown may have a bearing on this or that Service's prestige and future and is important to tomorrow's battlefield tactics and strategy. But, the overriding order of business is to see that such a countdown ability exists in time.

The men of the Kremlin will not hesitate to resort to sudden, devastating nuclear assault if they are once certain that the capability for immediate massive retaliation is even momentarily lost to the West. Meanwhile, reports of Soviet successes in ballistic missile development cannot be assumed to have other than some basis in fact.

Thus, the current *Jupiter* and *Thor* schedule of test firings plus reports that *Atlas* is moving to its launching pad is a source of hope rather than terror.

The proximate success of this unprecedented technological undertaking reemphasizes this country's inability to admit the impossible; and sets enviable standards for a young, precocious industry.

The contributions of the men behind these programs cannot be reckoned by the salaries they are paid or the fame they gain. It is unfortunate that the only means the Free World has to preclude war is to maintain the ability to win a war. But we know of no alternative. To this these men are dedicated.

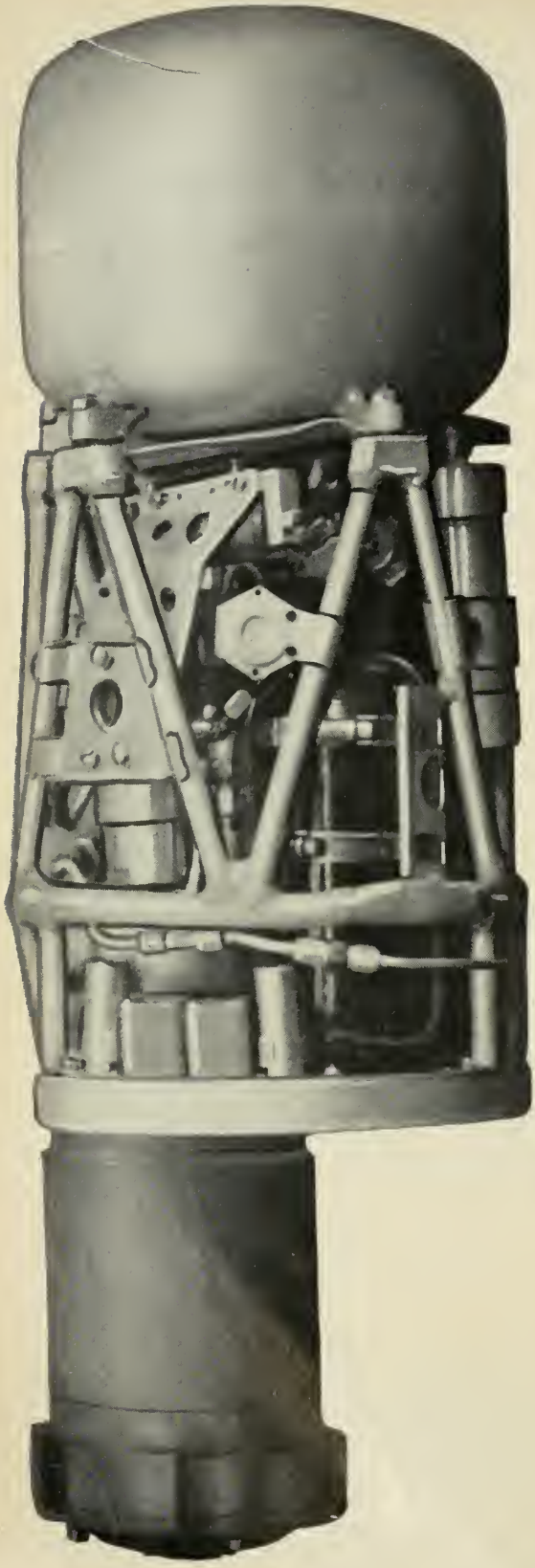
In this sense, it is only logical that at this level of prime importance — research and development — secondary considerations now be set aside; that Army and Air Force missile men shake hands, rather than hurl epithets.

If current roles and missions assignments are incorrect, this will soon be apparent. Now, it's more important to get a weapon in being than to fight over who uses it.

It is certain that the result of the many approaches will be better than that of any one. It is also certain that though this is a tool for war, the peaceful future of its progeny lies in the infinite reaches of outer space.

This is the beginning of the second era of man. If it were without its quarrels, it would not be human.

ROBERT H. WOOD



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MODERN TORPEDOES AND UNDERWATER MISSILES

cover picture:

*Blurred and eager, Northrop **Snark** leaps into free, unmanned flight. This bird is the country's first intercontinental missile. Subsonic en route, the **Snark** is supersonic in its dive on target. Experience with similar missiles against combined U.S. defenses indicates this concept is extremely difficult to intercept. It should be in SAC service by mid-1958.*

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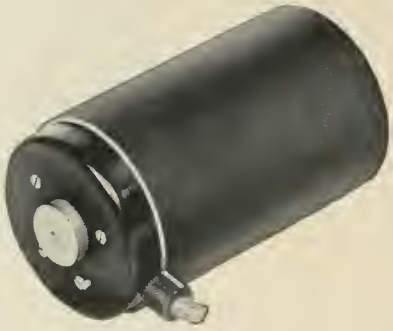

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Is Your Resume Attached?

when and where

APRIL

SAE Aeronautic Meeting and Production Forum, New York City, Apr. 2-5.

Spring Meeting, American Rocket Society, Sheraton Park Hotel, Wash., D.C., Apr. 3-6.

Engineering Management Forum, Statler Hotel, New York City, Apr. 4-5.

British Radio & Electronic Component Show, Grosvenor House and Park Lane House, London, England, Apr. 8-11.

American Welding Society, annual mtg., Hotel Sheraton, Philadelphia, Apr. 8-12. Welding Show, Convention Hall, Philadelphia, Apr. 9-11.

Annual Industrial Electronics Educational Conference, sponsored by IRE, Armour Research Foundation, Ill. Institute of Technology, Chicago, Ill., Apr. 9-10.

Southwestern IRE Conference and Electronics Show & Nat'l Simulation Conference, sponsored by IRE, Shamrock-Hilton Hotel, Houston, Texas, Apr. 11-13.

IRE PGTRC National Symposium on Telemetering, Sheraton Hotel, Phila., Pa., Apr. 15-17.

Symposium on Nondestructive Tests in the Field of Nuclear Energy, Morrison Hotel, Chicago, Ill., Apr. 16-18.

Second Annual Jet Engine Hydraulics Symposium, sponsored by Vickers, Inc., Hotel Statler, Detroit, Apr. 22-24.

Second National Industrial Research Conference, sponsored by Armour Research Foundation, Conrad Hilton Hotel, Chicago, Ill., Apr. 24-25.

Annual National Conference, Aeronautical Weight Engineers, Broadview Hotel, Wichita, Kans., Apr. 29-May 2.

Third Flight Instrumentation Symposium, Statler Hotel, Los Angeles, Apr. 29-May 2.

National Materials Handling Exposition, Convention Hall, Phila., Apr. 29-May 3.

MAY

1957 Electronic Components Symposium, sponsored by IRE, DOD and National Bureau of Standards, Morrison Hotel, Chicago, Ill., May 1-3.

Spring Meeting and Exhibit, Society for Experimental Stress Analysis, Hotel Statler, Boston, Mass., May 1-3.

Aero Medical Assn., 28th annual mtg., Shirley Savoy Hotel, Denver, May 6-8.

Armed Forces Communications & Electronics Assn. Convention, Wash., D.C., May 20-22.

ASME Design Engineering Conference, Coliseum, New York City, May 20-22.

National Telemetering Conference, Hotel Cortez, El Paso, Texas, May 27-29.

JUNE

First Annual National Career Conference, Sherman Hotel, Chicago, Ill., June 8-12.

Fourth International Automation Exposition and Military Automation Exposition, Coliseum, New York City, June 9-13.

ASME Semi-Annual Mtg., Sheraton-Palace, San Francisco, June 9-13.

National Conference on Military Electronics, sponsored by IRE PGME, Sheraton Park Hotel, Wash., D.C., June 17-18.

letters

Speaking of Lintz Basalt Why Not a Gravity Article?

To the editor:

Lintz Basalt in your February '57 Missile Miscellany is very interesting and an article on the current "Anti-Gravity" research projects would be an ideal follow-on.

With more than five major companies working on these projects for the past year, some of the outstanding progress could be reported.

J. E. Surratt, Jr.,
Vice-President,
Society of Aeronautical Weight Engineers, Inc.
Greenville, Texas.

As soon as we have collected sufficient evidence of specific work and proposals for such an article to be of real use to our readers, we plan to publish such a rundown. So much of a misleading, sensational nature has been published on this subject recently, we are proceeding very cautiously.—Ed.

To the editor:

I was quite astounded by the item in the Missile Miscellany column to the effect that the Silicate, Lintz Basalt, will not accelerate at 980 cm/sec. Since this is contradictory to all known physical laws if the deviation is within the limits of experimental error, I feel compelled to pursue the matter. As a graduate physicist actively engaged in the missile field, I follow your magazine closely and if past experience is any criterion I must concede that there could be some substance in this article.

James L. Morgan
C & M Enterprises
Box 512
Pacific Palisades, Calif.

To the editor:

In the February issue you published some information in your column "Missile Miscellany" which to me was strange and important. It concerned a mineral which you call "Lintz Basalt."

You specify that it gave spontaneously more heat than uranium and also that it would not accelerate at 980 cm/seg^2 in free fall.

I have spent two days at our library looking thru all our abstracts, including government information and have not yet found anything related to this "silicate." I would appreciate very much if you could tell me from what source you got that information.

J. Davila-Aponte
Physics Department
Universidad de Puerto Rico
Rio Piedras, Puerto Rico

To the editor:

This is with reference to the "Lintz Basalt." Two months before he died in 1929, Dr. C. F. Brush mentioned that he had found similar anomalies on other silicates, and other compounds of elements of high atomic weight, such as barium, lead, bismuth, and that he was in the process of correlating their impairment in falling velocity with their persistent generation of heat.

For 20 years he had been conducting experiments, with the greatest accuracy, to detect anomalies of different substances in their response to gravity, such as the ones you mentioned for the Lintz Basalt, and the zinc and bismuth pendulums.

Utilizing another test equipment to minimize the possibility of experimental error, the National Bureau of Standards conducted again some of Dr. Brush's calorimetric experiments. The results were substantially the same, leaving in their wake a big question mark.

During the last 25 years, has anyone probed beyond?

Jacques Cornillon
P.O. Box 137
Point Pleasant, Pennsylvania

That's a good question, M. Cornillon, one to which m/r, too, would like an answer—Ed.

To the editor:

In your February issue you published a notice on "Lintz Basalt" which develops heat permanently and is accelerated less than all other material.

I would appreciate it very much if you could advise me what Lintz Basalt is; I cannot find it anywhere. Furthermore if you could give me your source where I could find more about that phenomenon.

Dr. Curt Borchardt
19 Gormley Ave.
Toronto, Canada

More References On Lintz Basalt

To the editor:

Reference your letter of 26 February 1957 concerning Lintz basalt.

Thank you for the information on the reference you gave me, but nowhere in Mr. Brush's paper do I find anything concerning the acceleration of this basalt in free fall. Since this is the olive in the martini, so to speak, may I trouble you again for a reference concerning this portion of the statement?

Furthermore, in the March issue of m/r you mention NBS confirmation of his work. May I have the number of the report?

Finally, along with no doubt many other requests, may I have the reference on the zinc and bismuth plumb bobs.

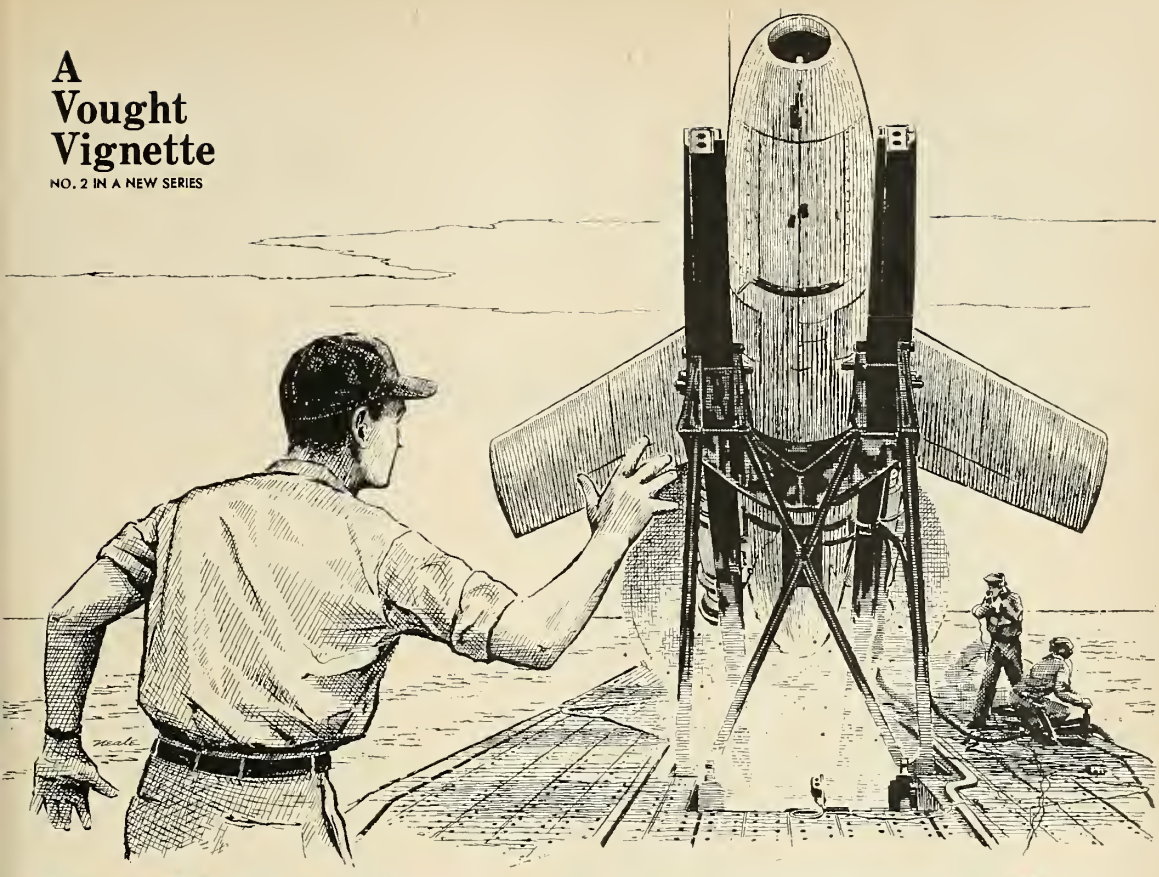
You have managed to stir up a fair sized storm of controversy with your conversation pieces.

Leslie M. Bagnall
5840 Coleman St.
Ft. Worth 14, Texas

You're so right. The reference given on page 10 (The Proceedings of the American Philosophical Society, Vol. 65, April 23, 1926, a paper by Brush) of the March m/r concerns only the constant generation of heat in Lintz Basalt. References to retarded free-fall are given in Vol. 206, No. 1232—II, page 143, of the Journal of the Franklin Institute, "Some Experimental Evidence Supporting the Kinetic Theory of Gravitation," by Charles F. Brush, M.E., M.S., Ph.D., D.Sc., Eng.D., LL.D. Brush's observation of the constant generation of heat in

A Vought Vignette

NO. 2 IN A NEW SERIES



The Missile Engineer with undersea legs

Jack Welch felt honored when he was tossed, fully clothed, into the Navy's sub harbor at Port Hueneme, California. In their own rugged way, submariners were extending him their thanks. He'd been a big help in the introduction of Chance Vought's Regulus I missile to the Navy's Undersea Fleet.

Months before his ceremonial splash, Jack had accompanied the Regulus aboard the submarines *Tunny* and *Barbero* as a representative of Vought's Missile Operations Engineering Group. A veteran of the Regulus flight test program and a collaborator on the conversion of the subs to missile carriers, Jack brought knowledge the Navy welcomed. Likewise, the Navy crews were to share with Jack some equally valuable experience.

Jack, with the submarines *Tunny* and *Barbero,* cruised the East and West Coasts, performed over 200 dives, and once prowled far west of Hawaii. The missile man helped the undersea crews complete initial checkouts of Regulus support equipment — culminating in the first missile launch ever made from a submarine. Then they went about solving environmental and supply problems that arose during tests. Jack added to his mechanical engineering experience a valuable store of electrical, weapon systems and Navy knowledge.

Back in home port, on the *Tunny's* quarter-deck, with a full crew assembled, submarine officers reviewed Jack's contributions. He'd gone beyond his duty as a technical advisor, they concluded. He'd become an expert submariner as well. In fact, he'd qualified for the Silent Service's Gold Dolphin insignia . . . and all hands would proceed at once with the traditional initiation. That's when Jack took his plunge.

Today, Jack divides his time between Chance Vought and a half-dozen Navy shipyards. His job is to see that current missile and ship design is meeting the missile needs of the Fleet. Problems are many, but Jack maintains there's a solution for each. "That's a lesson I learned from the submarine forces," he said. "They gave me a real indoctrination in a can-do attitude under actual operating conditions."

At Chance Vought the missile engineer belongs to a team that already has experienced every conceivable missile problem, from development to operational readiness. Here, current assignments range from theoretical work to the introduction of complete missile systems to the Fleet.

CHANCE VOUGHT AIRCRAFT
INCORPORATED DALLAS, TEXAS

letters

various materials was confirmed by E. A. Harrington of the National Bureau of Standards. The only report of his work on this subject m/r has so far found appears in the Proceedings of the American Philosophical Society, 1933.

It is entitled: "Further Experimentation on the Constant Generation of Heat in Certain Silicates." To m/r's knowledge nobody has attempted to duplicate Brush's observations of retarded fall.M/r would like to note that it is not attempting to promote Brush's "Kinetic Theory of Gravitation," but merely wonders about the possible significance of some of the experimental evidence he produced to support his theory, which—at first glance —seems to have some bearing on the basic assumption of the equivalence of gravitic and inertial mass.—Ed.

More On Red Rockets

To the editor:

When I saw on p. 43 of your February issue a picture of a Russian missile which "ascended to great altitude" in the 1930's, I immediately recollected a news item in an old *Bulletin* of the American Interplanetary Society (15, 1, Jan. 1932) which I quote:

> SOVIET ENGINEERS CONSTRUCTING TWO ROCKETS
>
> A dispatch to the New York Times from Moscow indicates that research engineers of the Leningrad Oseaviakhim are constructing two rockets . . . one . . . is planned to be shot to an altitude of thirty miles by means of powerful discharges; the other (is to be used for) carrying two passengers to a height of ten miles into the stratosphere. Both rockets will be cigar-shaped, constructed of light alloys and steel welded together . . . descent is to be made by parachute. A communication from Professor Rynin of Leningrad . . . states that a group of rocket experiments (sic) is now active in Soviet Russia . . . headquarters at Moscow . . . group consists of about 200 engineers and scientists.

Another news item (Astronautics 31, 7, June 1935) records:

> "Dispatches from Moscow announce that a Soviet stratosphere committee has ordered the construction of a rocket capable of attaining a velocity of 2,200 feet a second and a possible altitude of 34 miles . . . It is also reported that plans are being studied for a larger rocket designed to ascend several hundred miles.

I wonder what the connections may be between these various reports?

Frederick I. Ordway, III,
General Astronautics Corp.
P. O. Box 26, Oyster Bay, N. Y.

Wants More on Drafting In Missile Industry

To the editor:

I consider m/r an excellent aid to the American missile industry. Thank you for the many interesting articles contained within its pages.

May I ask that you consider the addition of a new department, under the suggested title "Drafting in the Missile Industry"? In my opinion this would not only be helpful but, would add greatly to your list of subscribers by offering

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information readily assimilated by all in the profession.

Further I feel that it is a point of great urgency to have a source of information from which the missile industry can develop standards, similar in organization to those of the aircraft and automotive industries.

William Brown
Design Draftsman
Utica-Bend Corp.
P.O. Box No. 12
Utica, Michigan

Wants More m/r's

To the editor:

Congratulations on your issue on Russian rockets and missiles! This has really shaken up several people that I know.

I would like to subscribe to three subscriptions to your magazine, and would like to get a set of back copies for our library.

H. J. Rand
Rand Development Corporation
12720 Lake Shore Blvd.
Cleveland 8, Ohio

Space Suit Swiped

To the editor:

I know you would like me to draw your attention to the anonymous boost I've been given from behind the Iron Curtain in the space-man illustration on page 74 of MISSILES & ROCKETS, February issue. The space man depicted in the photo of Waldislaw Geisler & Professor Satabun has been copied direct from my illustration for Martin Caidin's book "Worlds in Space."

Fred L. Wolff.
107 Michigan Avenue
Kenilworth, New Jersey

How About Sublimation?

To the editor:

Have you published anything in your magazine on the subject of evaporative cooling in the sense that a missile or rocket may be coated with a metal such as cadmium or mecury for the purpose of melting off during flight through the atmosphere upon the creation of heat through friction at supersonic speeds?

K. Ross,
Ross & Ross,
Springfield 3, Mass.

This general subject has been treated at various times in m/r. Note Henry P. Steier's report "New Telemetry Era for ICBM—Space Flight" in this issue. Aerophysics in the January issue mentions plastics in this connection.—Ed.

To Power a Satellite

To the editor:

. . . With the advent of the solar battery, the problem of power supplies for space vehicles has become less acute. However, for special applications, it is possible that there might be need for a radioactive battery of a type not mentioned in the article, "Power Sources for Space Flight" in the Dec. m/r.

An electrical power supply consists of a means of producing a current of electrons, or more basically, a means of separating positive and negative charges and directing the return flow of electrons through an external load. A radioactive Beta-emitting isotope represents an elemental charge separator. The Beta particle (electron) is expelled from the nucleus with an energy up to one million electron volts or more. To derive power from the radio isotope it is only necessary to surround the Beta source with a Beta absorber at a separation sufficient to prevent arcing (in vacuo).

A compact battery would consist of alternate plates of Beta emitter and absorber. The rate of decay, and therefore the current capacity, is constant over a short interval, but decays to ½ its initial value after one half-life period. The voltage is dependent only upon the external circuit, since the emitted electrons are capable of crossing a barrier of up to one million volts.

In selecting the isotope to be used, consideration must be given to the application and to the possibility of radiation damage. For a short-lived missile, a fast decaying isotope will give the most power per pound. With too short a half-life, however, handling becomes a major problem. A permanent satellite might require a half-life of many years. By selecting isotopes that emit Beta rays alone without any gama radiation, by-product

letters

radiation can be limited to soft X-rays due to Bremsstrahlung, or slowing down of the electrons in the absorber.

If radiation damage due to gamma rays can be neglected or shielded, a much larger selection of isotopes is available, many of which are fission products. In addition, the power per pound may be doubled by the use of an isotope whose daughter also is a Beta emitter.

Pr^{148} is a fission/product Beta emitter (without gammas) with a half-life of 13.8 days. A simple calculation shows that 0.176 amperes per pound of fuel can theoretically be obtained. Weight of the absorber, geometrical considerations, and reflection will probably reduce this figure and those below by a factor of ten or one hundred.

S^{35} with a ½ life of 87 days gives 0.116 amperes per pound.

T_m ^{171} with a ½ life of 1.9 years gives 0.003 amperes per pound . . .

Lyon McCandless, Jr.
4016—91st S. E.
Mercer Island, Wash.

To the editor:

In your February article "Russia's Guided Missile Program," noted photographs under heading of "Comparison of Some Typical USSR and USA Ballistic Missiles."

It has been my impression that the Honest John is definitely a rocket and not a "ballistic missile." Yet your heading does not mention rockets which to me is misleading especially at this stage of fog in the nuclear field.

My interest is that I am presently doing periodical abstracting; that is writing abstracts of articles appearing in periodicals for use by Transportation School Library at Ft. Eustis, Va.

Lorraine Wingerter
700 Jamestown Road,
Williamsburg, Virginia.

A ballistic missile is one that, once it has received its initial launch boost to speed, proceeds in a trajectory governed solely by natural laws, such as gravity, wind resistance, etc. ICBM is not guided once the last stage burns out and falls off. Honest John is aimed and fired. Once launched, it becomes ballistic. Both ICBM and Honest John are, of course, rockets. —Ed.

Credit to Md. U. Students

To the Editor:

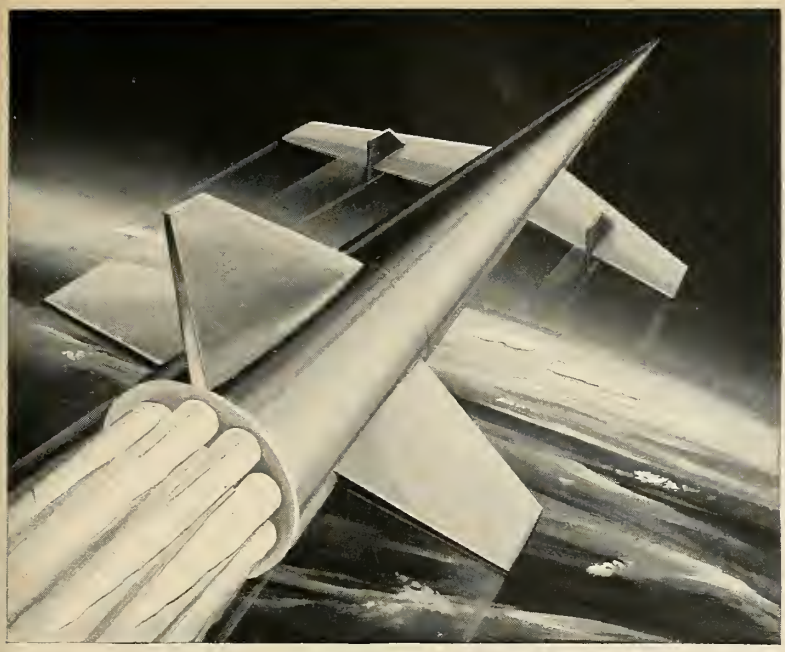
In the article on the Terrapin rocket . . . technical and the graduate assistants from the University of Maryland, unfortunately were not identified. Since they made a most important contribution to the program, I wonder if you could print their names: G. Bentley, R. Bettinger, R. Elton, C. Reber. . . .

S. F. Singer
University of Maryland
College Park, Md.

Oh! That Russian Spelling!

To the editor:

I am sad to find some rough errors in Russian names in your article "Russian Dogs Probe Upper Air" . . . In Column 1, Page 31, you cite Pomfomolfkaya



Which of these PROBLEMS fit your fields of interest in ROCKETS?

Bell Aircraft long a leader in liquid rocket development, produces aircraft and missile propulsion systems embodying the most advanced design concepts. Major efforts of the newly organized Rocket Division are directed toward the design and development of power plants, including turbine pumps, control valves, gas generators, pressurization systems and tanks.

Some of the problems which are under extensive investigation by the Rocket Division are:

1. Devise a method to study the formulation of propellant jets and droplets on injection and follow their behavior during the phases of mixing atomization, evaporation, and combustion.

2. Determine by means of specially designed apparatus, the coefficients of heat transfer to a liquid in the non-boiling, nucleate boiling, and film boiling regimes as functions of pressure, velocity, and bulk temperature.

3. Conduct an analysis of each component entailing fluid pressure losses, speed of operation, expected variations due to minute flow change and their effects on the component operation.

4. Plan testing and data analysis for liquid rocket engine design and development to overcome problems involving extreme temperature operation, turbine speed control, reliability, serviceability and maintenance.

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- Microwave Engineers
- Miniturization Engineers
- Nuclear Physicists
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- Rocket Test Engineers
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- Servo Valve Engineers
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letters

Pravda whereas it should have been Komsomolskaya Pravda, and you write of Professor Bladolravo instead of Bladonravov. In Column 2 you speak of Pokrovsky without giving his first name or otherwise identifying him . . . clearly included Pokrovsky's first name Alexis, and indicated his authorship of that account.

Your magazine is widely respected as a truly reliable scientific publication. No doubt it is zealously and jealously watched by Soviet Russians. Why expose your data and your reputation to criticism by Soviet Russians and possibly also by some of your American readers who know the Russian language, and who may soon begin to make "cracks" about your "abuse" of Russian names and words?

Such errors are mostly the result of hurried typing and typesetting and not enough proof-reading.

Albert Parry,
Colgate University.
Hamilton, New York

Спасибо, Мы Гуфд-Ed.

Definitions for Missileers

To the editor:

In our discussions of Rocketry, my associates and I have had some differences of opinion on the scope of some terms.

The terms in question are:

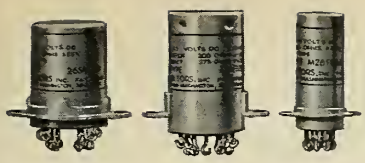
1. Rocket
2. Missile
3. Astronautics
4. Astrionics

We feel that you are the authority in this field, and have decided that we would all accept your definitions. Therefore, I am requesting that you send us your definitions of these terms.

Thank you for your assistance in this discussion.

John E. Heunessey
Glenn L. Martin Co.
Mail R536
Baltimore 3, Maryland

Traditionally a rocket is a vehicle propelled by a combustion motor which is entirely independent of external assistance, as from the atmosphere, for supporting combustion. It seems likely, however, that the term will develop to include any propulsive system which is independent of its immediate environment such as ion and photon systems and thermo nuclear propulsion. We buy Webster's definition of the word missile: "Capable of being thrown, hurled or projected so as to strike a distant target. A missile weapon or object, as a spear, arrow or bullet; also, self-propelled pilotless weapon, as a rocket or a robot bomb." Astronautics is the science that treats with or pertains to the operation of space craft, in contrast to aeronautics which concerns itself with aircraft. Astrionics pertains to the science, engineering and use of electronics as related to extra-atmospheric or space flight. It is obvious from these definitions that the missile isn't new but dates back to when barely-developed man first threw a rock at a Mastodon. Modern man has merely managed to give the "rock" sophisticated propulsion and some semblance of guidance. The definition of "missile" remains the same.—Ed.



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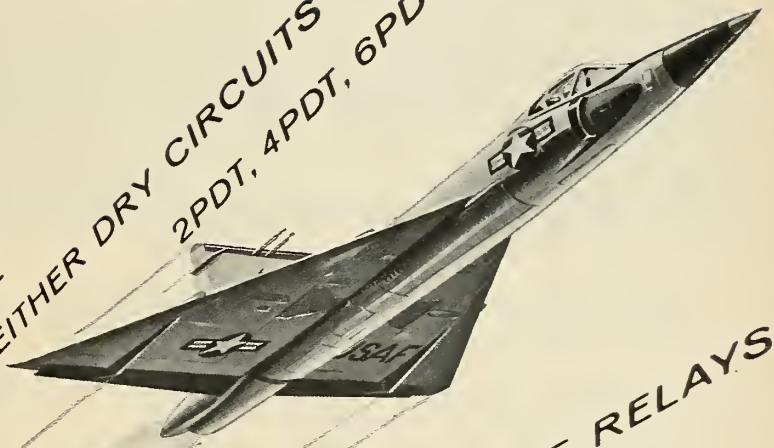

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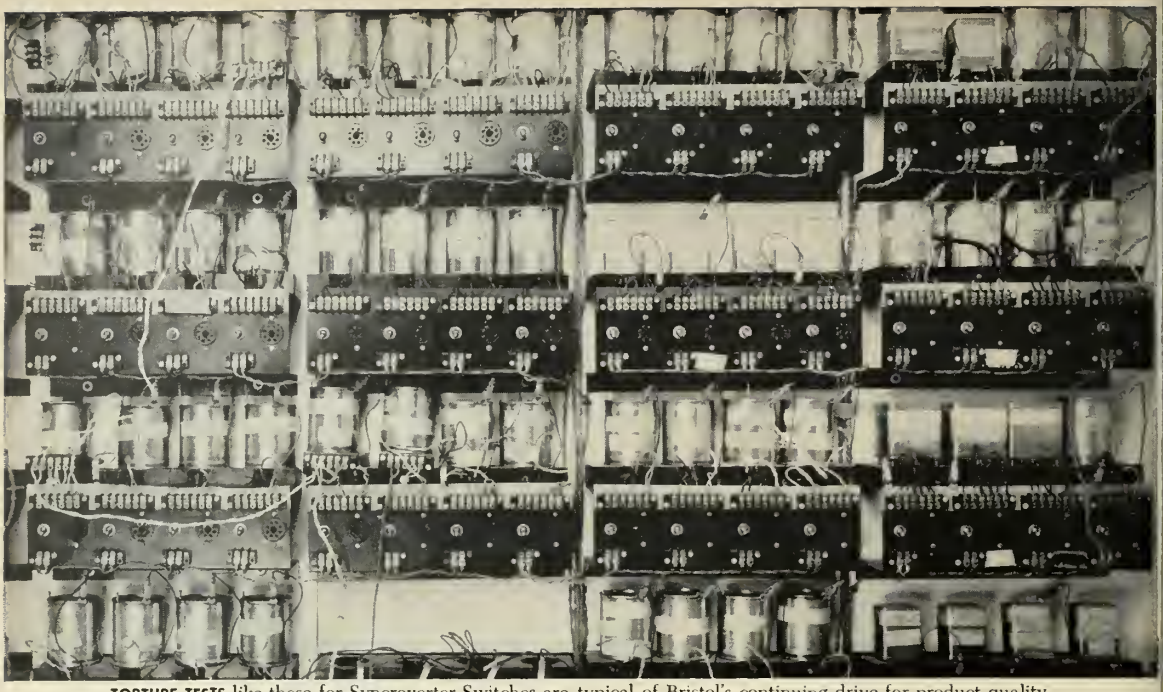

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Driving frequency range:	0-2000 cps (400 cps used for these characteristics)
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Coil current:	55 milliamperes
Coil resistance:	85 ohms
*Phase lag:	55° ± 10°
*Dissymmetry:	Less than 4%
Temperature:	—55°C to 100°C
*Switching time:	15° ± 5°
Operating position:	Any
Mounting:	Flange or plug-in—fits 7-pin miniature socket

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Temperature range:	—55°C to 100°C
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Contact ratings:	Up to 35V, 45 microamperes
Stray contact capacitance:	Less than 15 mmf.
Pull-in time (including bounce):	As low as 200 microsecands
Drop-out time:	300 microseconds
Life:	Over a billion operations under dry-circuit conditians
Mounting:	Octal tube socket; others available, including types for vibration to 2000 cps

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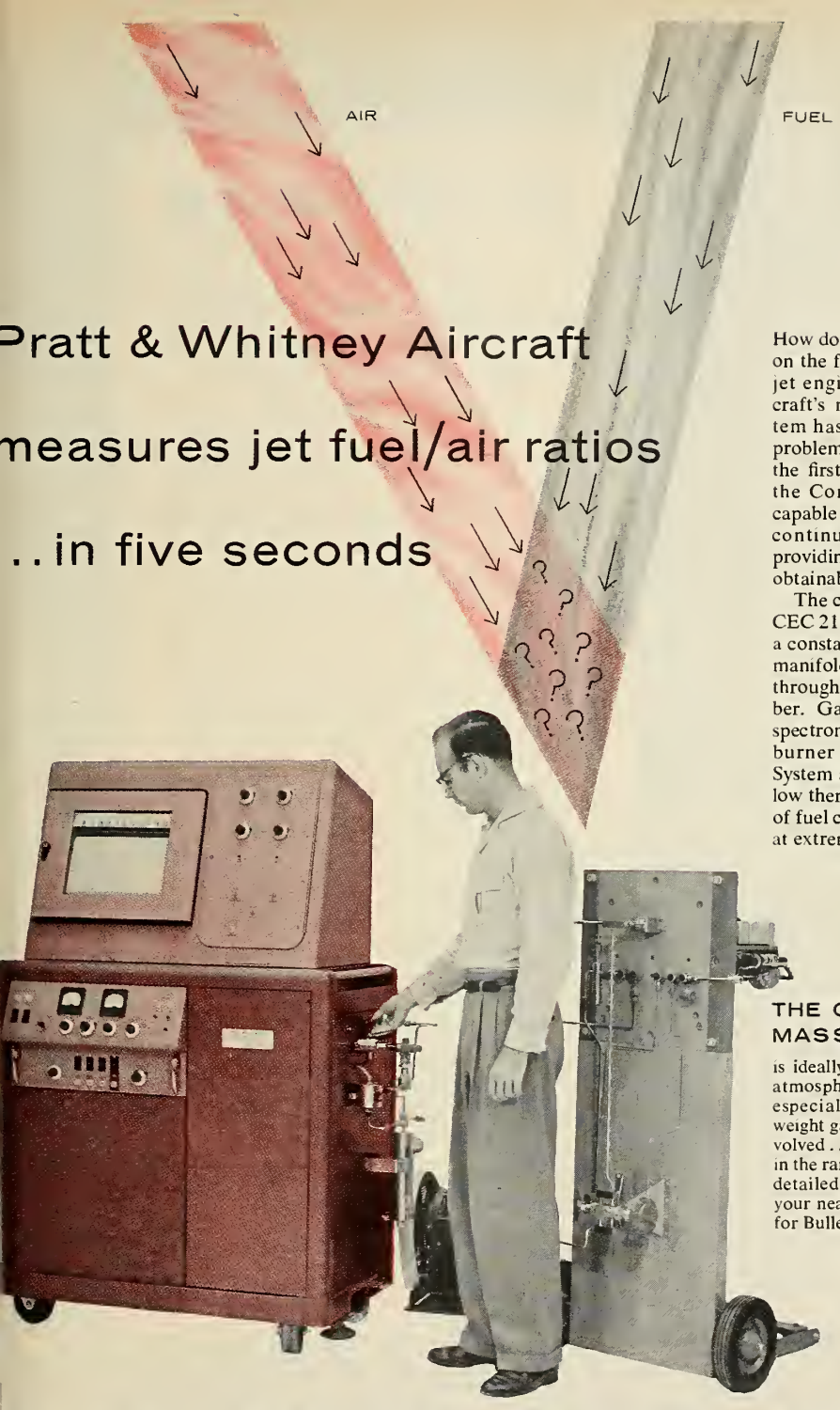

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ABMA Obeys Wilson; Tailors *Jupiter* to AF Needs

Denies Lack of Cooperation With AF Missile Evaluators

In an exclusive report m/r learns that:

Gen. Medaris never denied any Air Force JUPITER evaluation team entrance to Redstone Arsenal.

ABMA chief expects need for manned tactical air support may disappear by 1967.

Development of successful inertial guidance for long range ballistic missiles is an accomplished fact.

JUPITER development is going ahead full tilt with special emphasis on AF requirements.

In its March 18 issue, *Aviation Week,* ran a story announcing that Maj. Gen. John B. Medaris, Commanding, Army Ballistic Missile Agency, had refused a U.S. Air Force evaluation team admission to Redstone Arsenal which had been sent, the magazine claimed, "on direct orders from Defense Secretary Charles E. Wilson."

On March 18, Brig. Gen. J. A. Barclay, deputy commander, ABMA, issued the following statement in answer to press inquiries:

"On Nov. 28, 1956, the Army through a personal visit of Maj. Gen. J. B. Medaris, Commanding General, ABMA, to the office of Lt. Gen. T. S. Power, Commanding General, Air Research and Development Command, Baltimore, Md., extended an invitation to the Air Force to visit the Missile Agency to be oriented on the Jupiter IRBM program. While the Air Force has not availed itself of the invitation, it still stands.

"The Agency has never denied entrance, or access to information, to the Air Force.

"There has been complete liaison between the Air Force and the Agency since its establishment Feb. 1, 1956. An Air Force officer is a member of the Commanding General's staff. In turn, the agency has its own liaison officers at the Western Development Division of the Air Force in Inglewood, Calif., and at Patrick AFB, Fla., where work in support of ballistic missile development is carried on. As a result, there has been a free flow of information between the Army and the AF.

"Weaponization" of Army's REDSTONE means missile may soon be delivered to the field for operational use by combat troops.

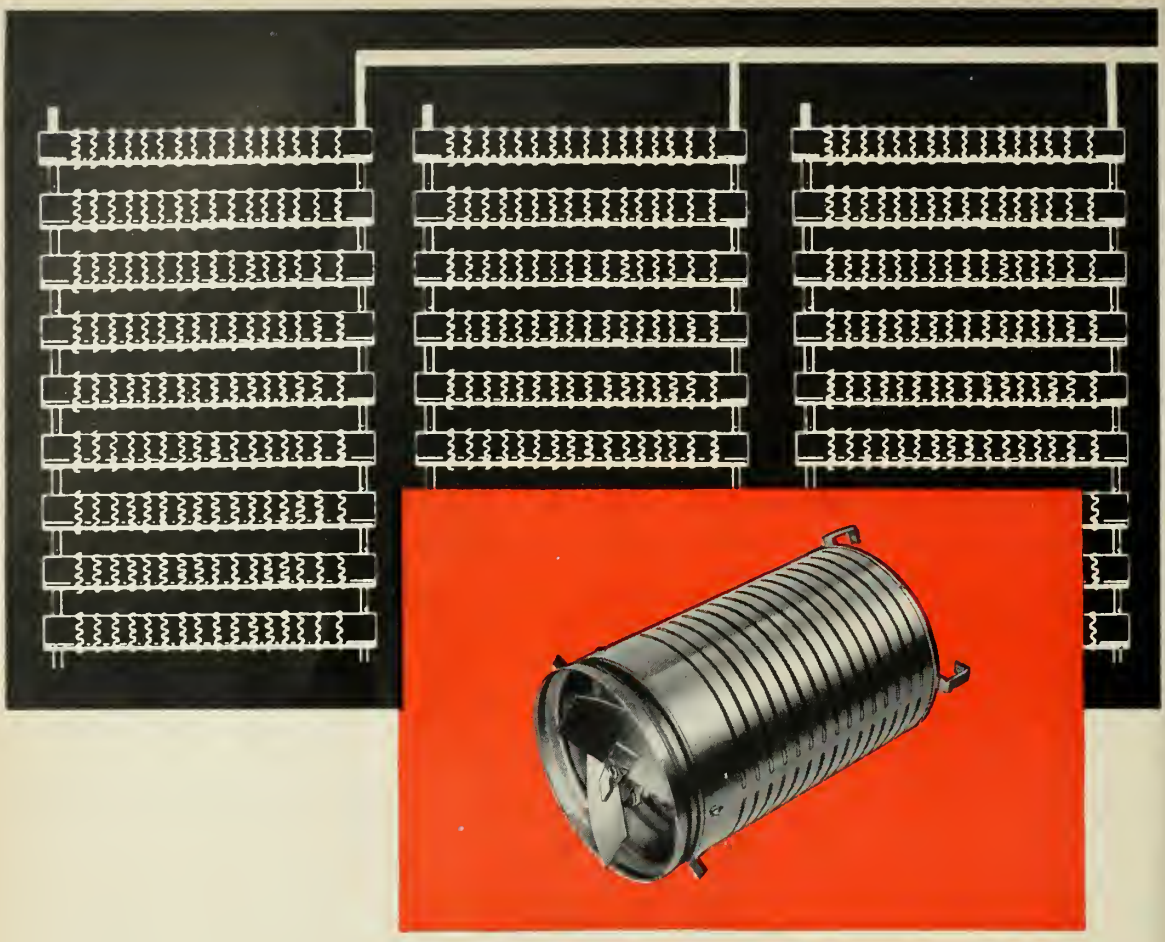
"In December, 1956, representatives of a civilian contracting firm engaged in development activity associated with guided missiles sought permission to enter the Agency for the purpose of evaluating our work. Since the firm was a direct competitor, it was considered inappropriate for them to evaluate the *Jupiter* missile.

"On March 19, 1957, representatives of WDD will attend a critique at ABMA on recent missile firings. Gen. Medaris will be visiting Maj. Gen. Schriever . . . during the current week on a West Coast tour of contractor facilities which had been planned for some time."

In an effort to clarify once and for all the Army's official position in the *Jupiter-Thor* dispute, m/r requested and was granted an exclusive interview with Gen. Medaris. m/r asked him first about the incident noted above.

Confirming the content of the press release quoted above, he went on to say that "any situation that did not allow the free flow of information between the armed services would be intolerable. All technical reports on our missiles are available to all government agencies involved in ballistic missile programs or having any interest in them. We answer their inquiries promptly on any details. WDD has an officer in my Agency who gets any information he wants, and who obtains for me any information I need about AF developments. It is perfectly ridiculous to imply that there has been any holding back of information between Government agencies in this business."

Next, m/r asked Gen. Medaris if Wilson's roles and missions memorandum had harmed ABMA. He replied that it was Wilson's right to establish roles and missions among the services; that "this is not my field. My concern is building successful missiles. I can't



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see any real connection between the color of uniform worn by the user and the agency that develops his weapon. Obviously it should be the agency which has the best facilities and the most capable people. We in the Army have made weapons for many years for the Air Force, the Navy and the Marine Corps. The Navy has made weapons for the Army. Whoever has the knowledge and the capability to complete the job in the shortest time should be selected. We cannot tie our developmental programs solely to the user."

Commenting on the advisability of continuing competing IRBM projects such as the *Jupiter* and the *Thor*, the ABMA Chief noted:

" I suppose the element of competition appears stronger in this case because two different services are involved. Actually there is competition in the ICBM field as well—but because it is between industries and under the aegis of one service, there is less press interest. There has to be selection in the field of new and vital weapons and the greatest intelligence must be exercised in determining where you can place your effort with maximum assurance of success. The broader approach with competition may be the only guarantee of producing one successful weapons system in the shortest time span. We cannot afford to back up and start over if we find the initial approach was wrong. The dual approach is justified if you have any doubt as to the positive success of a single effort on the required time scale.

"We are definitely going ahead with the *Jupiter*. We believe we will provide the country with a successful intermediate range ballistic missile. The time will come when a decision can be made as to selecting one of the IRBM systems for continuance. We are bending every effort to be at the forefront when that time comes. Somebody has to come up with the right answer. The country needs it."

He noted that since the agency was set up in February, 1956, ABMA had had practically no loss or turnover in scientific and professional personnel, but that, rather, many additional graduate and post-graduate scientists had been and were continuing to be employed. "I believe," he said, "our success can be explained by the fact that these people like the continuity of effort and the team spirit of a closely knit organization working on a complete missile project under one roof."

Asked how he felt about the fact that the AF had been designated the user service for IRBM's, Gen. Medaris replied that "we are working with an eye to the customer's needs. The project is going forward in the interest of the Air Force."

We then asked him when he thought the guided missile would replace the airplane. Stating that this would happen as aircraft became more vulnerable and as missiles took on added capabilities, he pointed out that increased missile use had already resulted in a cutback of tactical airpower.

"Our concern," he said, "must be to avoid exposure of personnel, particularly highly trained men, where the chance of survival has been lessened. If we confine the estimate to tactical air support, I would say it may be possible to relieve the air arm of this task in 10 years.

"However, there is no such thing as the ultimate weapon. In its time and place, that could have been said about gunpowder. There is always a contest between offense and defense; right now, offensive weapons are outrunning the defense in development. But inevitably the scales will tip back . . ."

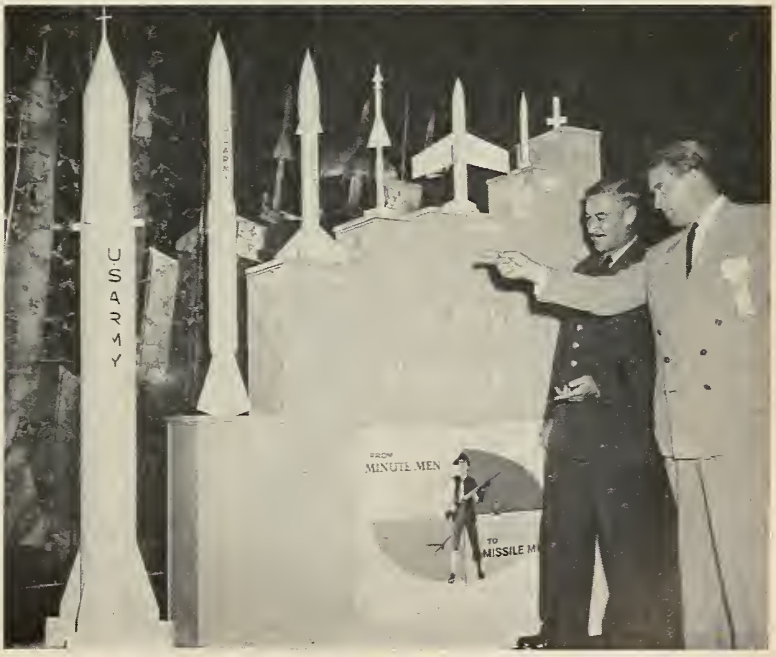
Asked what is behind the Army and Navy philosophy of relying chiefly on their own ordnance installations for missile development, whereas the AF relies on private industry, Gen. Medaris noted that the AF is used to dealing with the aircraft industry, but from the Army's point of view "when you talk missile development, you are dealing with a relatively new and highly complex art. Missiles require the application of all the physical sciences and the exploration of unknowns. There was no reason why industry should have built up a full-scale, balanced team capable of dealing with long range guided missile projects.

"These enterprises require the capabilities and experience of a completely integrated group, working in one place, so that you get the benefit of daily interaction between people whose abilities and problems are well known to each other. Then you have maximum efficiency. That is what we require. It's not a question of industry vs. government.

"At present it's possible to achieve this kind of integration only in government installations. If the missile field continues to broaden, however, some major industries will, over a period of time, develop fully integrated and capable missile teams of their own. Then the situation in those industries would be comparable to that we enjoy in my agency today."

Gen. Medaris refused to give any details when questioned as to ABMA's current missile development activities beyond saying that "weaponization" of *Redstone* was under way and that work on *Jupiter* was going ahead. He stated his view that "there has been too much publicity about missile projects and progress. If the other fellow knows what's coming, it makes it much easier for him to decide where to put his effort. It's not my job to help him."

Next, m/r asked him what he thought was the major factor in further missile development. He said that he



Maj. Gen. J. B. Medaris and top Army missile maker Wernher von Braun view their work.

believed the guidance factor has been licked and that from here on, "it is largely a matter of more efficient and more powerful propulsion systems." He stated that though today's systems were pretty good, they were, relatively speaking, at about the same stage of development automobiles were in 1940. He added that the preference for liquid or solid propellant systems depends on the job to be done; that sometimes the optimum solution to a missile problem requires both.

When asked if he thought the U.S. was ahead of Russia in the missile race, he said:

"I believe that in any area where it has been decided that it is essential to national security that we have operational missiles, or missiles in development, we are ahead and we can stay ahead. I have to qualify that by saying that the element of judgment is always there. It is impossible, with available resources, to develop everything we know to be feasible. So a high degree of selectivity is necessary. Each nation must make its choice of weapons based on the conditions which confront that nation. The circumstances confronting the Soviet Union and its Satellites, for example, are quite different from those which we must consider. The matter of selection in weapons must reflect the whole atmosphere of our defense against any threat of war."

Navy Converts *Loki* To Sounding Rocket

U.S. Naval Ordnance Laboratory has converted the Army antiaircraft missile, *Loki*, into a 100,000-foot altitude weather sounding rocket.

Called the *Hasp*, the missile is a single-stage, solid-propellant rocket that can be fired from conventional 5-inch Naval guns. Rocket motor and the dart, the smaller forward part, ascend as one unit to 2600 feet where burnout and separation occurs. The dart coasts upwards to 100,000 feet, at which point a timing device splits open the nose and ejects instruments to detect temperature and humidity in the ionosphere. Instruments return safely to earth by means of a balloon, meanwhile telemetering data from the various atmospheric layers through which it passes.

The *Hasp* dart was designed by J. L. Walthall, Jr., NOL project engineer. Project manager D. R. Williams expects to make the system good to 300,00 feet after modifications. First *Hasps* were fired last January, marking the first time weather rockets have been fired from a Naval rifled gun.

Launching Platform Ready for *Vanguard*

The firing and launching platform for *Vanguard* has been designed, built and installed in position at Patrick Air Force Base, Fla.

The platform will be used for testing and firing the huge, three-stage rocket which will attempt to place an artificial satellite in orbit around the earth. This is in support of U.S. participation in the International Geophysical Year, 1957-1958.

In the past, a single, large missile firing structure was limited in function to launching purposes and was not capable of static-testing and performance evaluation. This structure designed and built by the Loewy-Hydropress Division of the Baldwin-Lima-Hamilton Corp., not only launches the rocket but statically tests and evaluates performance as well.

Under its sub-contract with Glenn L. Martin Co., the Loewy-Hydropress Division will also be in charge of complete stand instrumentation, support stand mechanisms, as well as utilities and preliminary research—such as heat stress analysis.

This division of Baldwin-Lima-Hamilton Corp. previously made international news with the completion of the world's largest press—the 50,000-ton forging press for the Air Force Heavy Press Program.

The public record shows that construction of the *Vanguard* static test and launching platform is only one of a number of important missile contracts held by Loewy. The stability, strength and close tolerances required for large missile launching equipment is a natural for companies used the design and manufacture of heavy precision production equipment.

This exclusive shot of the VANGUARD launching platform shows Navy VIKING ready to go. Loewy-Hydropress Div. of Baldwin-Lima-Hamilton Corp. designed and built the structure.

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Would you like to learn how the "MAC Engineer" lives and plays? This pamphlet contains color pictures of typical middle-income homes in suburban St. Louis, and actual figures of cost, taxes, and utilities. With each home are pictures of nearby public schools. Also, cost comparisons are made with other areas concerning general cost of living, state gasoline tax, and state income tax. A two-year weather picture is included.

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Weight	15½ lbs.
Dimensions	6-11/32" x 5-3/16" x 9-3/16"
No. of Channels	14
Magazine Capacity	95' DuPont Lino Writ #4
Recording Speed Range	0.5" to 80" per sec.
Trace Identification	Beam Interrupter Type
Constant Acceleration	Above 25 Gravities
Shock Accelerations	Above 1500 Gravities for 20 Milliseconds
Temperature	—65°F to +165°F
Altitude	Up to 100,000' above sea level
Power Requirements	28 volts DC, 12 Amperes Maximum
Connectors:	
Power	WK-5-32S
Galvanometer	FK-C32-32S

This new recording oscillograph now makes it possible to eliminate costly telemetering equipment in missile, torpedo or similar testing. Its miniature size, extreme ruggedness and high recording speeds allow it to be installed directly in the test vehicle, where it will record all data and will withstand the high shocks and accelerations associated with the test.

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New Telemetry Era for ICBM'S and Space Flight

by Henry P. Steier

NEW YORK—Recognition was given at the 1957 National Convention of the Institute of Radio Engineers to the advent of a new era in telemetry, as man extends his need for radio information and remote control into outer space. A symposium on long range telemetry and remote control was featured at the convention.

M. V. Kiebert, Jr. who chaired the symposium described telemetry as a most important link in man's new search for space-knowledge.

Some years ago, Kiebert noted, he gave a paper in London, England at a joint Royal Aeronautical Society and Institute of the Aeronautical Sciences meeting, pointing out the impending obsolescence of pilots as a means of obtaining information.

As a pilot talking to pilots, he said, the statement was met with raised eyebrows and embarrassment from the audience. But now ten years later that day is here.

Some of the forerunners of pilot substitutes are already seen, Kiebert maintains, in automatic equipment on board the Boeing 707 jet transport, and when the rocket-powered aircraft arrives the pilot will be little more than the executive in charge of the flight.

Compared to future equipment and precisions, present day know-how is quite primitive. However, the first really head-on encounters with telemetry and remote control over long ranges and with high velocity vehicles are being experienced.

At this time engineers are wrestling with these experiences in military work on IRBM and ICBM test vehicles that are part of the vast R&D effort underway on these weapons systems.

A review of progress in telemetering of data from the Lockheed Missile Systems Division X-17 re-entry test vehicle was given in a paper prepared by Dr. R. J. Burke of the division, and delivered by N. Terveen, also with the missile division.

Terveen noted the relatively low cost of Lockheed's vehicle compared to an imaginary 4-passenger space ship. An airframe executive, Traveen said, has estimated the space ship would cost "$.3 x 10^9" whereas the X-17 without equipment on board costs "$.35 x 10^6," or 1000 times less.

The X-17 weighs about 6-tons. It is about the height of a four-story building and has three stages.

Before beginning with the basic tests for which the X-17 was conceived, Terveen said many flight tests had to be made to develop telemetry instrumentation and telemetry systems which would give assurance of getting back accurate data.

One difficult design area was joining the stages. The joints must be near perfect. They must take the structural loads and maintain rigidity and yet be able to separate easily.

If separation does not take place properly, the flight path or trajectory does not go as planned. Deciding whether a flight malfunction was due to poor separation or poor aerodynamic design was a problem for telemetry.

Another was determination of timing for first stage separation versus firing of the second stage. Second stage rocket nozzles when fired cause turbulence that can destroy everything in their vicinity. Instrumentation can be wiped out in a fraction of a second, and also the nozzles can be destroyed.

Instead of the usual break-wire strain gauges often employed, Lockheed used variable reluctance gauges applied to the principle tie bolts in the structure. Other gauges were used to indicate if the first stage did not return to earth after separation. What they got on the ground from this telemetry was pressure-time curves.

Each pound of instrumentation used in the third stage accounts for 140 pounds of gross take-off weight. A little over 14 pounds of such gear would mean an added ton of weight.

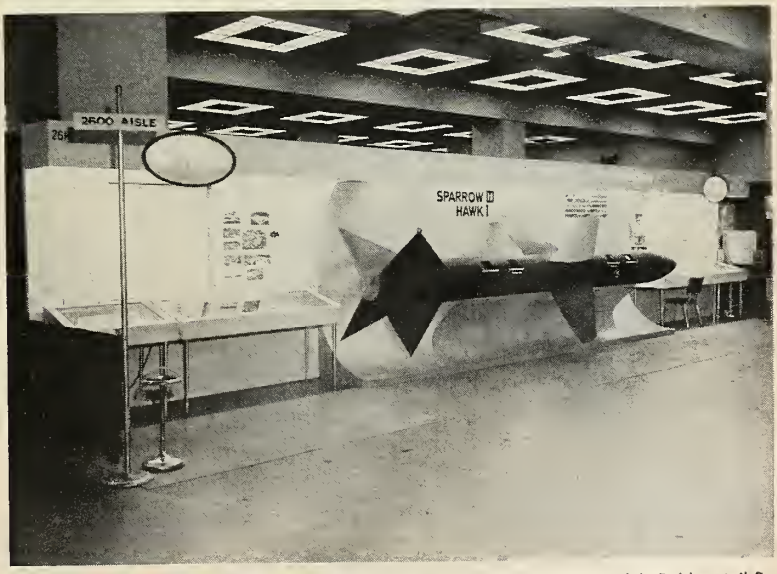
For its X-17 work, Lockheed engineers have developed a modified RDB standard commutation system that permits much better use of the inherent channel capacity by eliminating need to devote one-half the channel to signal synchronizing.

Fighting the weight-volume problem, Lockheed originally used an 11 ounce vacuum tube operated sub-carrier oscillator occupying 14 cubic inches. Now a 1¼ ounce system weighing 2/3 ounce and operating with transistors has been developed. The problem of temperature compensation was met making transistorization feasible.

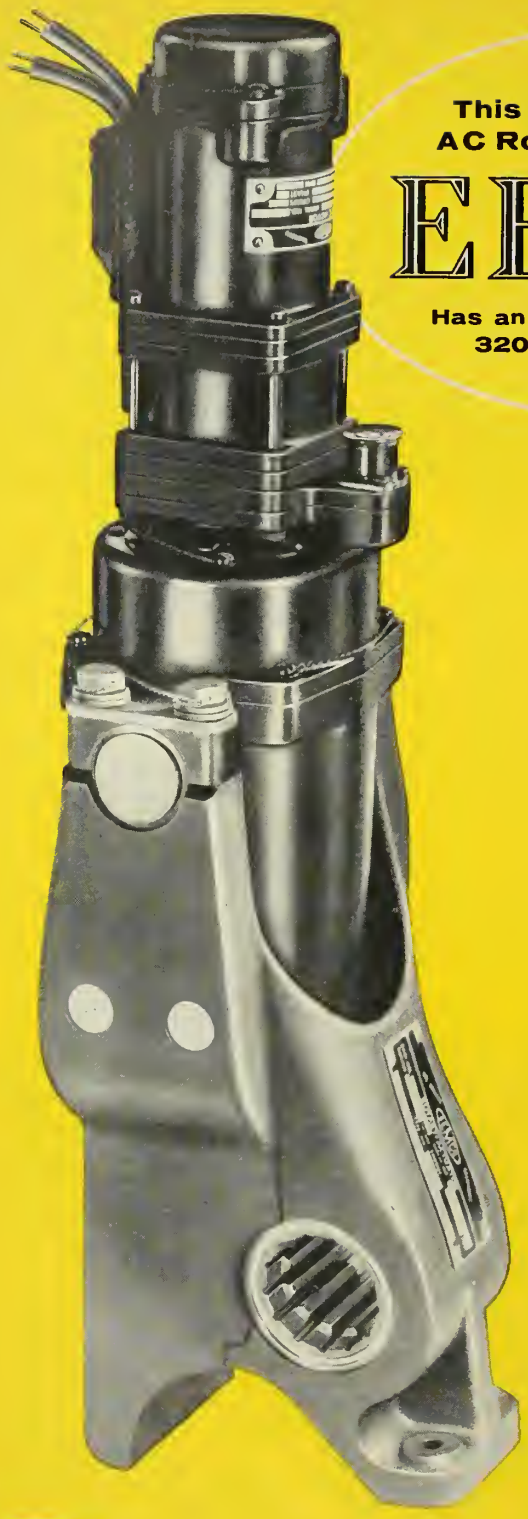
Several of these have been flight tested and maintain temperature stability of less than 1 percent over the entire temperature range encountered in the tests.

The system carried aboard the X-17 is FM/FM operating in the 215-235 telemetry band. Control is by crystal and output is 2 watts.

A big part of the job of this system is concerned with temperature information from thermocouples mounted in the vehicle's nose cone.



Quiet moment near Raytheon Mfg. Co's 1½-times actual size HAWK model. Rubber tail-fin ball saved many an eager eye: Slides were shown through missile's windows.



This New 400 Cycle AC Rotary Actuator by

EEMCO

Has an Operating Range of 320 to 480 Cycles ★

EEMCO Type D-822 400 cycle rotary actuator controls the trailing edge flap on the latest and fastest supersonic fighter aircraft now in quantity production for the United States Air Force.

★ One of the unusual features of **Type D-822** is that it operates on a frequency range of 320 to 480 cycles whereas Military Specification requirements call for a range of but 380 to 420 cycles for AC actuators and motors. The greater range eliminates need for a constant speed drive for the generator system in the aircraft which cuts down possible maintenance and at the same time reduces overall cost and weight considerably.

A torque-limiting AC clutch is incorporated in the motor in **Type D-822** which disconnects the high inertial load imposed by the motor's armature. A brake can be built into this mechanism if **Type D-822** is altered for use in some other capacity. Another feature is the adjustable non-jamming stops that are built into **Type D-822** which are especially vital on an actuator with this load magnitude.

For the past 15 years EEMCO has made a specialty of designing and producing special AC and DC motors and linear and rotary actuators for the aircraft industry. Its entire effort has been in this field. Reflecting the high standards of precision gained from this experience is the fact that EEMCO motors and actuators are included in the majority of the latest jet aircraft and missiles now being produced for our national defense.

SPECIFICATIONS FOR TYPE D-822

Normal operating load: 26,000 inch-pounds
Maximum operating load: 52,000 inch-pounds
Ultimate static load: 75,000 inch-pounds
Travel: 45 degrees at .625 RPM
Amperes: 4 amps. at 26,000 inch-pounds at 480 cycles on 200 volts
Weight: 35 pounds
Qualification: Type D-822 has been designed and qualified to meet applicable military and aircraft manufacturers' specifications.

EEMCO **ELECTRICAL ENGINEERING & MANUFACTURING CORP.**

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Terveen said instrumentation of the nose cone was a formidable task. The cone must be micro-smooth. The smoother the cone the more easily is heat transferred to the atmosphere during the re-entry flight.

If slight irregularities exist on the cone a "turbulent boundry layer" occurs which transfers heat to the cone at a high rate. Placing thermocouples must be done without disturbing either the smoothness or the homogeniety of the metal used.

A complex fabrication technique to do this has been worked out. Two problems remain. These are how to measure pressure at the nose cone, and what amount of metal has melted and blown away. One way to aid reduction of nose cone heating might be to remove large amounts of heat by designing for dispersal of molten metal.

An intriguing problem is what happens to radio signals that try to get through the highly ionized atmosphere around such a vehicle as the X-17.

Although Lockheed admits it has experienced a "peculiar phenomenon observed in the variation of radio frequency field strength under X-17 flight conditions" military security is close-lipped on just what has happened.

Long Range Telemetry

According to J. B. Wynn, formerly with the RCA missile test center, Melbourne, Fla. and now vice president Century Electronics Corp., significant changes in test range instrumentation have taken place in the last year.

The most noticeable changes have taken place in the case of radio telemetry equipment being installed by the Air Force at its Missile Test Center.

Whereas flight to an apogee of 100,000 feet, or about 20 miles was the maximum a few years ago, today it is realistic to talk of apogees of 300-600 miles, Wynn noted in a talk on long range telemetering reception.

At apogees near 500 miles the slant range to vehicles is around 2200 miles, and for tests on ballistic missiles achieving these ranges the Air Force has developed new high gain telemetry antennas for ground acquisition of data.

The old 2½ turn helical antenna served for five years, and in 1952 its gain was boosted to give 10-12 db by using a 7½ turn system. These gave reliable 200-mile range coverage for each site on the AFMTC range.

With the advent of ICBM tests, the Air Force now needs antennas with a 30 db gain to provide real-time data from these new, long range vehicles.

The first of these is about to begin operation. Even the longest range radars with their megawatts of power and using a beacon transponder technique for data acquisition can no longer do the job.

Their usefulness becomes even more apparent when the re-entry aspects of data acquisition are considered. In event it is impossible to pick-up data during part of the trajectory because of ionization or other interference, the telemetry system using the new automatic tracking antennas would be able to acquire data long before any other system in use today, Wynn said.

Tracking accuracies of ± ½ degree have been achieved. The lower elevation limit has been set at 2 degrees and maximum at 86 degrees.

The new antennas are big. Comparing old and new, the 2½ turn helical antennas weighed 50 pounds with a 30 inch diameter reflector dish. The new ones weigh 72,000 pounds exclusive of electronics gear, and have a 60 foot diameter parabolic dish with a possibility they may go to 85 feet.

It is certain large numbers of them will not be needed. Wynn said one at AFMTC and one in the Northern part of the East coast could cover the whole coast.

Four of the antennas will be installed by the Air Force, and this gives some idea of the vast coverage planned.

The ultimate range of the new antenna systems is believed to be far in excess of the 2200 mile figure discussed by Wynn, who was restricted by security from revealing exact range.

Electronics Designs Studied for Bombers

General Electric Co.'s Advanced Electronics Center, Ithaca, N. Y. has revealed that the company has a long range program leading to development of defensive electronic sub-systems for nuclear or chemically powered bomber vehicles expected to be operational in 1970-75.

I. Katz, consulting engineer with the Center, revealed the program at a meeting during the IRE National Convention. He said the nature of the environment surrounding such vehicles traveling at more than 2000 miles an hour will be such that wholly new electronic equipment will be needed to "see" through the interfering acoustical, chemical or nuclear radiation envelope in the wake of such vehicles.

Propulsion systems which are an-

ticipated would develop more power than the largest central power generating station anywhere in the world today, Katz said. Following the four engined vehicles will be a layer of gases at 4000 degrees R.

He predicted the noise level around the vehicle would be 190 db and inside would be 160 db. And, that an important new approach to electronic design would be required by the necessity to balance off equipment reliability against savings in weight through use of anticipated mission schedule as an index of how long the equipment should work properly.

NAA Ion Rocket Study Contract Let

The Rocketdyne division of North American Aviation, Inc., has been awarded a research contract by the Air Force to study the feasibility of ion propulsion.

Under the contract let by the Directorate of Advanced Studies, Air Research and Development Command, the division will explore ion propulsion as a possible source of economical power for missiles.

An ion propulsion system theoretically would obtain thrust by using high velocity charged particles, while conventional chemical rockets, ram jets, and turbo jets use high velocity hot gasses. Ions are atoms or molecules stripped of one or more electrons. In this form they are energized by electricity to create thrust.

Such a system would not produce anywhere near the amount of thrust developed by a chemical rocket propulsion system. At very high altitudes, an ion engine developing a few ounces or pounds of thrust might accelerate a vehicle weighing several thousand pounds to great speeds. To move the same vehicle at lower altitudes would require an engine developing thousands of pounds of thrust.

Because of its low consumption of fuel, an ion engine in theory would operate for several days or weeks. Conventional rocket engines consume fuel in a matter of minutes.

Ion propulsion is valuable only in the case of vehicles released well beyond the pull of the earth's gravity, say for example, about 24,000 miles out.

In this respect, the ion rocket would be a good second or third stage for a moon or interplanetary vehicle. Chemical rockets would provide the massive thrust needed to get beyond the immediate heavy pull of the earth's gravity.

NEW SWITCH NEWS

FOR CIRCUIT DESIGNERS

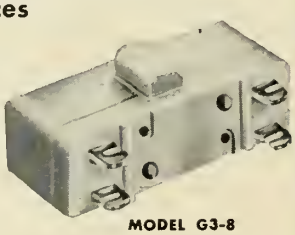
New subminiature sealed switch is environment-free; mounts interchangeably with MS25085

MODEL EF-3

Single Pole, Double Throw
Move. Differential, .004 Max.
Overtravel, .003 Min.
Oper. Force, 5 to 17 oz.
Release Force, 60 gram
Elec. Life Ratings:
150,000 ops. @ 125/250 V. A.C., 2.5 AMP.
100,000 ops. @ 125/250 V. A.C., 5.0 AMP.
50,000 ops. @ 30 V. D.C., (2.5 AMP., IND.; 4.0 AMP., RES.)
Amb. 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.

Tiny, new 40 amp. basic switch has high capacity, longer life and constant stability of tolerances



MODEL G3-8

Measuring only 1¾" x 43/64" x 43/64", the new Electro-Snap G3-8 Basic Switch handles current ratings up to 40 amps. A new method of combining Electro-Snap's double-break action with a heavy-duty switching element assures electrical and mechanical life of 100,000 cycles at large capacities; also provides constant stability of tolerances and accurate repeatability. New plastic compound case gives the switch an ambient temperature rating of −65° to +300° F. with extreme shock resistance. Small size makes it ideal for motor controls and compact automation 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, 30 ozs.
Overtravel, .025" Min.
Move. Differ., .055 ± .010

New 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 completely new Electro-Sna triple-pole switch simultaneous reverses current flow throug three windings of a 3-phase mot up to 1 H.P. and interrupts oth types of multi-switching install tions. Instantaneous "make" ar "break" snap-action of the thr poles is independent of the spe of actuation—even extreme slow moving cams can be used.

The K3-4 Series offers designe a wide variety of 3-phase circ hookups for servo-controls, limit movement of machine mer bers and as a start-and-stop swit which formerly were possible on with complicated relays or a nur ber of separate switches. A lar selection of standard actuato is available.

New small basic switch is low cost; directly interchangeable with AN3234 Specs

F2 SERIES

The new 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 wipi action rare in a switch of this size.

Durable case of special plastic gives the switch an ambie temperature rating of −100° to +275° F. or +375° F. Ava able, *at low cost*, in three basic models with a wide selecti 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 Applicatic
Operating Force, 7 to 12 oz.
Reset Force, 4 oz. Min.
Pretravel, 3/64 Max.
Movement Differential, .011 ± .0
Overtravel, 1/32 Min.

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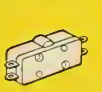
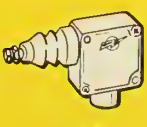
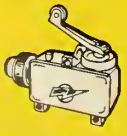


BASIC SWITCHES



DIECAST ENCLOSED SWITCHES



HERMETICALLY SEALED LIMIT SWITCHES

CONFORM TO MIL & AM SPECIFICATIONS

In addition, an ion propulsion system would be extremely useful in providing adjustment thrusts for keeping a 2000-mile high manned or unmanned permanent satellite in its orbit. At such an altitude there apparently are still "earth influences" as from traces of the atmosphere and some of the micrometeoritic dust and other particles that accompany this planet through its orbit. These will be bound to slow down any artificial satellite. Ion propulsion would certainly provide sufficient thrust to prevent such a vehicle from falling in out of its orbit.

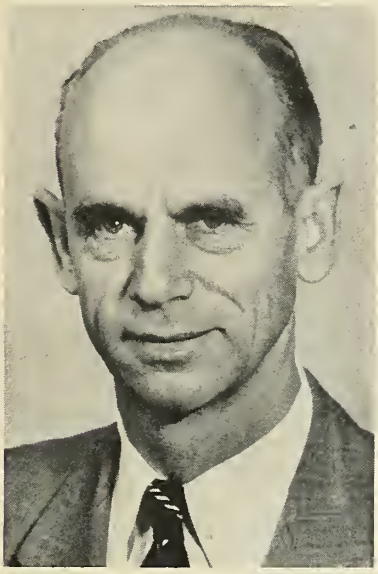
There is also the very good possibility that studies of ion propulsion will provide new knowhow that will ultimately lead to much more ambitious projects, perhaps even bearing on the basic nature or gravity.

Space Flight Confab For Businessmen

Advance reports on the "Age of Space" conference May 16th and 17th promise businessmen a practical short course in missiles and space travel.

Sponsored by the Southern Research Institute, the two-day meeting includes a *Redstone* test-firing demonstration at Redstone Arsenal.

Speakers include Dan A. Kimball, President of Aerojet-General Corp. and ex-Secretary of the Navy; Dr. Clifford C. Furnas, former Assistant Secretary of Defense, R&D; Dr. John P. Hagen, in charge of the Earth Satellite Program; Dr. Ernst Stuhlinger, Research Chief, Army Ballistic Missile Agency who helped develop the V-2,



DR. ERNST STUHLINGER

Maj. Gen. Dan C. Ogle, Surgeon General of the Air Force, F. L. LaQue, Vice President, International Nickel Co. and m/r's managing editor, Erik Bergaust, who will compare the missile science of Russia and the U.S.

Says SRI in the conference announcement: "Glamorous-sounding—even fantastic—missiles and space travel are rapidly assuming down-to-earth importance for the businessman who is, necessarily, concerned with practicality." Meeting takes place in Birmingham, Ala.

New Missile Camera

Bell & Howell has unveiled a new missile-scoring camera pod being built under Navy contract to provide an airborne record of missile accuracy in hits and misses.

Unit is built for mounting on the wingtips of target drones, pilotless planes or larger missiles and contains four 16 mm high-speed motion picture cameras. With one pod on each wingtip, the eight cameras are mounted to give complete spherical coverage as a missile approaches the target drone.

According to B&H, the system permits missile scoring at speeds up to Mach .95 and altitudes from 5,000 to 50,000 ft. A 200-foot film capacity is said to handle up to four missile passes.

Metal Congress Tells of New Materials

Materials and processes for missile applications were given much attention at the 10th Western Metal Congress of the American Society for Metals held in Los Angeles, California.

Titanium held the metals spotlight as the Metals Engineering Institute of the ASM programmed a special 5-day conference devoted exclusively to this subject during which time titanium was declared to have "arrived" as a bona-fide missile material, and increasing demands for titanium reflected its general acceptance.

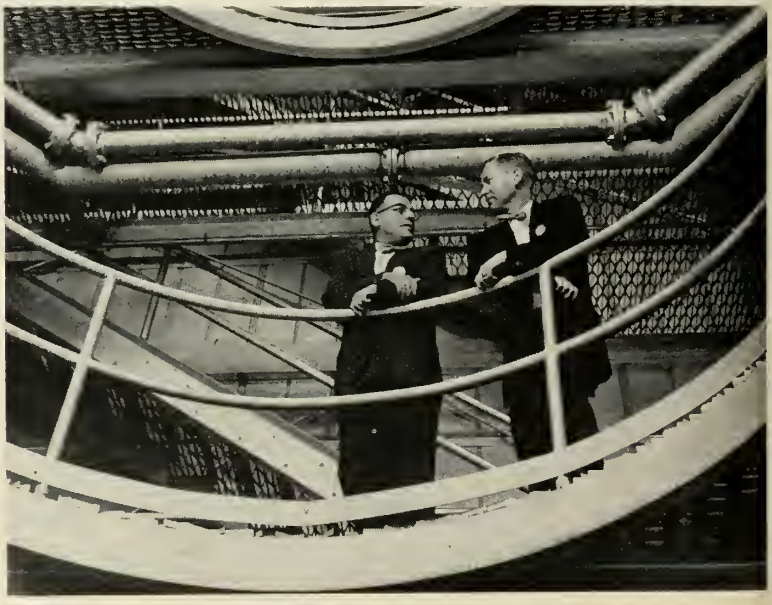
Despite increased use of titanium and titanium alloys, it was pointed out the material is no structural panacea for temperature problems encountered in missile flight above Mach 4, the point at which present titanium and its alloys become ineffective. If some method of cooling can be developed to maintain speed temperatures below those encountered at Mach 4, titanium may be used to an even greater extent. As with any material of recent development, the problem of applying it to today's designs must be solved before creating future designs based on the material's properties.

The economy of titanium in certain missile applications was declared a difficult decision, as the considerable cost expended for the weight savings gained must be balanced against the purpose of the missile. Until such time as titanium is reduced below its present cost level and new fabrication techniques are developed, designers must incorporate economy in their original concepts. Large and complicated forgings are a particular problem in titanium as forge shops do not have sufficient experience with the material. The only alternative is to machine the part from a solid billet, an extremely costly operation as the finished part may be no more than four per cent of the original billet weight of several hundred pounds.

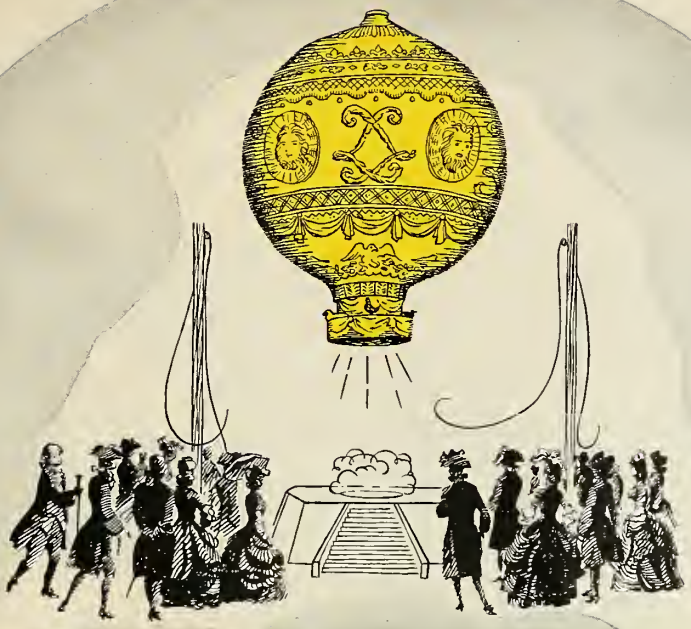
Present titanium alloys were noted as posing still another problem when used in forgings where heat treatment is required of parts with large cross sections in order to obtain maximum strength. This process changes the characteristics of the alloys sufficiently to make titanium's weight saving advantages open to question.

A discussion of titanium extrusions, as used in some current missiles, described the successful integration of the extrusions with titanium webs in box-beam construction by careful placement of rivets at the end of spotweld runs to minimize titanium's low peel strength. It is also possible to use the CHEM-MILL process to reduce web thickness overall and leave areas of greater thickness for large, load-carrying spotwelds.

Some problems of titanium may be averted temporarily by designing "around" them until a permanent solu-



Proof of progress in intercontinental ballistic missile development is in this fuel tank pressure test facility for the ATLAS recently completed at the San Diego plant of Convair Division, General Dynamics Corp. Chief engineer Mortimer Rosenbaum, left, inspects with J. R. Dempsey, Convair-Astronautics Division Manager.



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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missiles and rockets

tion is developed, it was declared. One of these is the relatively large minimum bend radii tolerated by existing titanium alloys, with new alloys expected to require an even larger radii and increasing the weight of the formed part. To anticipate this, new techniques such as creep-forming and hot forming are undergoing further study. Titanium alloy (6AL-4V) sheet is being formed successfully by the use of resistance heating and ceramic lubricants, but contamination and distortion are still critical in heat treatment of light gage sheets. Machined extrusions and welded angles are being used also to overcome forming problems.

Both resistance and fusion welding were credited with taking an ever-increasing part in missile applications of titanium, but the problem of providing an inert gas shielding during welding demands the component be designed with both sides of the weld accessible during fabrication. The accuracy of long resistance welding times, required in some applications, has been improved by incorporation of digital counting systems based on the British-developed Dekatron, a cold-cathode counting tube.

Titanium Users Cautioned

Titanium users were cautioned that although titanium has an unusual weld joint efficiency, only a few of the available titanium alloys are acceptable in welded structures for missile applications, and welding techniques should be rigidly controlled as no satisfactory non-destructive test of weld quality has been developed.

Tests of welded titanium were described as indicating welded joints of pure titanium and alloys containing primarily alpha stabilizing elements are not adversely affected by high temperature aging, but welded joints of alloys containing primarily beta stabilizing elements are extremely adversely affected by the same conditions.

The application of titanium in missile cooling tubes and heat exchangers was cited as an example of brazed components, although it was admitted that all problems in brazing titanium had not been solved.

The phenomenon of "creep," or flow of metal under heat and stress, was charged with being a principal factor limiting the use of titanium in missiles. Two of the newer titanium alloys containing aluminum, 6A1-4V and 5A1-2.5Sn, were said to have more creep resistance than eight per cent manganese titanium alloy, but exact data has not yet been determined to afford full application of these materials. Special equipment is being developed to obtain short-time, high-speed, high-temperature "creep" data by resistance heating at rapid rates and recording the results with special extensometers.

The problems of thermal expansion of titanium and titanium alloys were considered to present the designer with no more difficulties than any other material or material combination.

One property of titanium and its alloys detrimental to missile electronic application was described as its low electrical conductivity. When operating conditions rule out the use of any other structural materials because of weight and heat resistance requirements, titanium may be plated with a precious metal of high conductivity at little increase in cost or weight.

In spite of many excellent characteristics, titanium and its alloys were again described as not being the best possible materials for missiles from a structural-stress basis. This was attributed to the many types of load factors under which a missile component may be required to operate, and the many forms or shapes in which it may be used. However, work is continuing on the material efficiency curves for newer alloys which may be heat treated to

higher strength levels, and it is expected the new curves will be considerably higher than those of the much-in-use eight per cent manganese titanium alloy.

Several papers presented to ASM members dealt with progress in methods to determine mechanical properties of structural materials as applied to missiles. Nearly all outlined the rapid heat, rapid strain rate, and short temperature holding time approach to their investigations.

Molybdenum-Titanium Alloy Strong at High Temperatures

Other materials discussed briefly in relation to their missile applications were a molybdenum-base alloy containing .5 per cent titanium, which is claimed to have a higher useful strength at temperatures over 1600°F than any other presently known material, and precipitation hardening stainless steels.

Liquid propelled aircraft rockets were given a boost in a paper presented by Walter S. Tenner and Paul T. Barnes of the Naval Ordnance Test Station. Described as a "5-in., high-velocity, unguided, air-to-air rocket, the LAR (Liquid Aircraft Rocket) is propelled by liquid bi-propellants, although a solid propellant commonly is used in small rockets."

"The performance of liquid rocket propellants," Tenner said, "has many advantages over that of solid propellant rockets. The principal disadvantages are problems of 'hardware' and assembly.

"Since the originally used mechanical joints were unsatisfactory, welded joints were developed for some areas.

"A program was then initiated to determine the feasibility of welding the entire missile. Early tests indicated the use of an automatic welding process would be necessary to attain the desired results.

"Prototype welded missiles were fabricated and fired successfully."

The LAR is in the pilot production stage and, with simplified hardware assembled by welding, is claimed to be competitive in cost with solid-propellant rockets. Its performance was declared to be "outstanding."

Non-destructive testing was the subject of another large group of papers in which the use of X-ray, eddy currents, ultrasonic flaw evaluation, magnetic particle inspection, isotopic examination, fluorescent penetrants, and nuclear studies were described as finding wide application in the missile and rocket field.

RIAS Wants Sphere 2000 Miles in Space

RIAS, Inc., a subsidiary of The Glenn L. Martin Co., last month proposed firing a recoverable 150-pound sphere 2000 miles out into space with the idea of using emulsion sheets for measuring cosmic energy in free space. Basic proposal consists of stripping a vehicle like *Vanguard* of all guidance and special satellite launching gear and shooting it straight up.

That way, Martin designers W. J. Benckert and R. T. Patterson figure, both payload and terminal altitude could be materially increased over that hoped for from *Vanguard.*

Of the total 150-pound sphere, only about 50 pounds would be available for scientific payload. The rest would consist of an outer shell to take the brunt of reentry. Presumably it would be made of a material that would dissipate heat by melting and/or sublimation during initial reentry and deceleration. In addition the sphere would contain a parachute (or series of them) for lowering the payload to earth unharmed. It would also include a radio beacon for locating it on the ground.

It's estimated that it would spend 40 minutes above the atmosphere and attain a top speed of 13,000 miles per hour on reentry. Analysis of the emulsion sheets to determine the nature of primary cosmic radiation in space would, Martin estimates, require several months of work by a hundred or more research workers.

This is a hypothetical proposal by Martin, since no contract now exists for making the attempt.

Bristol Develops Practical Missile

Bristol Aircraft Ltd. reports the development of "an entirely practical" missile (probably a SAM, according to the Society of British Aircraft Constructors). Bristol made this statement when the Ministry of Supply authorized the release of a photograph of an early Bristol supersonic vehicle known as *Bobbin.* Now some years old, this device was developed for test work on guided weapons and on Bristol's *Thor* ramjet engine.

Bristol has released a limited amount of information on the testing of *Bobbin.* It had a long, spiked nose which stuck into the ground on landing. Supersonic parachutes, developed by the Irving Air Chute of Great Britain and G. Q. Parachute companies, slowed *Bobbin* down from very high speeds so that when it landed on its nose spike, it was virtually undamaged.

The parachutes themselves underwent novel tests over Salisbury Plain, in Wiltshire, before being fitted to *Bobbin.* A dummy test vehicle was dropped from a *Canberra* at very high altitude and accelerated in free fall to well above the speed of sound—producing a sizeable sonic bang. Six ribbon parachutes were released by time switch before, their work done, they were jettisoned automatically. In falling away, they drew out a 30 ft. nylon parachute which lowered the test vehicle gently to the ground. In this way, *Bobbin* became the first British-designed recoverable test vehicle.

Tests to design and manufacture the long nose spike were performed by using a dummy vehicle which was dropped vertically from a crane. Decelerometers and high-speed cameras measured the rate of impact. To establish how the nose spike would react to various types of terrain, half-scale models of the test vehicle were dropped from a helicopter over the Woomera range in Australia.

North American's X-10 Ends Successful Test

ERRONEOUSLY LISTED as dead, North American Aviation's *Navaho* is still a very much alive project. While the contract has been terminated on the intermediate XSM-64, the basic contract for a successor air-breather to the Northrop *Snark* continues in force (see Industry Highlights, p. 144). Meanwhile the program has not been without its benefits.

NAA's retrievable X-10 has been applauded by the Air Force as an "invaluable source of important data." Announcement that the missile-on-wheels had wound up a series of successful test flights was made early this year. It was flown hundreds of miles at supersonic speeds under full automatic control to prove out its design and guidance systems.

The X-10 is powered by two turbojet engines. Its landing gear makes it recoverable for repeated use.

This vehicle is part of the SM-64 *Navaho* weapons system research and development program. Earlier the 14-foot *Nativ*, a single ballistic missile, was successfully tested.

X-10 lands smoothly—coming in with nose high, easy touch-down. Note position of canard stabilizer. X-10 has been applauded by Air Force as "invaluable source of important data."

The *Navaho* weapons systems program goes back to 1945. *Navaho* is one of the most controversial missiles of the day. Big question mark: How good is an aerodynamic intercontinental missile in tomorrow's hypersonic age? Another one: Is the *Navaho* a competitor of the *Snark* or vice versa and can we afford both? Ballistic missile enthusiasts may think there is no need for a *Navaho* but General Curtis LeMay seems to think differently. He wants a long-range missile while waiting for the ICBM.

Now in advanced stages of development, *Navaho* flight testing was undertaken at the USAF Missile Test Center, Florida.

Design and manufacture of the *Navaho* guidance and control systems is the responsibility of North American's Autonetics Division. A third division, Rocketdyne, builds rocket engines for the missile, which will be rocket-boosted to flying speed and then powered by ramjets.

Work on the *Navaho* has been underway for some time in North American's Missile and Control Equipment operations (MACE) at Downey, Calif. MACE operations involve major phases of missile airframe design, rocket engine propulsion, automatic guidance and control equipment. North American says its MACE technical force "is being expanded greatly."

NAA's Missile Development Division started in 1946 with a few men working in a corner of the company's Los Angeles plant. Today the Missile Development Division has grown to about 7,000 workers.

The company began experimental work late in 1947 after completion of studies in airframe, and propulsion. These included possible nuclear power and automatic guidance and control systems. In May, 1948 the first research missile was sent up at Holloman Air Force Base, N. M. This was the *Nativ* and eight of these were built and flown. The staff soon outgrew its Los Angeles quarters and moved to its present location in Downey.

In 1950 the SM-64 *Navaho* missile project was born.

Growing out of NAA's Missile Development Division were: The Autonetics Division, Atomics International Division and the Rocketdyne Division. The four divisions today employ nearly 25,000 persons and have earned for North Amercan the reputation as "the country's best integrated and probably biggest missile research organization."

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Many full-wave, bridge and center-tapped assemblies of these rectifiers are available in this sturdy package.

Type	Max. Recurrent Inverse Working Voltage — e_b (Volts)	Min. Zener (breakdown) Voltage — E_Z (Volts) (Note 1)	Max. RMS Voltage (Volts)	25°C Ambient Max. Avg. Forward Current—I_o (Milliamps.)	Max. Avg. Forward Voltage at I_o=500 mA (Volts)	125°C Ambient Max. Avg. Forward Current (Milliamps.)
HDMP4 HDMP4A*	400	500	280	350	1	150
HDMP5 HDMP5A*	500	625	350	320	1	130
HDMP6 HDMP6A*	600	750	420	300	1	115
HDMP7 HDMP7A*	700	850	490	280	1	100
HDMP8 HDMP8A*	800	950	560	265	1	80
HDMP9 HDMP9A*	900	1050	630	250	1	65
HDMP10 HDMP10A*	1000	1150	700	240	1	50

Note 1 — Measured at a reverse current $|I_z|$ of 0.1 mA
Note 2 — Cathode is electrically connected to the case
* — Axial lead types

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Rocket Trends

By Erik Bergaust

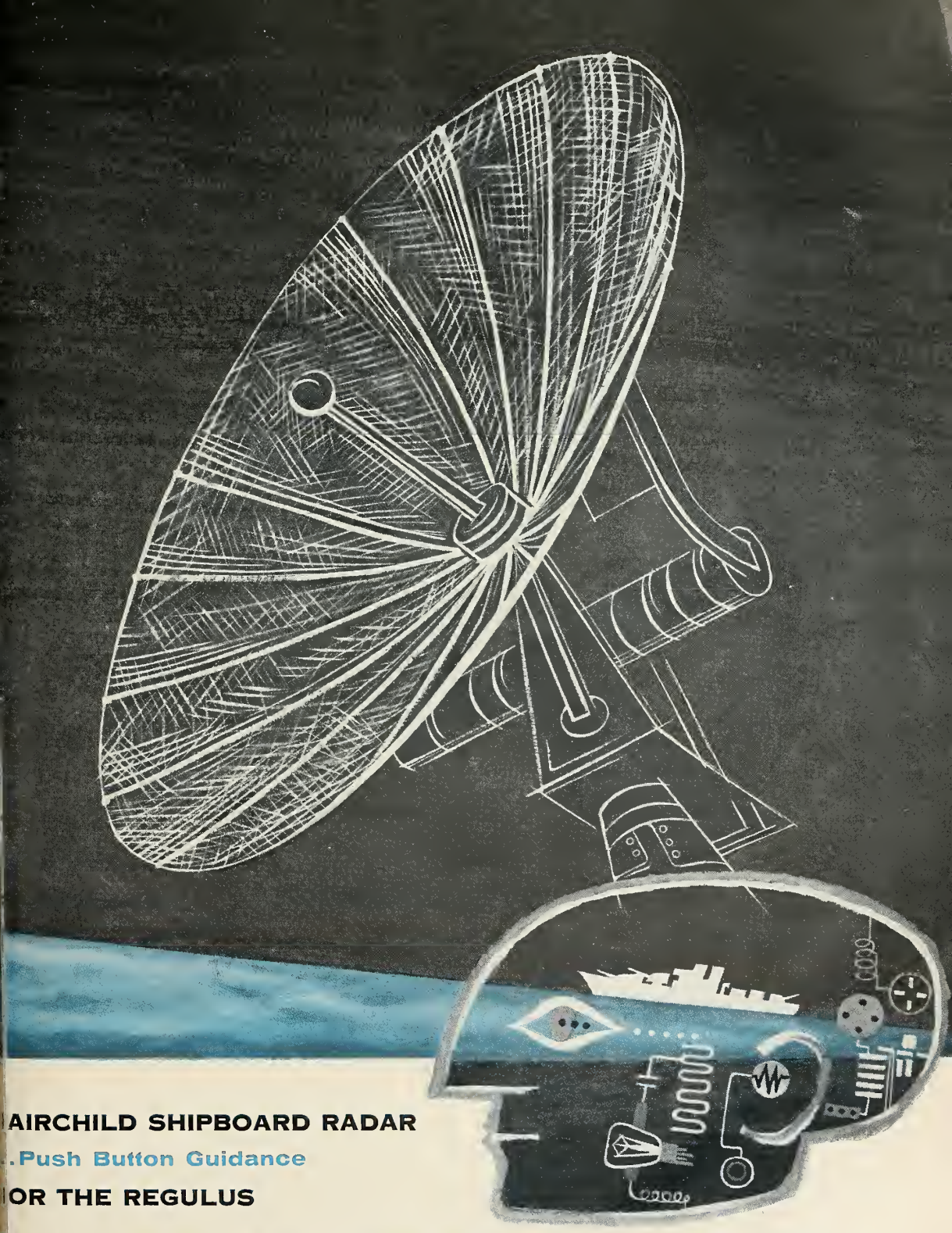
Even the experts seem to ignore what's wrong with our intermediate-range ballistic missile program. Certainly, the problem is not the otherwise harmful interservice battle between the Air Force and the Army. However, the seemingly ignorant high-echelon orders and rules on roles and missions, that have caused this Army/Air Force controversy, will determine something more important by far. They will determine if we will win or lose the race with our potential enemies.

It has been our privilege to discuss this serious problem with top military leaders. We have interviewed secretaries, generals and admirals for hours and hours—and have traveled thousands of miles to get the true story—and have found that the Air Force is doing a terrific job on the most important of our current missiles, the ICBM. In fact, the prototype of the *Atlas* ICBM is being readied now for its maiden flight. (It might have flown by the time this issue of m/r reaches its readers. *More than a dozen Russian submarines were spotted off the coast of Florida as m/r went to press.* Navy blimps are busy watching the unwanted visitors.) Could it be this accomplishment is based on the fact that the ICBM program has never been hampered by interservice rivalry? Apparently the *Atlas* ICBM now is in a more advanced stage than the *Thor* IRBM. Likewise, we have found there's no doubt about the Army's IRBM capability. The Army's ballistic missile capability is so excellent it is possible that they will demonstrate it by sending a space satellite into an orbit around the earth early this summer.

We have discussed the ballistic missile program with senators and congressmen. Says Sen. John D. Sparkman: "Let the Army develop the *Jupiter,* the Air Force the *Thor* and the Navy the *Polaris.* In a future war, we'll need all of them." Certainly, the Air Force should have an IRBM. On the other hand, it is utterly ridiculous to knock out the Army, because the Army has a *requirement* for this kind of *long-range artillery* if it is to stand up against Russia in a future atomic war.

This is why we must have a full-fledged IRBM program, and we cannot afford to cut it short now. Because the real problem is Russia. What are we doing about the fact that the Communists launched a 650-mile operational ballistic missile (the *Comet*) two years ago? From submarines! Are we overlooking that the Russians now have operational IRBM's? And that their missile subs have been spotted off our coasts? When will we wake up to reality and comprehend that the Russians carried out a full-fledged missile research and development program with intense eagerness (from 1945 to 1950) before we even started to think of any accelerated high-punch missile projects? Who are the military leaders in this country who dare kill any ballistic missile project, as long as only a handful of *Thor* and *Jupiter* prototypes have been built, and it takes at least one year to get an evaluation, and two or three to get them into production?

That's what is wrong with our IRBM program. The fact that we're trailing Russia—dangerously. This is the issue. But it appears our defense leaders do not want to understand this. And another thing: this absolutely fantastic idea that has been played in the press lately, that this country is about to provide Britain and possibly France with intermediate-range ballistic missiles! Let's stop fooling the public. We don't have any such missiles. They are two or three years away. We might get them sooner if the services were given the go-ahead on a sound competitive basis—without being hampered by morale-breaking, nerve-racking policies. (We have learned reliably that the "give-away" IRBM will be a *Thor* with *Jupiter* guidance.) Such policies never serve any useful purpose. And certainly not now, when the most important of all battles is being fought: the technological race between this country and Russia.



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missiles and rocke

Washington Spotlight

By Henry T. Simmons

Final determination of the fate of the North American *Navaho* ramjet missile will be made by the Air Force next fall. As of now, it appears that two principal conditions must be met if the intercontinental weapon is to go into large-scale production: It must make an excellent showing during current tests at Patrick AFB, Fla., and unexpected roadblocks must crop up in the ballistic missile development program. Furthermore, they must be serious difficulties—bad enough to delay introduction of the ICBM three years or more beyond the operational date expected for the *Navaho*. Any lesser delay would probably persuade the USAF to step up production of the Northrop turbojet *Snark*.

•

Even should everything favor increased support of the *Navaho*, there remains the knotty problem of where to find the money. If really serious troubles hamper the ICBM, of course, funds can be withdrawn from that program and applied to *Navaho*. But the North American weapon will still be just one of many projects clamoring for money. Probably its most important competitor will be the WS-110A intercontinental chemical bomber projected by the USAF as a replacement for the B-52. NAA and Boeing are expected to submit their WS-110A entries about June, with an Air Force evaluation several months later. Should really tough problems arise in the ICBM program, the Air Force may be more inclined to fall back on a traditional manned bomber concept rather than strike out into new and unfamiliar production, maintenance and operational territory with the *Navaho*.

•

The Air Force is still studying the failure of the *Thor* IRBM on its maiden flight at Patrick early this year. The trouble was apparently caused by a recalcitrant valve in the engine starting system. Probably because of an explosion which occurred when the liquid oxygen came into contact with an impurity in the valve, the valve itself failed to close tightly. This permitted a portion of the LOX which should have gone to the engine to recirculate, thus starving the combustion process so that the rocket sagged back to the ground. The airmen hope to duplicate the exact circumstances of the accident.

•

Army procurement of guided missiles is heading upward even faster than in the Air Force. The soldiers expect 50% of their total procurement funds will go for birds in fiscal 1958, beginning next July 1, compared with 23% just two years ago.

•

Although the existence of a guided missile called the *Corvus* has been known for more than two years, it was not until last month that the name could be nailed to a specific project. It seems that a $16 million Navy contract awarded Temco in January provides for design and development of the weapon. *Corvus* (Latin for Crow) is a long-range air-to-ground missile to be carried by a brand new Navy attack fighter for which a competition has just been established. It is believed the Temco weapon is a descendant of Fairchild's *Lark* research missile.

•

Rep. Carl Vinson (D-Ga.) has scotched chances for an early hearing on the *Thor-Jupiter* by his House Armed Services Committee. Rep. George Huddleston, Jr., (D-Ala.) had urged a secret hearing on the IRBM program, but Chairman Vinson said it would not be wise. "I am mindful of the pending court martial action which has a direct bearing on this matter and I feel this committee must do nothing that could prejudice the court martial in any way," he wrote.

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VOL. 2 NO. 4
APRIL, 1957

missiles and rockets
MAGAZINE OF WORLD ASTRONAUTICS

m/r exclusive:

USAF's Long-Range Missile Program

IT HAPPENED in the early evening of September 6, 1944. People of Chiswick-on-Thames, London, had just finished their evening meal. At 6:38 this evening, at Wassenaar, on the outskirts of The Hague, Netherlands, the first military rocket capable of approaching a predetermined target at a speed greater than sound and with no advance warning was launched. It was an awesome weapon, forty six feet in length, and weighing 2,200 pounds. Its speed was 3,500 miles per hour, and at the height of its trajectory it reached a point 50 miles above the surface of the earth. It was an all-weather weapon, and most fearsome of all, there were no counter-measures against it. The effect was devastating. The people of Chiswick-on-Thames felt it. For this was the first "target" to be hit by a liquid-propellant ballistic missile.

The dramatic launching of the first rocket attack in history was born of desperation on the part of Hitler. Following early and easy victories in Poland and France, Germany suffered defeat in its efforts to conquer England by air attacks. This set-back was followed by collapse of the German invasion of Russia. Clearly, something desperate was necessary, and the rocket seemed to be the answer. Following the initial rocket offensive 26 additional missiles were directed toward London during the next ten days. Between September 1944 and March 1945, approximately 1,500 V-2 rockets were showered on England.

Thus, comments after the war by leading military figures, that such an offensive, if perfected in the early days of the war, could well have defeated the Allies. General Eisenhower, writing in his book, Crusade in Europe, stated "It seemed likely that if the German had succeeded in perfecting and using these new weapons earlier than he did, our invasion of Europe would have proved exceedingly difficult, perhaps impossible. I feel sure that if he had succeeded in using these weapons over a six month period, and particularly if they had made the Portsmouth-Southampton area one of their principal targets, 'Overlord,' (codename for the planned cross-Channel invasion of France), might have been written off."

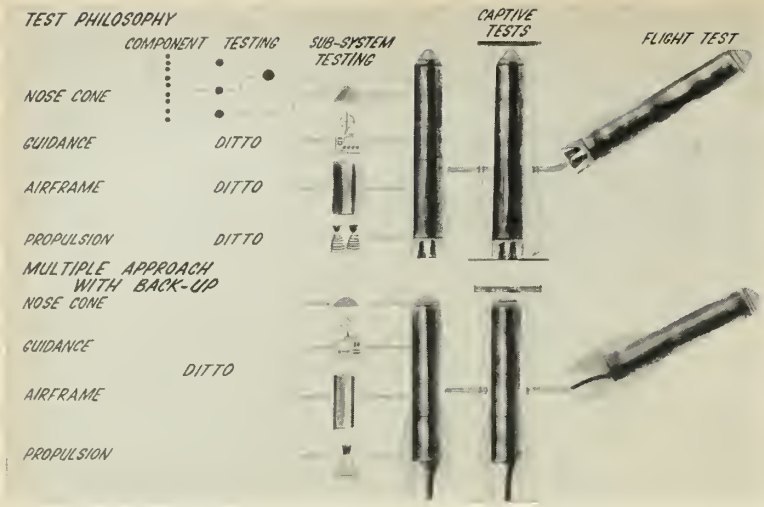
This article on the history and development of long-range ballistic missiles, and the role our Air Force plays in the important ballistic missile race with Russia, outlines the philosophies behind long-range missile weapon systems as well as some of their psychological effects on our society. The article was prepared by m/r managing editor, Erik Bergaust, and Vincent B. Hackett, Field Engineer, Telecomputing Corporation.

In the years immediately preceding the outbreak of war, one of the most closely guarded secrets in Germany was the experimental work being done in the field of ballistic rockets.

Early in 1930 General, then Captain, Walter Dornberger, Dr. Ernst Steinhoff and Dr. Wernher von Braun were busily engaged experimenting with the theory of such missiles for the German Army Ordnance Corps. In March of 1936 Colonel-General Werner von Fritsch, Supreme Commander of the Army, was persuaded by Dornberger and von Braun to visit the early experimental station in Kummersdorf to inspect the work under way. This visit resulted in an allocation of funds for future experiments, and a decision to approve von Braun's plan to move all operations to an isolated spot, previously selected by von Braun, on the coast of the Baltic Sea. This occurred in 1937. The new location, Peenemünde, was destined to become a source of prime interest to the British High Command before the war was brought to an end.

Hitler was showing enthusiasm over the progress developed in the missile program. In June 1943 he visited Peenemünde to observe first hand what might be expected. Already desperate, he visualized the possibility of opening a decisive attack on England by a new and terrifying vengeance weapon, which might serve to prevent any plans of crossing the Channel into France.

He left Peenemünde determined on all-out effort as a new and final effort to create panic among the Allies. Evidence of this desperation is afforded by his statement to German military associates on June 10th that, if the



Western Development Division's test philosophy for the two intercontinental ballistic missiles Atlas and Titan. Convair's Atlas is being readied at Patrick AFB for its maiden flight test; Martin's Titan—which got under way later than the Atlas—may fly at the end of this year.

German forces would hold on for a short time longer, London would be razed and England would be forced to surrender. He gave the date of October 30th as the date for the beginning of such attacks. It is said that Hitler ordered 30,000 rockets for immediate production, thereby indicating the degree of confidence in the new weapon. It was an unrealistic program. One thing was evident. Hitler planned to rain rockets on London in a desperate effort to bring England to her knees. England's duty was clear—crush the new menace at its origin, Peenemünde.

On the night of August 17th, 571 heavy RAF bombers struck from a level of eight thousand feet. This sorty resulted in the loss of forty aircraft, but the results were worth the loss. Drawings due to be issued to the workshops were burned, 715 personnel were killed, including Dr. Thiel, the commanding military officer.

Reports from Britain indicate that over 1,000 V-2's alone fell in and near London over a period of seven months. The number of homes and buildings destroyed ran into the tens of thousands. Only due to the fact that the Canadians in March 1945 captured the launching sites in Holland was much greater damage and loss of life prevented. There is no record that a single V-2 was intercepted or shot down once under way.

According to Dornberger, 9,300 V-1's were fired day and night against England—about 6,000 reached the English coast—4,300 V-2's were operationally directed against England and over 2,100 against other targets. The last V-2 fired was on March 27, 1945 at 4:45, and its target was Orpington in Kent. This last rocket was the 1,115th to fall on England—Casualties for the entire period of firing was 2,511 killed; 5,869 seriously wounded in London, and 213 killed and 598 seriously wounded elsewhere, according to Dornberger.

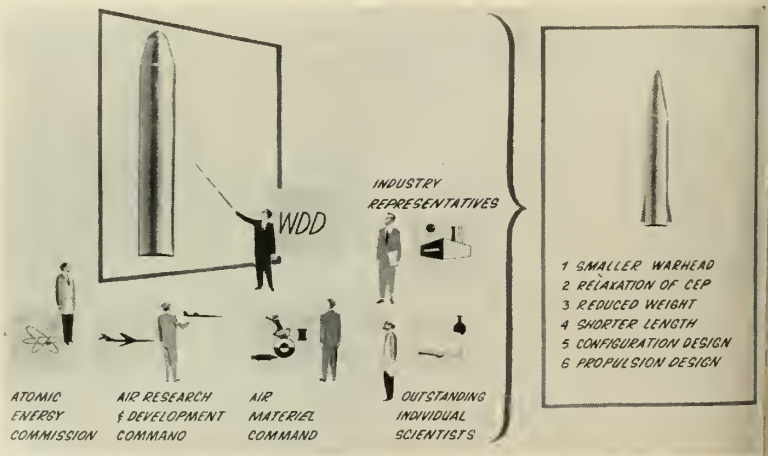
The history of the V-2, the world's first ballistic missile weapon, and the statistics on death and destruction caused by this weapon, clearly indicated that this kind of missile was here to stay—that highly advanced ballistic missiles would be included in any modern defense system. As a matter of fact, the art of missile science has advanced so rapidly since the days of the V-2 that 50% of the USAF budget will go for missiles within the next two or three years. And Russia puts an equally great emphasis on these weapons. There are, in fact, indications that the Russians might be ahead of us in many phases of missile development. Some of her ballistic missiles have already reached the production stage . . .

America Takes Advantage

Project "Paper Clip" has meant a lot to American technological and scientific advancement. This was the program under which top notch German scientists were taken to this country. Ballistic missile know-how was brought to the United States and the US Army could establish an important ballistic missile program. American industry, thus, became familiar with the art. The need for missile engineers turned into a boom with more need for specialized training and education. During the last 12 years a whole separate industry has emerged from the early backyard experiments that took place at White Sands with captured V-2s.

In 1946 the Air Force assigned to Convair a research contract for Project MX-774, in a sense the predecessor to the *Atlas*. But the early project was cancelled out one year later, in 1947, because of the Defense Department's economy "review" of this and other seemingly "unnecessary" weapon system concepts. Of course, the Air Force knew only too well that this was dangerous. They watched how the Army proved the feasibility of ballistic rockets. They knew the Russians were working on long-range ballistic missiles. They knew it was necessary to carry out an intercontinental ballistic research and development program. Obviously, the Air Force would have to become the service in charge and control over long-range missiles, eventually. This weapons concept was nothing but strategic bombing.

In 1951 the Air Force came into the act again. And this time top Air Force planners played their cards so



The Air Force' ICBM programs represent a great industrial challenge. This illustration shows the military and civilian elements involved.

that it would never again be possible to kill any phase of the projected ballistic missile program.

Thermo-Nuclear Break-through

The Air Force ballistic missile program encompasses the largest concentration of men, money and materiel on a science-industry military basis that has ever been achieved. The end product required—an operational intercontinental ballistic missile at an early date.

The thermonuclear break-through in 1952-1953 was a major break, according to WDD Chief, General Bernard A. Schriever. The possibility of high yields in reasonable packages meant that accuracy requirements could be relaxed, that it was now technically possible to develop a reliable guidance system, and that the overall weight of the missile could be considerably lessened.

In August 1954, the Western Development Division of Headquarters ARDC was established in Inglewood, California. WDD was to have responsibility and authority over all aspects of the program with the specific purpose of reorienting and accelerating the ICBM program in order to achieve the earliest possible operational capability.

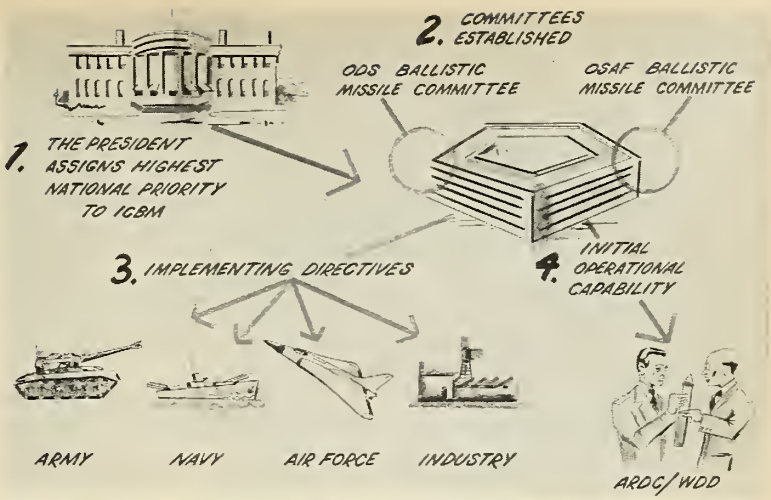
By January of 1956, the Air Force Ballistic Missile Program had been expanded to include the IRBM *Thor*. The ICBM program already had under development all the subsystems such as propulsion, guidance and nose cone, which were required for the *Thor*. Therefore, only the Douglas Aircraft Company, which has the airframe, assembly and test responsibility, was added to the list of industry contractors. Tapping the ICBM program provided a special opportunity for maximum saving in development time and money.

The establishment of WDD by the Air Force was indeed a unique and important management step. It marked the first time that the Air Force would retain full and complete management responsibility over a major development effort.

The concurrent development and production of the Air Force's Ballistic Missile Program under the management of an overall team is an integrated approach without precedent. The program is on schedule. Milestones are being met and the WDD Chief is confident that they will continue to be met.

The Air Force firmly believes in the policy of utilizing the demonstrable effectiveness of all elements of U.S. science and industry. Accordingly, the strongest scientific - industrial - military team possible has been assembled by the Air Force in all fields of ballistic missile requirements in support of this, the nation's highest priority program.

Without this philosophy and without the wholehearted response of science and industry, the task could not be accomplished.



The President of the United States has assigned top national priority to the ICBM program —overall simplicity for conducting the program is emphasized.

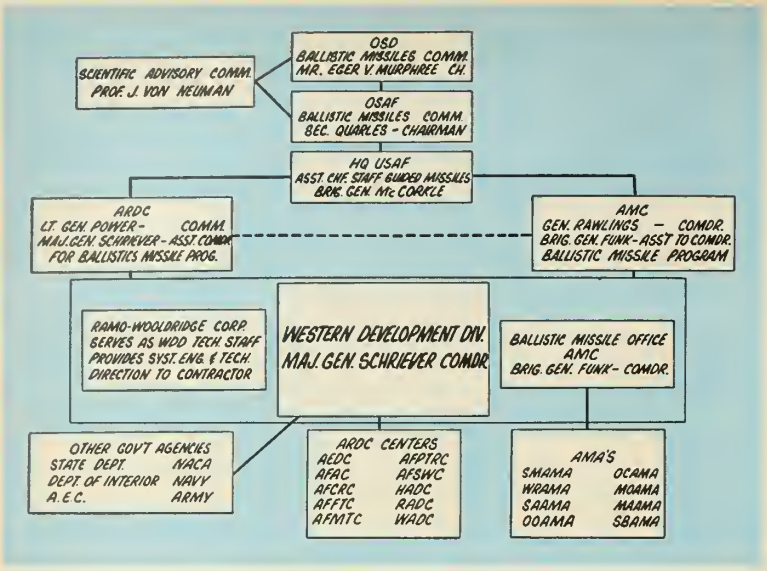
USAF Missile Management

Three elements are making up the total Air Force long-range missile systems organization management; first, the Western Development Division, which is part of Headquarters, Air Research and Development Command. WDD has the overall responsibility and authority for the program and supervision of the management complex. Secondly, the Ballistic Missile Office, which is part of Headquarters, Air Materiel Command, performs all the contracting activities of major contractors and administers the contracts.

The Ballistic Missile Office supports the operational activity in terms of maintaining supply records, procuring the necessary level of spare parts,

THE TWO DECADES OF BALLISTIC MISSILE DEVELOPMENT

1937	German Army Activates Ballistic Missile Program
1942	First Ballistic Missile Flight—German V-2
1944-1945	6000 V-2s Produced 3600 V-2s Launched At Allied Targets
1946	Russia Accelerates Ballistic Missile Program V-2 Program In This Country Reaches Peak USAF Project MX-774 Study Contract (Convair)
1947	Defense Department Economy Review—MX-774 Cancelled
1951	USAF Project MX-1539 Second Study Contract (Convair) ICBM Program Initiated—Convair *Atlas*
1952	*Atlas* Component Program—Seven-Engine Design Gets Underway
1952-1953	Thermo-Nuclear Breakthrough
1953	USAF Establishes Strategic Missiles Evaluation Committee, Dr. Von Neumann, Chairman US Army Fires First Redstone Ballistic Missile
1954	USAF IRBM/ICBM Program Is Accelerated
1955	USAF Starts ICBM Component Tests
1956	Russia Fires *Comet* IRBM From Submarine
1957	US Starts Flight Test Program For IRBMs and ICBMs



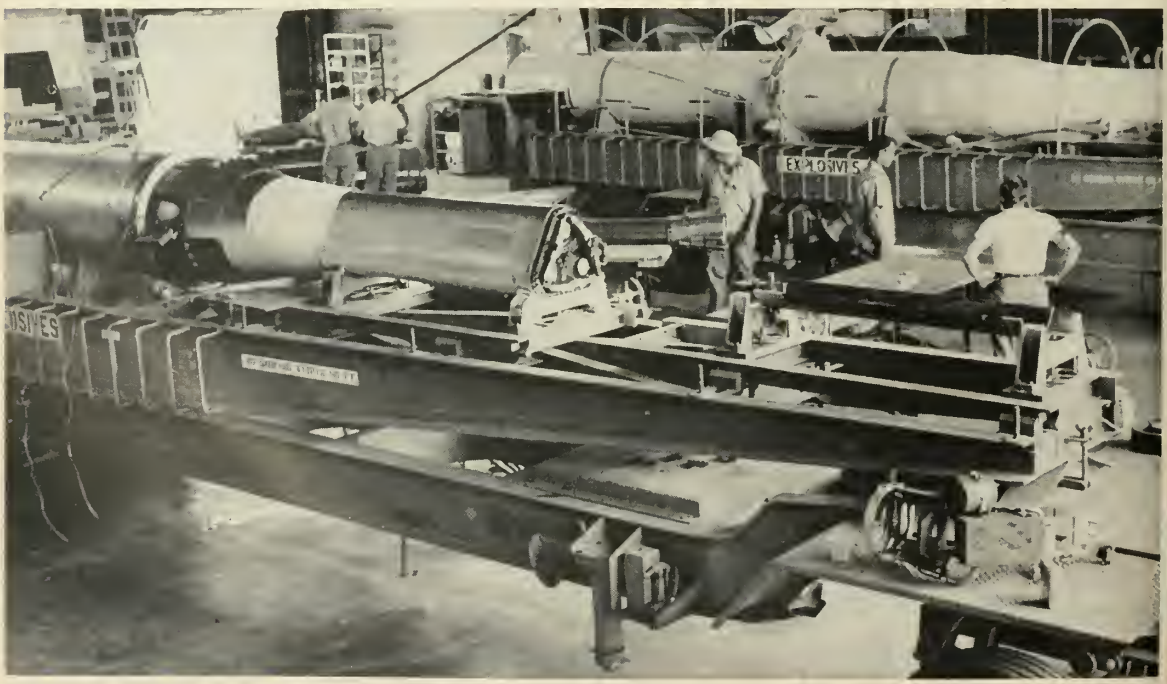
Organizational chart showing the various functions and the jurisdiction pertaining to the Air Force long-range missile projects.

establishing maintenance procedures and affecting necessary transport of parts and missiles.

The third element is the Guided Missile Research Division of The Ramo-Wooldridge Corporation, which has the systems engineering responsibility. The Air Force has found it necessary to have a systems engineering manager to integrate the subsystems. For example, the same basic power plant that powers the *Thor* missile also provides the basic propulsion element for the *Atlas*. For the *Atlas* the Air Force uses a combination of engines, while a single engine is used in the *Thor*. From the standpoint of the thrust chamber and most of the basic plumbing and what goes with it, the engine is the same. The nose cone is being developed by General Electric and will be used both on the *Thor* and the *Atlas* in the early operational missile. Later on there will be different specification, but the approach under development will get the Air Force there quicker. In the guidance area Bell Telephone Laboratories has the radio inertial guidance system contract—this guidance system will be used both for the *Titan* and the *Thor*. Consequently, the Air Force has to centralize the technical direction of contractors to be sure the BTL system is compatible to both the *Thor* and the *Titan*. The Air Force could not delegate down to Martin and to Douglas; it needs an "umpire," because they will run into differences, naturally. For instance, one contractor will want something just a little bit different than the other one. That is why the Ramo-Wooldridge Corporation was called upon to monitor the program. So far, this has worked fine. And the Air Force actually is *ahead of schedule* on several of the evaluation and test phases of the ICBM program.

Certainly, the Air Force has come a long way. The Air Force and American industry have proved that practically any technological challenge can be met. Yet, many experts question whether we are so well off in comparison to Russia. But this might be a result of getting the program underway late, something which is dictated by

Two X-17 reentry test vehicles at Lockheed's facility at Patrick Air Force base being assembled on the strongbacks which will carry them to the launching pad. X-17 plays important role in the Air Force long-range missile research and development program.



politicians. The Air Force cannot be blamed for this.

Nevertheless, the Air Force has been pushing these programs hard, and we are now reaching the point when even Air Force spokesmen talk about using ICBM hardware for the purpose of sending rockets to the moon—as part of the ICBM training program for launching crews.

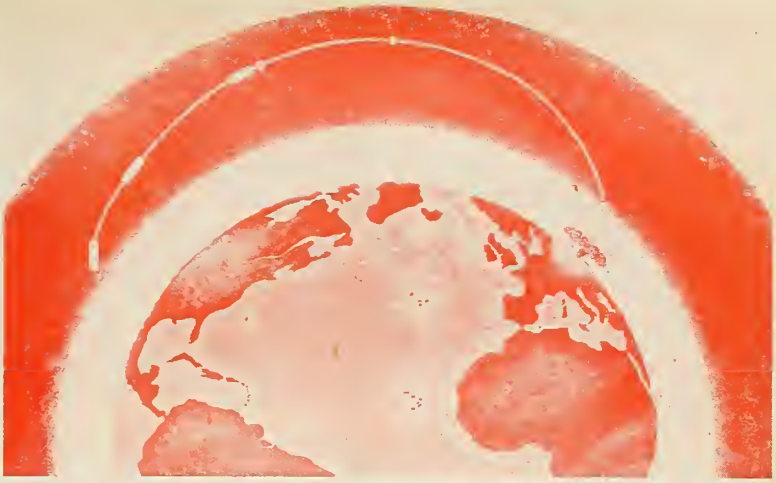
A Military Leader and Sound Industrial Planning

The Air Force's eagerness—from an early date—was inspired by General Bernard A. Schriever. He has been pushing the program hard—and being the born leader, he has truly built the backbone of the Air Force ballistic missile program. He is charged with the responsibility of keeping the Air Force on the right course, at the right speed —and well ahead of our potential enemies.

However, let us not forget that the Air Force Ballistic Missile Program is a typical American *industrial challenge,* and that the Ramo-Wooldridge Corporation, as program monitor and engineering manager, has contributed much to the advancement of the projects involved. R-W is actually a typical American firm—although its functions in the Ballistic Missile Program are unique.

The record of the company in this work, on behalf of the national defense effort, has been unusually good. One of the reasons — possibly — is that the Ramo-Wooldridge Corporation at its inception sought and succeeded in establishing a close liaison with Thompson Products, a typical American "big business" firm.

A measure of the importance which is given by Thompson Products to its affiliation with The Ramo-Wooldridge Corporation is the fact that under arrangements existing between the two companies, R-W has access to funds in excess of $20,000,000 to finance its operations and expansion requirements for the next few years.



The main areas of ICBM design and development include propulsion, airframe, staging, reentry and warhead. Air Force seeks to employ overall simplicity, standardizing engines, nose cones, warheds.

While control of the company is vested in the hands of its key employees, the assistance provided by Thompson Products is not limited to the extensive financial backing it provides. In addition, the business and industrial experience and services of this large organization are made freely available to Ramo-Wooldridge. The extent of the interest and assistance is indicated by the fact that the Chairman of the Board, President and two Vice-Presidents of Thompson Products serve on the nine man Ramo-Wooldridge Board of Directors, and give freely of their time to help the executives of the organization make certain that business matters are handled with an adequate level of professional competence. The relations between the two companies have been strengthened still further by the election of three of the officers of Ramo-Wooldridge to the Board of Directors of Thompson Products.

In summary, the ingredients that should provide The Ramo-Wooldridge Corporation with a high probability of remaining a stable ballistic missile program manager are: a field of activity characterized by a demand for competence far exceeding the supply, a staff organized around experienced men with an outstanding record of accomplishment in this field, and an unusual degree of business and financial soundness provided by the strong support of a large and stable company. ★

This illustration shows how the Air Force selects contractors for the long-range missile projects. While all prime contracts have been let long ago, thousands of subcontractors have become involved recently. Subcontracts are still being awarded.

The Ramo-Wooldridge Story

THE ROLE OF The Ramo-Wooldridge Corporation in the Air Force ballistic missile program includes a number of functions under the heading of Systems Engineering and Technical Direction. To be more specific, these functions should be broken down into a group of tasks. One of them is to create an overall research and development plan; a plan that considers what the technical state of the ballistic missile art ought to accomplish to get consistency and a compatible compromise between what science says is possible, and what the military believes it needs.

Next, R-W translates that research and development plan into what one might call an *action plan* that considers what industry can do versus *time*. Selection of the most qualified industry for the myriad of important tasks connected with the ballistic missile program becomes a major consideration. Yet this cannot be done without consideration of the total facility problem.

Ramo-Wooldridge must, in effect, take the initiative for the technical side, and while working very closely with the Government, with the Air Force, and with industry, translate the R&D plan into an accompanying facility plan. All of these things must be done at once, and each feeds back on the other. It's the chicken and the egg problem again. A facility program must go along with an R&D plan and specify, for instance, so many test stands in certain locations near the engineers who are actually going to do the detailed development.

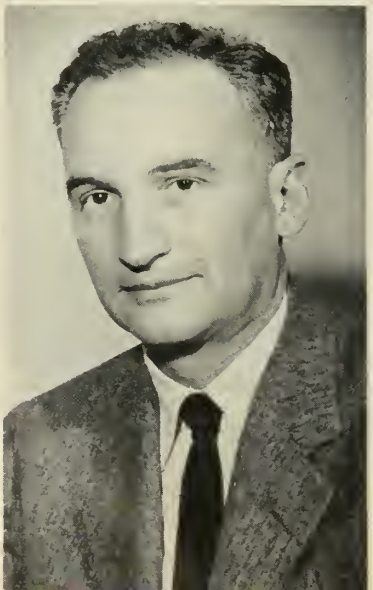
It is necessary for the systems engineer to see that such facilities are provided on schedule. So, the ideal thing then is to create an R&D plan with all its related and supporting annexes, a *facility plan* which considers military requirements, scientific fundamentals, industry know-how and facility acquisition.

At the same time, Ramo-Wooldridge must consider the backup programs. Where is the technical art closest to the limit of what you can be certain about? Ramo-Wooldridge cannot raise the question of whether something is fundamentally possible. They must create a plan which relates these things from the beginning, in such a way that one can have confidence that the whole project can be brought off. They can only be concerned with *how* to bring it off in the *shortest* time, by the best use of the nation's resources.

Indeed, Ramo-Wooldridge must decide reliabilities at various stages of the program: how far should the Air

Dr. Dean E. Wooldridge, President; Treasurer.

Dr. Simon Ramo, Executive VP, and Sec.



Force go with component testing; and when should the Air Force take on the expensive and more dangerous *systems test?* What will the Air Force *learn* from the initial systems test? Should the Air Force allocate *early testing* for the purpose of getting the team in shape; getting the whole proving ground proven out?

Basically, the Ramo-Wooldridge Corporation conducts research, development, and manufacturing operations in the field of electronic systems for commercial and military applications, and in the field of guided missiles. The company is organized around a central group of scientists, engineers, and administrators who are said to have unusual records of recent accomplishment in these fields.

Both because of the national need and the inclination and experience of the key people, emphasis in the Ramo-Wooldridge Corporation is on the development of products containing *a high degree of scientific and engineering newness*. Every facet of the organization and the operational procedures are designed to fill the special needs of the scientist and engineer.

A certain amount of pioneering spirit is required of those who work together to help develop our big ballistic missiles. All of them enjoy the air of adventure, but most of them, particularly scientists and engineers, like to feel that the odds in favor of eventual success are fairly high. Combined with the probability that early affiliation with a fast-growing organization is likely to lead to a rapid increase in individual responsibility and reward, the result can make for a stimulating and fruitful career. This concept, in particular, applies to the ballistic missile program monitor, the Ramo Wooldridge Corporation.

Major elements in any evaluation of ballistic missile prospects of this young company include (1) the general scope and promise of the field in which the company is engaged, (2) the competence of the organization relative to competition, and (3) the adequacy of the financial backing and business management. With respect to the first two points, there can be no doubt that there is a tremendous national need for greater competence in electronic systems analysis, engineering, and development. The Ramo-Wooldridge Corporation expects to maintain its reputation for competence in this field.

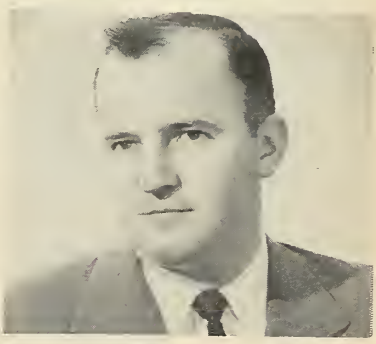
No matter how bright the promise seems, it is still easy for a young company to fail if it is not adequately financed, or if its business management is inept. Both of these contingencies have been guarded against by establishment of strong ties with Thompson Products, Inc., one of the soundest and most highly respected large companies in the United States. Thompson Products, with headquarters in Cleveland, Ohio, has served the automotive and aircraft industries for many years. In addition to an enviable growth record going back for many years, and a volume of business of several hundred million dollars a year, Thompson Products is known for its enlighted management policies, both with respect to personnel relations and operational techniques inside the company, and for its aggressiveness in the development of new fields of interest.

There is no field today that ranks higher, either in importance to the national welfare or in the degree of challenge offered to the scientists and engineers, than that of guided missile development. The strong professional background of its scientists and engineers made it about inevitable that the Ramo-Wooldridge Corporation would take an active part in guided missile development programs. That's why responsibility for the Air Force Intercontinental Ballistic Missile and the Intermediate Range Ballistic Missile Programs—as far as overall systems engineering and technical direction are concerned—was given to the Ramo-Wooldridge Corporation.

An essential policy established by the Ramo-Wooldridge Corporation is that of maintaining a strong program of supporting research in fields related to the company's major technical areas of activity, but not otherwise directly associated with development projects.

While some supporting research can best be done within the operating divisions that are responsible for development projects, other research work is more appropriately done within separate organizational units. The Aeronautical Research Laboratory and the Electronic Research Laboratory are the divisions in Ramo-Wooldridge that are exclusively devoted to basic or supporting research.

Such research, through the development of new techniques, which are improved and refined goes a long way toward insuring the maintenance of advance scientific and engineering standards throughout the organization. ★



The Ramo-Wooldridge Big Five for Missiles from top to bottom: Dr. Louis G. Dunn, VP and Director of Guided Missile Research Division; Dr. Edward B. Doll, Program Director for the ATLAS, Guided Missile Research Division; William H. Duke, Program Director for the TITAN; Dr. Reuben F. Mettler, Program Director for the THOR; and Adolph K. Thiel, Assistant Program Director for the THOR.

WHO'S GOT WHAT?

The nation's mushrooming ICBM and IRBM missile programs, already approaching the $1 billion mark in allocated Defense spending, have spread in octupus fashion to virtually every segment of U.S. industry. At last count the two programs listed some 17 prime and more than 200 subcontractors.

From the "big five" basic weapons project—Convair's *Atlas* and Martin's *Titan* in the intercontinental category and the Douglas *Thor*, Army Ballistics Missile Agency's *Jupiter* and Lockheed *Polaris* in the intermediate range role—key development contracts for their propulsion, guidance, nose cone structure have dispersed the projects coast to coast.

Only a handful of the key participants have been named. Even fewer have been officially pinpointed to specific projects.

Here's how the big five projects shape up:

Convair's *Atlas*—Air Force has awarded an initial contract valued at $145 million for airframe development, excluding propulsion, guidance and nose cone work. Convair Astronautics Division, organized specifically to handle the *Atlas* and future projects of its type, expects to begin occupying its new $41 million plant at Kearny Mesa near San Diego in June. Eventually, employment in Astronautics Division will reach 6,600.

In *Atlas* propulsion, prime producer is North American's Rocketdyne Division, although Aerojet-General is prominently tabbed as supplier of a second-stage power unit. Rocketdyne, which will supply the *Atlas*' two estimated 100,000 lbs. thrust liquid rocket motors, last month occupied its new $4 million plant at Neosho, Mo. The new midwest location is part of an overall $13.2 million construction project there to gear the division for ballistic missile propulsion work.

Nose cone for the Convair ICBM is being developed by General Electric's Missile & Ordnance Systems Department formed during the past year at Philadelphia. As an index of the pressing task at hand, GE already has subcontracted fabrication of nose cone structural components to Republic Aviation Corp. in a $500,000-plus project.

For guidance, the *Atlas* project looks to General Motors AC Spark Plug Division and another GE department, Heavy Military Electronics, at Syracuse, N.Y. AC's guidance is inertial in variety, that of GE involves radio ground guidance techniques.

Martin's *Titan*—An initial USAF development contract totaling $358 million has reshaped the geographic organization of its prime airframe contractor—The Martin Co. The *Titan* program, centered by Martin in a new $10 million facility in Denver, is already outgrowing the bounds of initial planning.

As a result, a $2 million plant expansion is already in the mill. Present employment of 2,500 is expected to reach 5,000 next year.

Titan propulsion is assigned to Aerojet-General at Azusa, Calif. Prime contractor for nose cone development is Avco Manufacturing Corp. at Lawrence, Mass. with Lockheed Aircraft Corp.'s Missile Systems Division lending research support to both the *Atlas* and *Titan* nose cone R&D effort via its X-17 research project.

In *Titan* guidance, American Bosch Arma Corp. of Garden City, N.Y. is spearheading inertial guidance development and Bell Telephone Laboratories/Western Electric Co. at Whippany, N.J. is working on radio guidance.

Douglas *Thor*—The Air Force's IRBM entry, already in the test stage, is supported by an initial development and evaluation contract totaling $67.5 million. In addition to AF contracts of $1,305,500 and $2,340,083, Douglas is investing $3 million in facilities for *Thor* development and testing in the Sacramento, Calif. area. Contracts amounting to $2 million already have been let for construction on a 1,700 acre site there.

Propulsion for the *Thor* is being handled by NAA's Rocketdyne Division, guidance by AC and Bell Laboratories, all repeaters from the ICBM program.

In all three USAF ballistic missile projects, two other firms hold key contracts. The specialized task of developing warheads belongs to Sandia Corp., Western Electric subsidiary at Albuquerque, N.M. Engineering responsibility and technical direction for all AF ballistic missiles is vested in Ramo-Wooldridge Corp.

Jupiter—Army's IRBM under technical cognizance of Army Ballistic Missile Agency at its Redstone Arsenal has airframe development assigned to Chrysler. Total funds amount to an estimated $140 million. Prime production of propulsion has been awarded to North American for a 135,000 lb. thrust liquid rocket, although Aerojet-General is known to have developed what it calls the "largest solid rocket ever used" for the *Jupiter* IRBM.

Polaris—newest of the IRBMs, resulting from Navy split with the Army in intermediate range ballistic missile development, has airframe development at Lockheed Missile Systems Division. Also in this project are Aerojet-General Corp., presumably with the large solid rocket it developed for the *Jupiter*, General Electric and Massachusetts Institute of Technology, both of the latter in guidance development.

In addition to these prime development assignments, American Machine & Foundry Co.'s Turbo Division is developing auxiliary power units for unnamed missiles.

Two missile firms, Associated Products Corp. of Pomona, Calif. and Hallamore Electronics of Anaheim, Calif. have opened Denver facilities as subcontractors to Martin in the *Titan* program. Hallamore is also subcontractor to Convair in the *Atlas* project.

Baldwin-Lima-Hamilton Corp. holds subcontracts from Martin for *Titan* test stands and, in turn, has contracted with Beckman Instruments, Inc. to supply specialized computers. Douglas also has ordered Beckman data processing equipment to speed *Thor* research.

Burroughs Corp. holds contracts for data processing equipment in the ground control equipment for the IRBM/ICBM program. Fruehauf Trailer Co., Los Angeles plant, is building special *Thor* truck-trailers under a $1.5 million subcontract from Douglas.

But these are only a few of the 200 subcontractors active to date in the ICBM and IRBM in the programs. The roster of the unnamed, obviously even more impressive by its numbers alone, remains to unfold.

SPACE POWER

When US Air Force becomes US Space Force

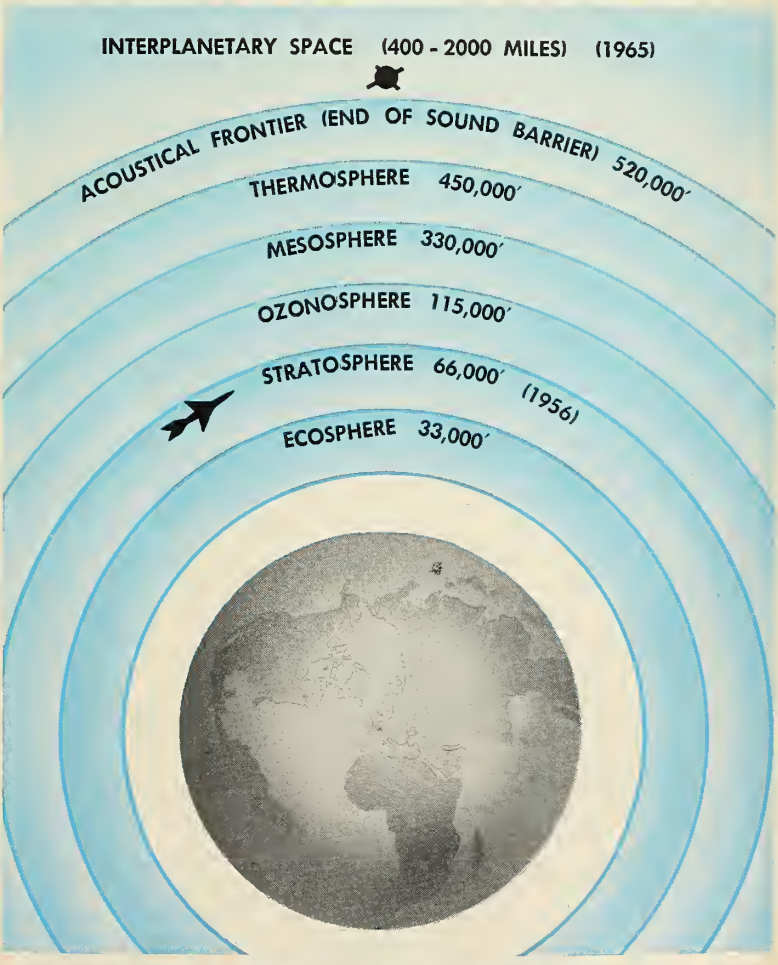
by Dr. Donald Cox
The Martin Company

AT SOME historic moment between July, 1957, and December, 1958, a great, three-stage rocket will roar upward from the sands of Patrick Air Force Base in Florida. Shedding its expendable parts as it rises, the rocket finally will reach the fringe of outer space. Here, 200 miles away from earth, it will release a gold-plated sphere about the size of a basketball. This object named *Vanguard* will be the first of many artificial satellites.

The *Vanguard,* propelled by its own momentum, will follow an elliptical orbit at an initial speed of 18,000 mph. For a while, the speed will counterbalance the earth's gravitational pull, and the satellite will complete one revolution about once every 90 minutes. Eventually, as momentum slows the satellite the *Vanguard* will sink into the denser atmosphere nearer earth until it is consumed by friction.

Briefly, the disintegrating satellite may resemble a meteor to earthbound observers far below. But by then, instruments rested in the *Vanguard's* shell will have transmitted vital data to the scientists of more than forty nations, whom we are encouraging to track the satellite. In time, these men and women who represent participating countries in the 1958 International Geophysical Year, will translate the space messages into knowledge that may help mankind make use of infinity for commerce or for war.

Dr. Hagen, the Chief Scientist in charge of the *Vanguard* project, stated on a recent TV interview that he hoped the first satellite would: 1. help us find the true shape of the earth, 2. discover



Above the troposphere, which ends at 13,000 feet, man's stairway from up to out begins. Now the technologically more advanced nations are vying for top-dog position in the stratosphere. Within a decade unmanned vehicles will carry this race into interplanetary space.

The Legal Aspects

One of the interesting developments at the American Rocket Society Spring Meeting in Washington earlier this month was the Space Sociology Seminar in the afternoon session on Thursday, April 4, which was presided over by Dr. Theodore von Karman, Director of the Advisory Group for Aeronautical Research and Development of the North Atlantic Treaty Organization.

Andrew G. Haley, General Counsel of the American Rocket Society, read a paper on "Space Law and Metalaw—Jurisdiction Defined." In his talk Haley pointed out that he had been criticized by Mr. A. E. Slater in a recent issue of the Journal of the British Interplanetary Society for not adequately defining the *jurisdiction* of space law. Haley stated that after making a careful study of the writings of authorities on the subject, he determined to seek out a definition of space jurisdiction based upon principles derived from scientific considerations.

"At about this point in my quest," Haley said, "I received a telephone call from Dr. Theodore von Karman inviting me to spend the evening with him. He had just arrived in Washington from Paris.

"By coincidence, this summons started a chain of memories. One of these was in the autumn of 1942, when 'the Boss,' as I was privileged to call the good Doctor, advised me confidentially that the University of California at Los Angeles was to award him an honorary degree and would I be kind enough to attend the presentation. A short while later, at the general convocation, the Provost of the University of California at Los Angeles, awarded the Boss with the degree of Doctor of Laws! On the way back to Pasadena, we had a great deal of fun speculating on the future career of Attorney von Karman.

"So a few weeks ago as I pondered on space law jurisdiction, and my forthcoming visit with the Boss, my mind went back fifteen years to this incident and I decided, as of old, to discuss my problem with the good Doctor. As always, Dr. von Karman formulated a precise answer as to the jurisdiction of space law. During the evening he told me that he had delivered a paper last year at a luncheon at the University of California, Berkeley, entitled 'Aerodynamic Heating—the Temperature Barrier in Aeronautics' and in that paper he had occasion to use a diagram made by Masson and Gazley of the Rand Corporation showing the possible ranges for continuous flight in the velocity-altitude coordinate system. Later on, he sent me a copy of his paper which contains the Masson and Gazley diagram. He said that this diagram, although designed to show the variation of velocity versus altitude for various values of dynamic pressure and equilibrium pressure, could readily be used to show the regimes of atmospheric and extra atmospheric flight and to depict the jurisdictional boundary lines thereof.

"I have re-done the Masson and Gazley diagram to indicate a line showing orbital velocity and another line showing the boundary of the Keppler regime [escape velocity].

"Conditions for accomplishing aerial flight, that is, circle at constant altitude, is weight = aerodynamic lift plus centrifugal force. The aerodynamic weight decreases with altitude because of the decreasing density of the air and in order to maintain continued flight beyond a certain point, centrifugal force must take over. Consider the flight of Captain Ivan C. Kincheloe, in which he took the X2 rocket plane to 126,000 feet altitude. His flight was strictly an aeronautical adventure and did not partake of space flight. At M = 3 aerodynamic lift carries 98% of the weight and only 2% is centrifugal force, or 'Kepler force.' However, it will be noted that in the corridor of continuous flight when an object reaches *approximately 275,000 feet* and is *traveling at 35,000 feet per second,* the Kepler force takes over and aerodynamic lift is gone.

"I have reproduced the Masson and Gazley right side curve—so-called temperature carrier, or heat barrier, simply to show the present state of the art, and thus to delimit the corridor of continuous flight. This line has nothing to do with the jurisdictional question as improved techniques in cooling and discovery of heat resisting materials will undoubtedly change this curve.

Thus, the jurisdiction question is settled from a scientific angle."

the true nature of the earth's atmosphere, and 3. find out about the sun's ultra-violet and infra-red radiation. Outerspace travel may take a few years, but the time for contemplation has already arrived.

Men must be mentally and emotionally prepared for the revolutionary experiences now in prospect, including an understanding of some of the political, military, economic and social implications involved.

We have discovered a new frontier with problems similar to those of western America in the latter 19th Century. Like the settlers in the old West who lost their claims if they did not protect them, so we have the challenge of exerting our claims over space, and keeping it out of the hands of enemy "rustlers."

"Space" and "Spacepower"

The atmospheric frontier or interplanetary space begins between 400 and 2000 miles up. This is known technically as the exosphere.

Space vehicles, when they are perfected will be beyond the earth's gravitational pull and beyond the sound barrier, about 450,000 feet up.

When man breaks through the envelope surrounding the earth, he will, from a military standpoint not only have to be on the lookout for possible "Martians" in space but more immediately will have to assure himself that his nation's air space is controlled and adequately protected.

Spacepower is dependent on airpower control in the atmosphere below the space frontier. They should never be thought of separately.

Due to the limited altitudes of present-day air vehicles, powerful military nations in peacetime can control their air space as a privileged sanctuary under the rules of international law. The advent of space satellites, guided missiles, and space ships whether atomic, chemical, or rocket powered will lead to a revolution in national air sovereignty.

From the launching of the first earth satellite, a new era will have begun, i.e., the ending of national control over air space. For space is truly international, no matter how one cuts it. Any point at 200, 300, or 1000 miles up probably dominates parts or all of two or more nations on the face of the earth simultaneously, and this makes for complications in the problems of international relations regarding former aerial domains.

The elimination of national air and space boundaries would mean a 'fait accompli' victory for President

Eisenhower's open sky policy, whether other nations accept this fact by signatures on diplomatic documents giving permission, or not. For once the first satellite is launched, it will only be a matter of time before powerful aerial cameras are perfected to transmit pictures of enemy territory and installations back to earth. Constant inspection of every country, city, and body of water can be maintained by such satellites, and could set our warning bells ringing against any future Pearl Harbor buildup.

In a June 1956 issue of *Life* magazine, Charles J. V. Murphy wrote ". . . an effective space platform, equipped with cameras and telemetering devices, would provide either the Russians or ourselves with a means of continuous surveillance of each other's industrial and missile deployments—crucial intelligence in a period when nations will have power to obliterate their enemies."

The higher the altitude, the more earth's surface will be dominated by any one space vehicle—former safety zones on earth will be all but eliminated. Still to be determined is the altitude at which a nation's air sovereignty ends and "open" space begins.

Another thing that will end national boundaries, is the necessity for dispersed, international ground control nets to guarantee that space vehicles reach the proper altitudes for operation. While flying over foreign territory, a space vehicle must often rely on ground control stations in that country to gain the proper altitude.

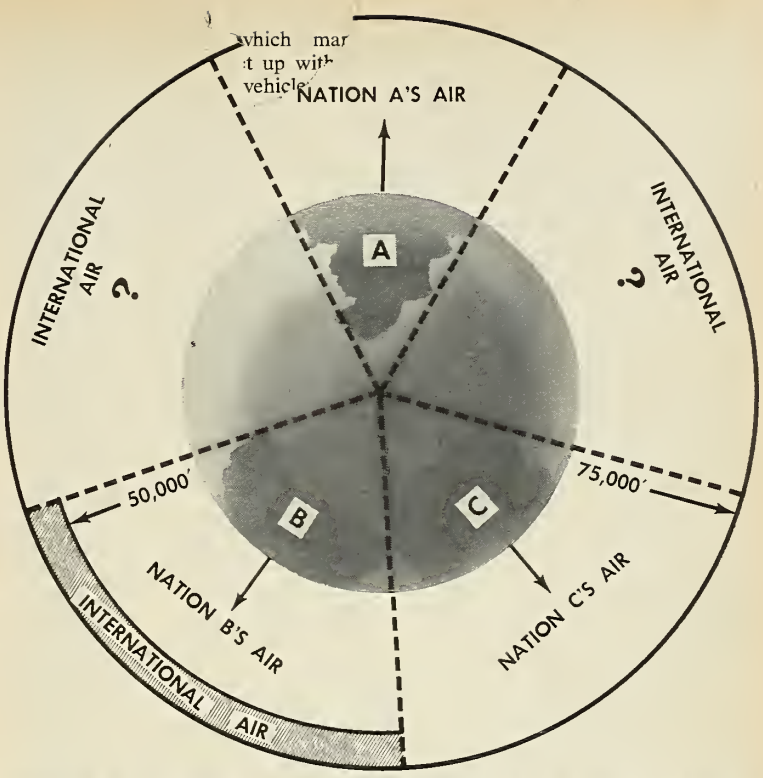
Thus, a few of the larger territorial nations could hamper other nations' attempts to perform high altitude flying if they try to retain their "sovereign air space."

The second obvious change brought by the conquest of space is: The limitations of any single nation's spacepower will depend on the speed, altitude, and staying ability of their space vehicles.

These three factors will become a primary deterrent of future conflict, as long as peace-loving nations can keep their vehicles out the farthest and up the longest without refueling.

These three factors alone, however, will not guarantee that nation A will always be able to exert its will of space control over nation B and C.

The interrelation of each of these factors is significant because you cannot have one without the other. To obtain the highest altitudes, great speed is necessary and inability to attain the higher altitudes prevents great speed. The addition of "staying ability" guarantees that the duration, speed, and



International law now reads that a nation holds sovereignty over all above and below the surface of the earth under its control, plus a pre-stated distance out over the water. This is a simple concept that has worked reasonably well for thousands of years. However, it cannot be extended indefinitely outward to the infinite reaches of galactic space. It probably won't even work 500 miles up. The top illustration shows how vertical aerial boundaries become radial when vast altitudes are considered. Both diagrams emphasize the importance of maintaining technological superiority in order to get manned vehicles to the highest altitude.

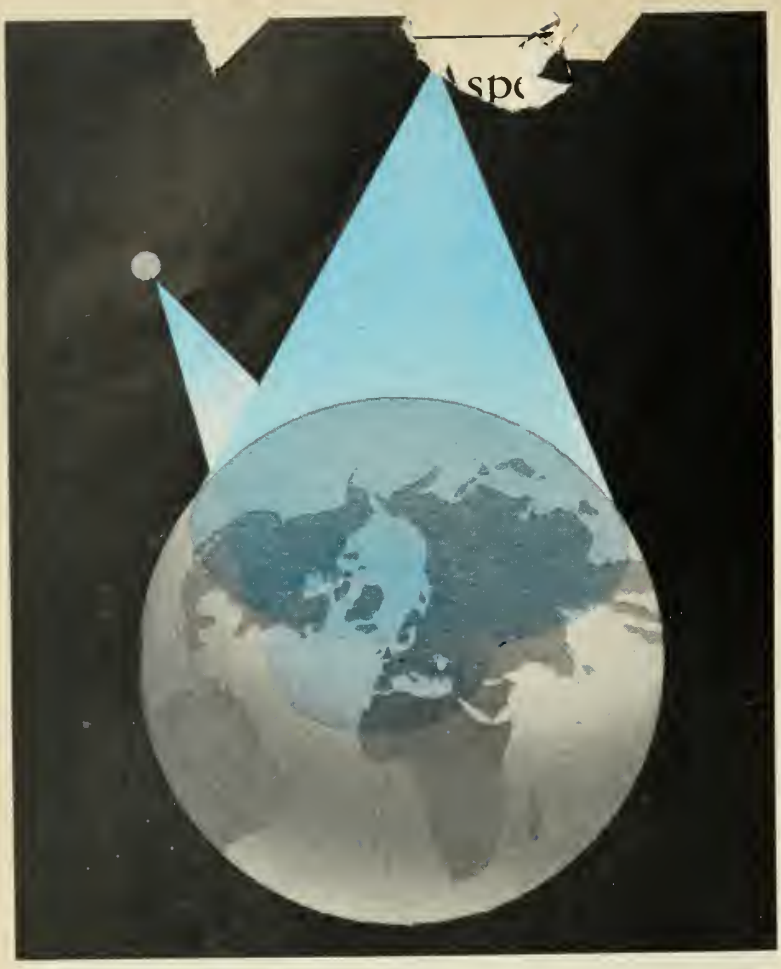


Diagram shows how a satellite will be able to dominate more than one nation at a time. The higher the orbit of the satellite, the greater earth area will come under its surveillance. Additionally, either manned or unmanned space satellites at the higher altitude would be in an advantageous position to take action against those below. In the one case missile assault would be aided by gravity; in the other, it would be hindered.

height of any vehicle will remain constant—otherwise, it will fall back to earth and lose speed as it re-enters the denser atmosphere.

Control of Space

Current U.S. Air Force doctrine is based on control of the air. Since the degree of control by our (and our allied) air forces is relative at any given moment, several factors become apparent when we extend this theory to "control of space."

The higher man ascends through the fringes of the atmosphere and into the frontiers of outer space, the more difficult it will be for him to control absolutely the significant portions of the air ocean and space between him and earth. This assumption, when extended to its logical conclusion, would lead one to believe that to retain comparative control of air and space, nations would have to numerically or qualitatively increase their air and space vehicles in direct proportion to the additional miles of altitude. They would have to provide for complete serveillance and countermeasures.

The characteristic of vertical employment is one of the advantages of airpower and space power over land and water-borne war weapons. The extended application of this characteristic to higher altitudes multiplies the problem of control over the dominions of outer space and the earth's atmosphere. The nation that masters speed and altitude coupled with staying power will be in a better position to dominate the world even though the problems and areas of control are more difficult in scope.

Such a nation could also better guarantee freedom of flight although fixing set frontiers in the layers and spheres of the atmosphere and space would be difficult to determine.

The Higher Out, the Easier Control

To offset the disadvantage of higher altitude—more space to control in all directions—is the advantage of being on top. It's like standing on the summit of Mt. Everest, with all the rest of the known earth's crust below.

So it is true of altitude in space. Knowledge that other nations have not ascended as high as you, gives the top nation a feeling of security that no others can have, a command control of the earth. On this point Professors Stefan Possony and Leslie Rosensweig in a significant article entitled "The Geography of the Air," published in May 1955 in the *Annals of the American Academy of Political and Social Science* wrote:

". . . As man reaches upward to the outer atmosphere new political problems arise, the nature of which we are not yet able to grasp. Heretofore, the relations between nations took place on what in practice was a plane. During the time of low altitude flying, the relations between nations and military forces were determined by the geometry of a spheroid's curved surface. This period of close-to-the-ground flying was, and still is characterized by 'the polar concept.'

"Henceforth, international relations will be geared to the more difficult geometry of a large spheroid enveloping as its core a smaller and impenetrable spheroid; the earth. But even more confusing, the radius of the outer spheroid—symbolizing the aeropause or the altitude which man has attained at any given time—is expanding.

"The most advanced nation technologically will operate within the highest aeropause, while the spheroid circumscribing the aerial capabilities of the more backward nations will have shorter radii.

Hence in the future, the geography of power will be described by several enveloping spheroids of different sizes. It will be a far cry from the geography of the battles of Yorktown and Bastogne, or even from the aerial battles of World War II. Truly a new *Weltbild* is emerging."

Technically, as Dr. Wernher Von Braun pointed out you can bomb a certain spot more accurately from 2,000 miles out in space than 5 miles up in the air from the target—since you would have control of the bomb all the way to the target in the former situation, but not in the latter.

Sustained Flight Vital

Those nations which can successfully launch and maintain the greatest number of manned and unmanned satellites in space, will have more op-

portunities to exert their will in the air and space medium.

This fact makes the perfection of long-range, nuclear-powered air vehicles a significant step forward in maintaining air and space superiority. The prolongation of flight around the earth by manned nuclear air vehicles will help make possible a continuing space sentinel system, not possible before.

The perfection of nuclear powered air and space vehicles will make control more feasible as a nation's nuclear power capabality increases. Such sustaining ability at the highest altitude and with the greatest speed will enable the leading nation to achieve five fundamental military aims: (1) persuasion, (2) neutralization, (3) denial, (4) destruction, and (5) capture. Applied spacepower would make the first three particularly effective. The last two—destruction and capture—need never be carried out if the first three are applied judiciously by the space power nation exerting them.

Space Counter Measures

Nuclear powered space vehicles would have to be knocked out somewhere in space rather than at their launch sites, unlike the current theory of stopping aggression on the ground before launching. As this type of vehicle is not a land-oriented vehicle, there is only one place it can be destroyed, and that is in its natural habitat—air space. To concentrate on finding an enemy's space launching sites on land would be well nigh impossible after hostilities had started unless one was thinking of a preventative war. Even then, the main threat which would already be air and space borne, could not be overlooked.

As more potentially destructive vehicles will be in flight rather than at their launching sites at the outbreak of hostilities, an added burden is placed on the defender nation. In some respects it would be an almost impossible task for a nation to defend itself against a multitude of enemy "flying saucers" constantly whirling around the earth in their space orbits.

With the *Vanguard* test firing program already under way, perfection of the ICBM in sight and with serious plans to go ahead with hypersonic boost glide vehicles, the problems of space flight and control are not somewhere in the eventual future. They will first arise during the next decade, develop to full proportions during the life of the current generation.

These combat space vehicles pose a defense problem which defies the limits of man's imagination. This also holds for the planetary objects, cosmic particles and meteors which man-made air vehicles will meet up with in space. Either the space vehicles will have to ward off such objects or suffer the consequences.

In one sense, as we stand on the threshold of space, we find ourselves in a similar state as the hunter on a safari at the edge of a dense jungle. The size and number of his weapons, will determine how far into the jungle he can penetrate with hopes of returning safely. He knows that he can't go too far in if he doesn't have the implements to fight his way out alive. Such is the military problem facing the Western World as it ventures into the space frontier.

The Ultimate Challenge

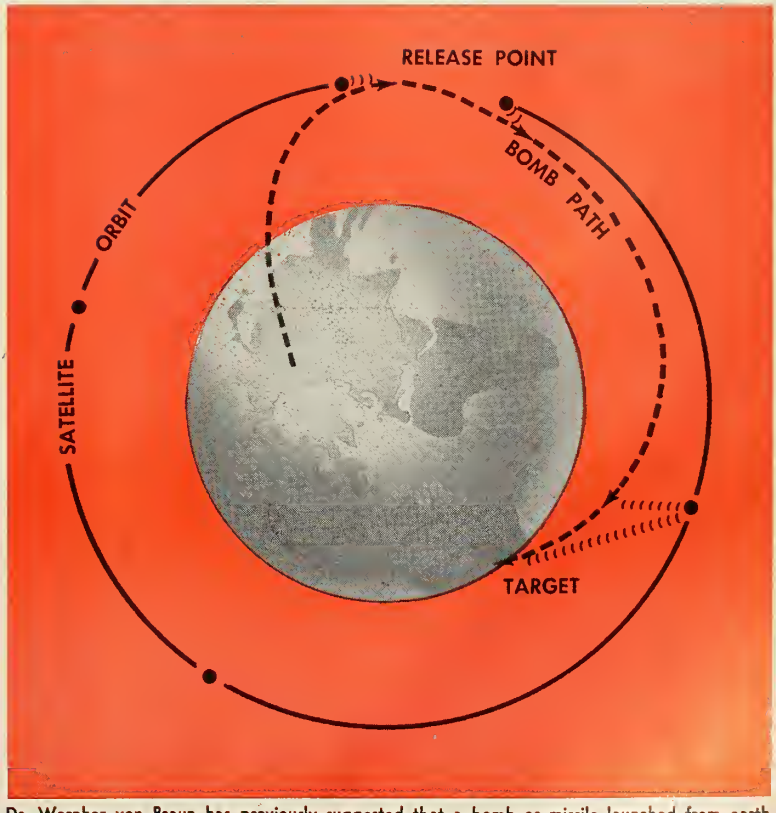
The public relations department of the Glenn L. Martin Co., prime contractor for the first satellite launching vehicle *Vanguard* in speaking of its forthcoming endeavor, remarked:

"Thus one day soon, in the hour before sunrise, as men the world over train their binoculars upon a brilliant point of light in the sky, they may well reflect upon the universality of man's faith in the infinite future of man."

This "reflection" is needed now to help coin a valid space doctrine to keep the myriad space satellites, rocket ships, intercontinental missiles and space stations from getting out of control. Such a doctrine is necessary to provide a secure foundation for "spacepower" in the future, and to aid us in understanding the technologically complex struggle for control of the earth's air and space beyond.

As the air and space revolution gathers momentum, we are challenged as never before to face up to the tasks of our new international spacepower and learn to cope with its unchanging nature. The hopes and fears of our civilization are tied to the necessity of such an understanding now.

Space flight will help to modify the world—rather than divide it. True space flight to the planets and the stars will only come after the world is united and the threat of war removed. This is the ultimate challenge to mankind, so that spacepower can be used for predominately peaceful purposes. ★



Dr. Wernher von Braun has previously suggested that a bomb or missile launched from earth could be picked up by a manned satellite, carried half way around the earth, released and guided down to its target—another concept of importance when considering space-power.

CONTACTS FOR CONTRACTS

If you want a contract with the Air Force Office of Scientific Research, first familiarize yourself with the basic thinking of the men who run it.

AFOSR is one of 12 centers of the Air Research and Development Command, with headquarters in Washington, at 14th Street and Constitution Avenue Northwest. It has been given the mission of conducting the *exploratory* research program for the U.S. Air Force. The word "exploratory" is the key to its aims and objectives.

Admittedly, exploratory research, as defined by AFOSR, has a relatively low success probability, but a very high pay-off if successful.

The table of organization of AFOSR shows how well organized is this branch of the Air Force. It includes nine divisions representing basic scientific disciplines; behavioral sciences, mechanics; aero-medicine, combustion dynamics, physics, chemistry, solid state sciences, mathematics and nuclear physics.

These divisions are grouped under four "directorates." These are the Directorate of Bio-Sciences, the Directorate of Aeronautical Sciences, the Directorate of Physical Sciences and the Directorate of Material Sciences.

There are also the Directorates of Advanced Studies, of Research Information and of Procurement.

In establishing contact with AFOSR, a prospective research contractor should address his original letter of inquiry to the Commander, Brig. Gen. Hollingworth F. Gregory. A contractor's contacts with the organization will generally be with the division covering the scientific discipline, which handles the technical aspects of contracts, and the Directorate of Procurement, which deals with the financial aspects of negotiating, renewing the contract.

A primary proposal should state the field of investigation, the specific objectives, previous work done, the method of investigation and the estimated total cost. It should also list the names of the principal investigators and what percentage of their time would be devoted to the project.

The preliminary proposal is evaluated by the appropriate technical division and its consultants. If it is favorably received, the investigator should be prepared to submit a more elaborate and detailed proposal, for which instructions will be furnished.

The Armed Services Technical Information Agency in Dayton, Ohio, provides a service for the exchange of scientific and technical information to prime contractors of the military departments and, under certain circumstances, their subcontractors.

But for those contractors, or prospective contractors, who want a detailed statement of the research interests of AFOSR in the fields it covers, a 16-page booklet on the subject can be obtained by writing to AFOSR.

1. **Directorate of Aeronautical Sciences.** The Mechanics Division of DAS is interested in aerodynamics, aerostructures, and both aerodynamic and structural problems at high speeds. Aim of its aerodynamics program is to assure the continued growth of this science and to evaluate new knowledge.

Principle subfields of interest are: subsonic flow (Mach 0.8), hypersonic flow (Mach 0.8-1.1), supersonic flow (Mach 1-5), hypersonic flow (Mach 5), internal flows, aerothermodynamics, rarefied gas dynamics, turbulence and facilities, instrumentation and techniques for model and full-scale testing.

Fluid mechanics is another subject of considerable interest to the Mechanics Division. At hypersonic speeds, not only is a vehicle—whether an ICBM or an earth satellite—heated to extreme temperatures, but even the air around it undergoes changes in state and composition. These changes, it is pointed out, have marked effects on aerodynamic and structural design considerations. Research interests in this area encompass the determination of the fluid dynamics and the chemicophysical laws governing vibration, dissociation, recombination and ionization of gases and their effects on the aircraft structure.

The Combustion Dynamics Division of the DAS is primarily concerned with the physical and chemical processes by which energy is provided for the propulsion of aircraft. This includes the problem of energy storage, which requires thorough basic knowledge of the various forms of potential energy: nuclear, atomic and molecular binding energies, as well as gravitational and electromagnetic potential energy.

2. **Directorate of Bio-Sciences.** The Aeromedical Division of this directorate is interested in biological and physiological operational and environmental stresses. The object is to provide protection against various adverse conditions and to improve performance under those conditions.

The Behavioral Sciences Division of this directorate initiates both basic and exploratory research that will contribute to the better understanding of human behavior. This division encourages "interdisciplinary" research in the psychological, anthropological, sociological and psychiatric disciplines, utilizing existing research personnel and facilities.

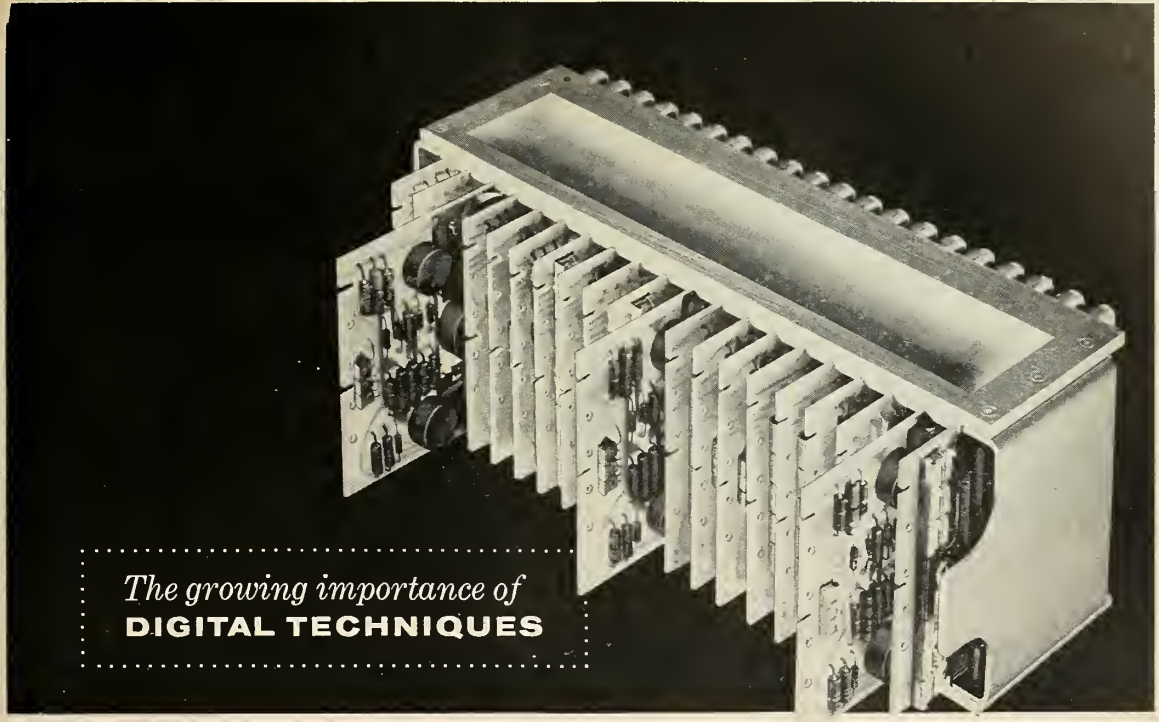
3. **The Directorate of Physical Sciences.** The Physics Division is concerned with the study of atoms and molecules as the basis for interpreting many of the properties of matter. It is also interested in the properties of electro-magnetic radiation which are used for communication or detection.

In the field of atomic and molecular physics, infrared and ultraviolet radiation, thermodynamics and statistical mechanics, molecular structure, acoustics and hypervelocity particles are all of particular importance to AFOSR.

The Nuclear Physics Division of this directorate is concerned not only with the development of nuclear power and its related problems but also provides information to improve the properties of materials. For example, new applications appear possible in the use of nuclear resonance which would aid in the chemical-trace analysis of certain types of impurities. The division also is interested in nuclear structure and reactions, cosmic rays, fundamental particles and nuclear instrumentation.

4. **The Directorate of Material Sciences.** The Chemistry Division of this directorate is interested in many subjects, including: the theory of chemical bonding, chemical reactivity, new compounds, high-temperature materials, catalysis, surface chemistry, photo chemistry, non-equilibrium kinetics, nuclear chemistry and high-temperature reactions.

The Solid State Sciences Division of this directorate has established its ultimate aims as follows: (1) to make better use of desirable physical properties of solids for Air Force use and (2) to discover new phenomena that might lead to novel applications.



The growing importance of
DIGITAL TECHNIQUES

As recently as ten years ago it was just becoming evident that digital techniques in electronics were destined to create a new and rapidly growing field. Today, incorporated in electronic computers and other equipment, they constitute one of the most significant developments in scientific computation, in electronic data processing for business and industry, and in electronic control systems for the military. In the near future they are expected to become a major new factor in industrial process control systems.

The digital computer for scientific computation is becoming commonplace in research and development laboratories. Such machines range from small specialized units costing a few thousand dollars, to large general purpose computers costing over a million dollars. One of these large computers is a part of the Ramo-Wooldridge Computing Center, and a second such unit will be installed the latter part of this year. The digital computer has not only lightened the computation load for scientists and engineers, but has made possible many calculations which previously were impracticable. Such computers have played a major role in the modern systems engineering approach to complex problems.

Electronic data processing for business and industry is now well under way, based on earlier developments in electronic computers. Data processors have much in common with computers, including the utilization of digital techniques. In this field, teams of Ramo-Wooldridge specialists are providing consulting services to a variety of clients on the application of data processing equipment to their problems.

The use of digital techniques in military control systems is an accomplished fact. Modern interceptor aircraft, for example, use digital fire control systems. A number of Ramo-Wooldridge scientists and engineers have pioneered in this field, and the photograph above shows a part of an R-W-developed airborne digital computer.

These, then, are some of the aspects of the rapid growth which is taking place in the field of digital techniques. Scientists and engineers with experience in this field are invited to explore openings at The Ramo-Wooldridge Corporation in:

Automation and Data Processing
Digital Computers and Control Systems
Airborne Electronic and Control Systems
Guided Missile Research and Development
Electronic Instrumentation and Test Equipment
Communication Systems

The Ramo-Wooldridge Corporation

5730 ARBOR VITAE STREET · LOS ANGELES 45, CALIFORNIA

The Rocketdyne Boom:

Engines for USAF's Long-Range Missiles

WHILE SECURITY restrictions prevent a presentation of rocket engine facts in terms of thrust, specific propellant combinations and production figures, it is generally conceded that the rocket engine industry has made tremendous strides in rccent years, permitting U.S. long range missile development to progress at an unprecedented and confident pace.

Some hints of this progress have been disclosed:

The range of the German V-2 propulsion system could be increased by from 50 to 100 per cent if we were to build a missile today of the same size, weight and payload.

The ultimate performance of propelled rocket engines liquid is governed only by the rate at which propellants can be pumped into the combustion chamber and burned efficiently.

In the field of fuels, research scientists see a 50 per cent increase in power potential before they reach an energy barrier. Beside the standard V-2 alcohol and liquid oxygen propellant, two other potent combinations of fuel and oxidizer have been brought into standard use today: nitric acid and aniline; and gasoline and oxygen.

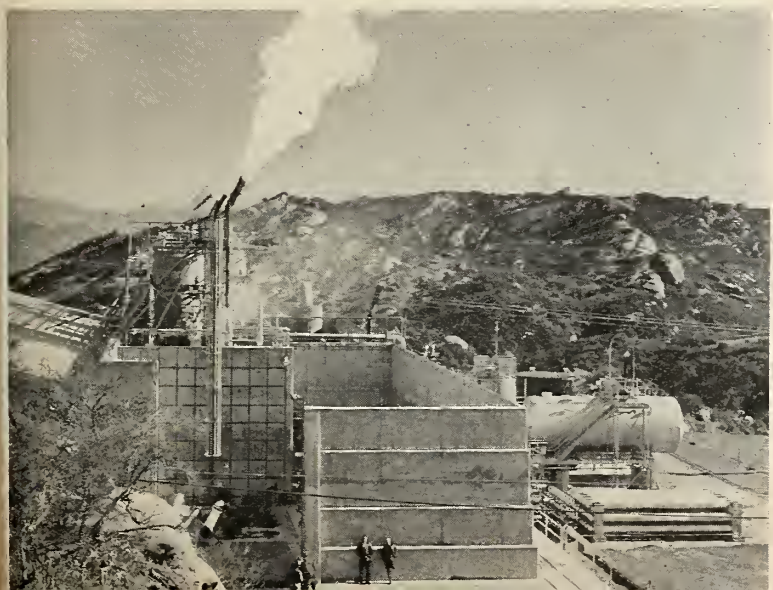
Other promising indications: development of 12-inch-diameter gas generators that produce in the order of 10,000 isentropic horsepower in hot gases to drive turbopumps and successfull operation of the 50,000-lb. liquid propellant rocket engines in 120 test sled runs, indicating that new reliability standards are being achieved in the use of liquid fuel rocket engines.

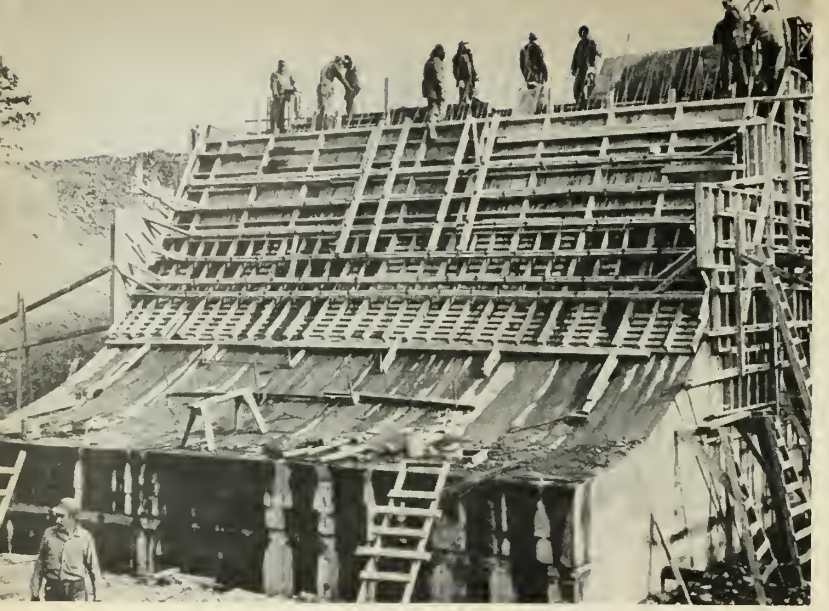
These and other advances may be interpreted as significant indications that long range missile propulsion, through the use of high-thrust liquid propellant rocket engines, has caused a major technological break-through in this decade.

Starting with the Geman V-2 scientists and hardware following World War II, U.S. long range rocket propulsion technology progressed from the Air Force-North American *Navaho* propulsion system through the Army-Chrysler *Redstone* and into the realm of the Air Force's Ballistic Missiles Program in the intermediate and intercontinental range brackets (*Atlas, Titan, Thor*). Recent reports have placed the Army-Chrysler *Jupiter* alongside the *Thor* in the 1500-mile class.

Today's long range missile propulsion systems are the direct result of early confidence in the future of rocketry expressed by U.S. industry,

Long range propulsion systems require new—and expensive—facilities and techniques. Here, at Rocketdyne's Propulsion Field Laboratory in California, afterburners ignite gasses used in test of rocket engine gas generator. Note desolate, unpopulated area.





Rocket test rises stand from Missouri countryside as Rocketdyne pushes construction at its 200-acre test complex at Neosha. A major part of the ICBM program, this plant will test and construct high thrust liquid propellant engines.

and 12 years of engineering achievement in a field new to technology.

A leader in this field is Rocketdyne, a division of North American Aviation, Inc., now supplying high thrust rocket engines for virtually all of the long range missile programs.

The Canoga Park, California firm today employs more than 10,000 persons almost exclusively in the development and production of long range liquid propellant rocket engines for the Air Force's *Atlas* and *Thor* programs, the Army's *Redstone*, and *Navaho*.

Company officials were optimistic over the future of high thrust rocket propulsion following World War II, when NAA was asked by the Air Force to undertake development of the *Navaho* long-range guided missile.

Starting with a nucleus of five research engineers in 1946, NAA President J. L. Atwood and others began the task of recruiting a scientific staff for the job, expecting that missile development would be the logical extension of the airframe business.

When progress had been made in their studies of high-speed aerodynamics, heat transfer and related subjects, the Air Force accepted an NAA proposal for institution of a long-range research and development program.

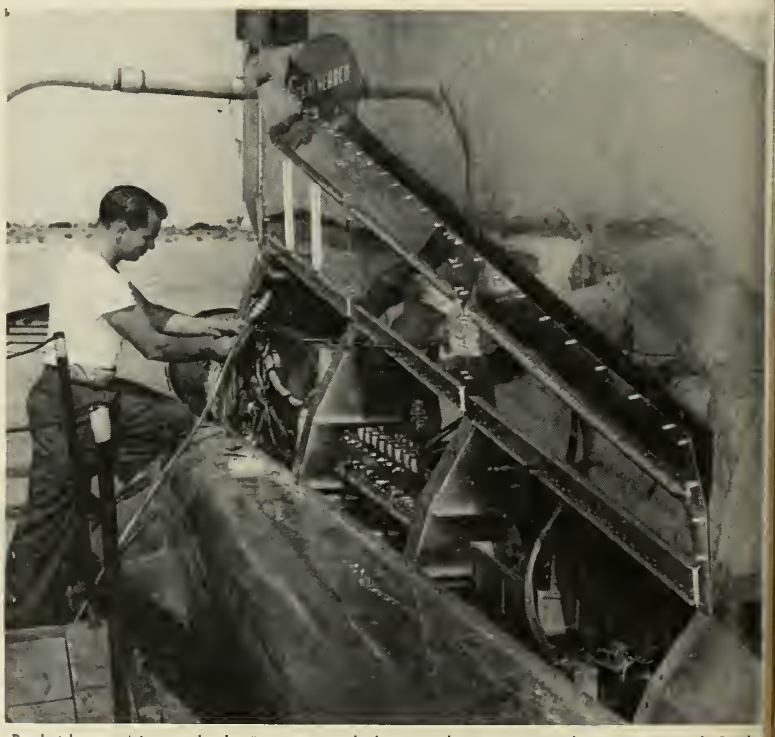
The late 1940's saw the establishment of a Propulsion Field Laboratory in the Santa Susana Mountains near Los Angeles, on 600 acres of isolated mountainside. Thus was born U. W. technology in the field of large, liquid propellant rocket propulsion.

After only eleven years in rocket propulsion Rocketdyne has brought the issue out of the doubtful stage and into the hands of assembly line production experts, who today are turning out rocket engines in much the same manner as fine quality automobile engines. Highlighting the division's manufacturing effort will be the full scale operation, this August, of the nation's first plant devoted exclusively to the production of long range rocket propulsion systems in Neosho, Mo. The $13 million Air Force-owned plant, including a 200-acre acceptance testing complex, is expected to employ 1,000 persons by late this year.

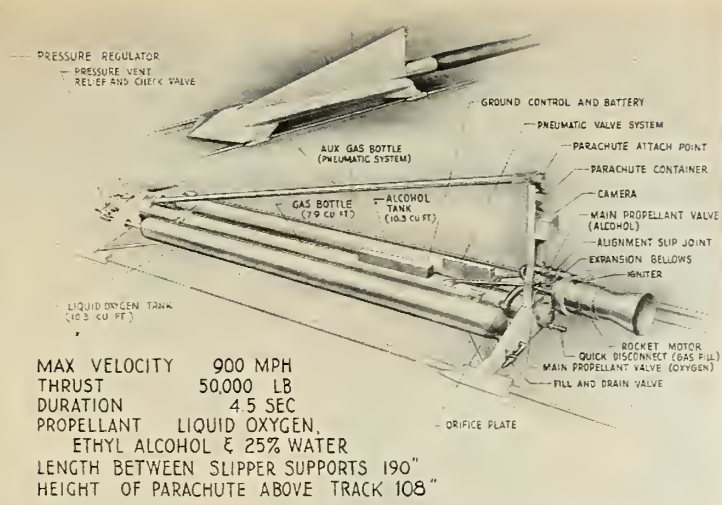
While early confidence in the future of long range rocket propulsion is largely responsible for Rocketdyne's success, company officials cited these factors as helping to close the area of doubt over the past 12 years:

A top level team of engineer-managers has been brought into the picture. Led by General Manager Samuel K. Hoffman, 55, with 32 years experience in aeronautical engineering including a professorship at Pennsylvania State; and Assistant General Manager Charles W. Guy, 40, who has been active in aircraft engineering and administrative posts since his graduation from MIT in 1939. He largely shoulders administrative jobs to free Hoffman for engineering decisions.

Other key men in the Rocketdyne management picture: Chief Engineer Thomas F. Dixon, 41, 10 years in long range propulsion engineering with NAA; Propulsion Field Laboratory Manager James A. Broadston, 48, 21 years with NAA and probably the Na-



Rocketdyne engineer checks 50,000 pound thrust rocket engine used in 5000 pound Cook parachute sled. Capable of reaching 900 mph in 4.2 seconds, this unit has successfully completed 120 test runs and boasts a largely trouble-free record of performance.



This schematic drawing shows operative details of the Cook sled propulsion system. In one tenth of a second from firing sled is accelerating at 10 G's, its engine having reached 80% of full thrust. Water wall that stops it gives 65,000 pounds resistance.

tion's top specialist on large rocket engine test: Preliminary Design Chief George P. Sutton, 37, author of "Rocket Propulsion Elements," vice president of the American Rocket Society; Neosho Plant Manager Joseph P. McNamara, 46, who was assistant to the division manager at NAA's Kansas City plant during World War II and has 22 years of diversified engineering experience; Research Chief John Tormey, 38, with 11 years' research experience with NAA, who directs efforts of 140 Rocketdyne researchers and is a top authority of high energy rocket propellants; Factory Manager Ross Clark, 45, who progressed from the position of assembly mechanic with Northrop Aircraft through 24 years of manufacturing experience to lead Rocketdyne's production effort.

Production experience gained during World War II on the F-51, B-25 and other airplanes has enabled Rocketdyne managers to recruit, train and utilize technical talent on a large scale. This explains why the organization has been able to expand from 4500 to 10,000 people within one year with a minimum of confusion. High-geared indoctrination programs, classroom training, quick dissemination of fresh information all figure in this program.

More than 4,100 persons are engaged in some phase of Rocketdyne's engineering effort today. Emphasis has been placed on attracting and training combination engineers. Test engineers, for instance, help design test stands, then assume responsibility for their operation. This requires civil, mechanical and electrical engineering know-how.

Development of hardware is based on solid, factual experience. Extensions of technology are founded on lessons already learned rather than unproven hypotheses. The result is a steady progression toward objectives.

From the standpoint of basic engineering design, there has been no sharp distinction from one stage to the next, with the exception of several components, whose redesign was necessary. Generally speaking, the components, controls, inter-connects and operating sequences were improved on the basis of test experience. The development of thrust chambers, turbopumps, propellant feed systems, feed system controls, gas generators and gas generator controls followed a logical sequence of improvement.

When necessary to meet tight military schedules, Rocketdyne has set up double shifts in production and testing activities. Maj. Gen. B. A. Schriever, commander of Western Development Division, ARDC, has cited Rocketdyne's double shift testing program in keeping production and delivery of engines on schedule.

Since completion of Rocketdyne's 316,000 square-foot Main Plant building in Canoga Park, California, in November, 1955, expansion has been rapid. In addition to the Neosho plant, operations have required addition of a 50,000 square-foot engineering annex and an 88,000 square-foot material building and six other supporting facilities within the last year.

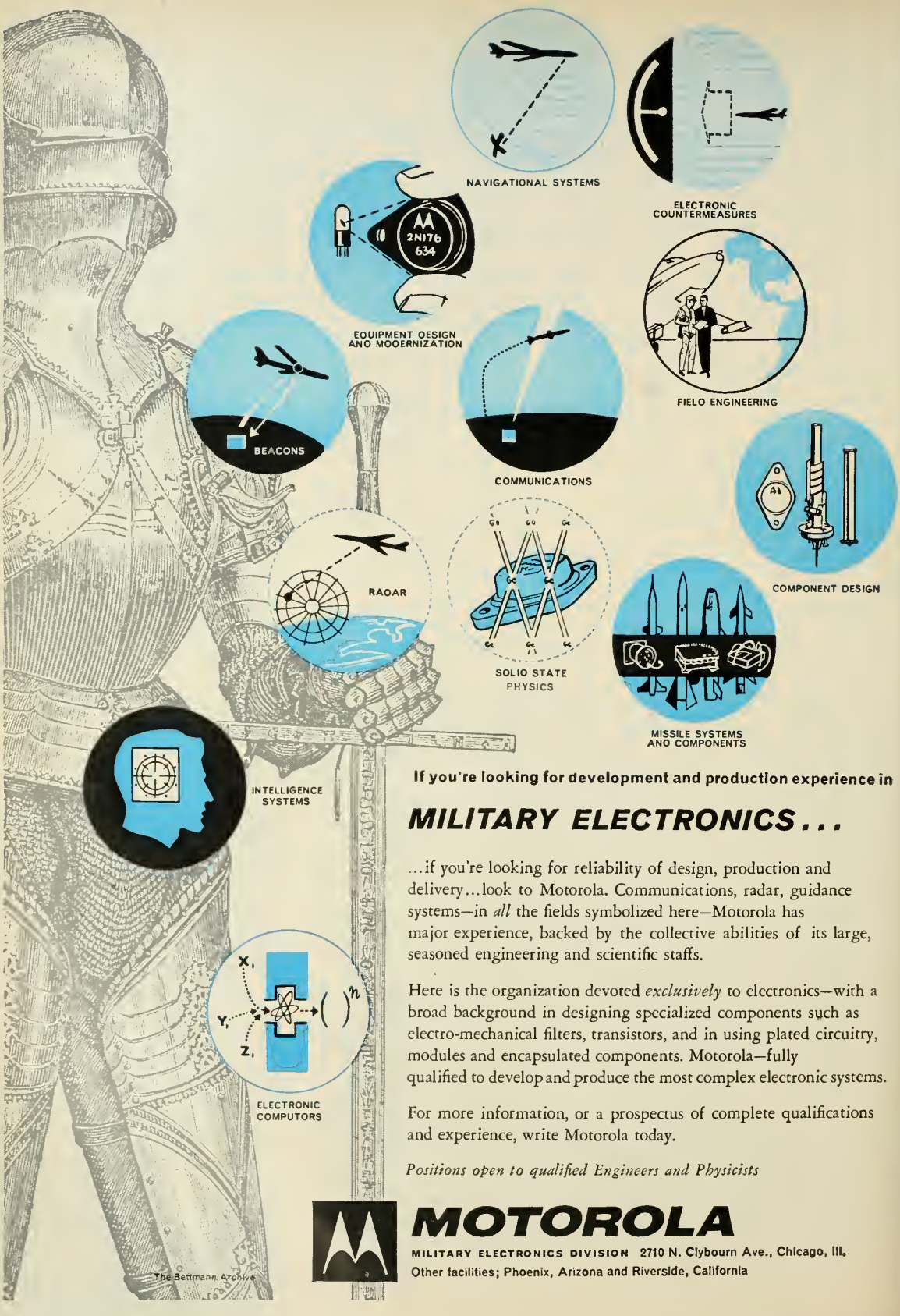
While development of the art at Rocketdyne has been sober and well planned, engineers have not hesitated to follow strange pathways in their quest for fresh knowledge. As a result, their explorations in fluid mechanics, supersonic aerodynamics, thermodynamics, electronics and other fields, performance and reliability standards thought impossible 10 years ago have been achieved.

A good example is the problem of turbopumps. Pound for pound, the rocket engine turbopump is probably the most powerful pumping device ever developed by engineering skill. Because of the rigid requirements of turbopumps, Rocketdyne engineers have undertaken the analysis, design, development and testing of high pressure ratio supersonic turbines, high-speed gear boxes, radial and axial flow pumps, rotating and liquid gas seals and other mechanical components. The development of each presents a challenge.

In the field of instrumentation, the challenges have been similar. Typical of electronic advances at Rocketdyne is the IDIOT (Instrumentation Digital On-line Transcriber), which converts rocket engine test inputs at the rate of 10,000 per second, recording the numbers in binary code and magnetic tape. By playing back the tape through a digital computer, it is possible to process 4,800,000 separate readings in less than 15 minutes. Thus long range propulsion test data is almost immediately available for analysis, and performance improvement time is greatly reduced.

Such developments are significant in view of the fact that the tempo of our long range missile development—for the Nation's defense and for exploratory space travel—is governed only by the rate of our technological advancement.★

This pump shaft leads to underground receiving tanks at Rocketdyne's Neosha, Mo., plant. The company began moving in last month.



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Inertial Guidance for Air Force High-Punch Missiles

Jam-Proof Guidance Has Come a Long Way But Accuracy Still Remains Big Problem

By J. M. Slater

Autonetics Division, North American Aviation, Inc.

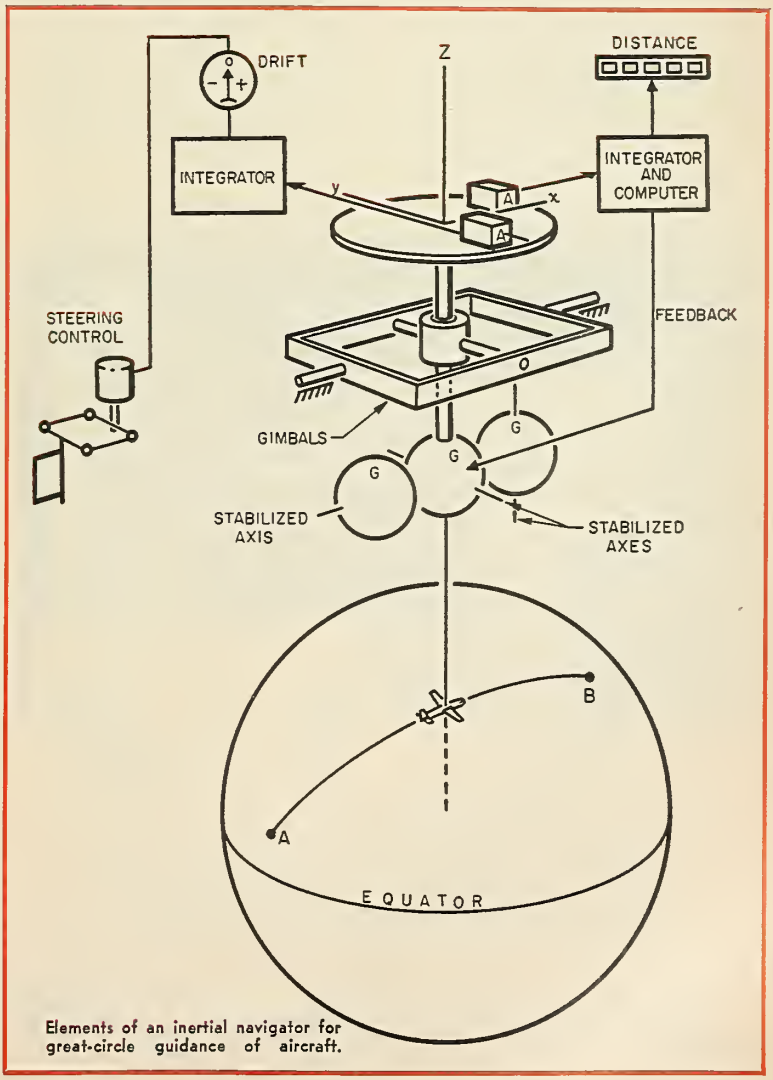
INERTIAL GUIDANCE is the science and art of determining a vehicle's velocity and position and other quantities necessary for guidance, by measuring and integrating accelerations.

Inertial guidance is an absolute method, one which makes its measurements in terms of mass, length, and time—as interrelated in Newton's second law of motion. It can be a strictly self-contained system, not requiring any information from outside. Its ultimate accuracy is limited only by the degree of the instrumentation's perfection. In ballistic-rocket guidance the operation is primarily one of establishing the correct initial velocity (speed and direction) during the boost stage, for a trajectory or orbit which will intersect the target. All the guidance occurs in the first few hundred seconds, after which a "free fall" condition obtains.

The heart of the system in each case is typically a set of orthogonally disposed accelerometers capable of producing an output signal linearly proportional to acceleration (or to a time integral of acceleration). The accelerometers are mounted on a gimbaled, gyroscopically stabilized platform, to establish a fixed coordinate system unaffected by maneuvers of the craft. A computer integrates the accelerometer signals to determine velocity and position, and feeds back signals to the accelerometers, the gyroscopes, or both, for compensation of disturbing factors.

Aircraft Navigation

In Fig. 1 a stable platform is shown as part of a representative system for guiding an aircraft on a great-circle course from a point A to



Elements of an inertial navigator for great-circle guidance of aircraft.

a point B on the earth's surface. The accelerometers are disposed along course and transverse to course.

Any transverse acceleration—due, for example, to a cross-wind—is detected and integrated twice with respect to time, the second integral corresponding to distance off-course (drift). The rudder is controlled from the drift meter in the proper sense and amount to keep drift zero. In the case of a cross-wind the aircraft will thus be automatically pointed into the wind at the correct angle.

Longitudinal acceleration must be sensed and integrated to determine distance traveled. Now gyroscopes tend to remain angularly fixed in inertial space. Therefore in the absence of control, the gyroscope assembly would not follow the curvature of the earth as the aircraft moves from A toward B, and the longitudinal accelerometer would be progressively tilted backwards. This is undesirable, as a component of the acceleration of gravity would be sensed, and confused with acceleration of the craft. To prevent this, a feedback of single-integrated acceleration is provided as a control torque on the gyroscope which stabilizes about the transverse axis. With proper adjustment of scale factors in the feedback channel, the gyroscope can be caused to rotate (precess) in space about such transverse axis y, at exactly the same angular velocity as that of the aircraft about the center of the earth. Thus the accelerometer table is kept level.

A very important consequence of this feedback is that the system is given the properties of a long-period simple-harmonic oscillatory system. If scale factors have been properly selected, the oscillation period (as measured at a stationary point at the earth's surface) turns out to be equal to two-pi times the square root of the quantity: earth's radius divided by the earth's surface gravity (g). This is the so-called Schuler period, and one result following from its use is that acceleration errors do not yield a cumulative position error, but rather an oscillatory error.

So far, earth rotation has not been mentioned. It must be compensated, because the gyroscopes in themselves cannot distinguish between rotation of the earth relative to the aircraft and rotation of the aircraft about the center of the earth. In general some component of earth rotation appears on each gyroscope, and must be compensated. The computer applies control torques thereto, as a function of position along the course, to synchronize them with the rotation of the earth. Thus earth rotation is cancelled out.

Earth rotation, however, can still give rise to certain accelerations which do not correspond to changes in vehicle movement relative to the earth—the quantity of interest. Among these are centripetal acceleration associated with the earth's rotation angular velocity, which is sensed at the accelerometers even when the aircraft is stationary; also the horizontal component of the acceleration of Coriolis, which is a function of aircraft velocity as well as earth angular velocity. The total magnitude of these accelerations is usually at most only a few per cent of that of gravity. Compensations may be computed by the computer and applied as biases to the accelerometers to "blind" them in effect to these false inputs.

Ballistic-Missile Guidance

The operations in guiding a ballistic missile are closely related in principle to those performed in precision gunnery. In firing a shell the three predeterminable variables are inclination and azimuth of the gun and size of the powder charge, which last determines muzzle velocity.

In a ballistic missile the corresponding variables are inclination and azimuth of the missile and the velocity at time of cutoff of the rocket motor. After this point the missile follows a path determined by gravitational laws.

One can get a feeling for which variables are critical with the aid of a garden hose and nozzle. If it is held at an angle somewhere near 45 degrees, waving it up and down through a considerable angle will have negligible effect on how far the water goes. Swinging the hose sideways produces an aiming error. The same effect, amplified by the increased range, is present in ballistic missiles such that an aiming error of one milliradian—0.05 degree—produces an error of about one mile at a thousand miles. Equally critical in the garden hose experiment is manipulation of the valve to control the stream velocity.

The primary function of a ballistic-missile guidance system then is to insure that azimuth, inclination, and velocity at the time of rocket motor cutoff are correct for the given target. If it could be assumed that the missile would not be translated from a predetermined flight path in any direction by winds, unpredictable variations in motor thrust, or other agencies, during the powered portion of its flight, then it would be sufficient to set in predetermined values of these quantities.

Such a simplified guidance plan was actually followed in the early Ger-

man V-2 rocket practice. Azimuth and pitch were established with the aid of a set of gyroscopes analogous to ordinary flight instrument gyroscopes, and cutoff velocity with the aid of a single-integrating accelerometer or "velocity meter" (of gyroscopic-pendulum type) disposed along the longitudinal axis of the missile.

Such a scheme is of limited application, both because of unavoidable factors which could displace the missile from the intended guidance path and of the difficulty of making the accelerometer respond only to the desired quantity, acceleration along the flight path. The direct-mounted accelerometer will, of course, respond to a component of the acceleration of gravity g, which component is equal to g times the cosine of the angle equal to the instantaneous inclination of the missile to the vertical. This angle is difficult to predetermine correctly so that a sufficiently accurate compensation can be made.

For high accuracy a three-axis gyroscopically-stabilized platform could be utilized essentially similar to that described for flat-trajectory navigation, except for having a third, vertical accelerometer-integrator channel.

A somewhat idealized and simplified system of this sort is sketched in Fig. 2. Assuming for the moment a non-rotating earth, the platform is initially set, and thereafter maintained orthogonal to the vertical guidance plane through AB. The missile typically takes off vertically, and during the powered stage is rotated through some predetermined angle W—using the stable platform as a reference—toward the target B. The x and z-axis integrated-acceleration signals give components of the missile velocity vector. Rocket motor cutoff is initiated when the magnitude of this vector reaches a predetermined value. The lateral accelerometer signals are integrated and used in a drift-corrector in a manner similar to that in airplane navigation.

Actually, due to the fact that the earth is rotating, the missile will appear to an earth-fixed observer to be deflected laterally during the ballistic phase of the trajectory. To hit the target, the *initial* conditions must be set so as to give exactly the right "lead." This problem does not apply to aircraft navigation, where earth rotation is continuously compensated.

Although the present article is intended primarily merely as a sketch of principles, a misleading impression of simplicity might be gained unless some mention is made of the practical problems of instrumenting inertial guidance systems. These are some of the most severe in the whole field of engineering and manufacturing technology. The technique is based on force-balancing and force-measuring operations of the most delicate and precise sort, which must be carried out under non-ideal conditions.

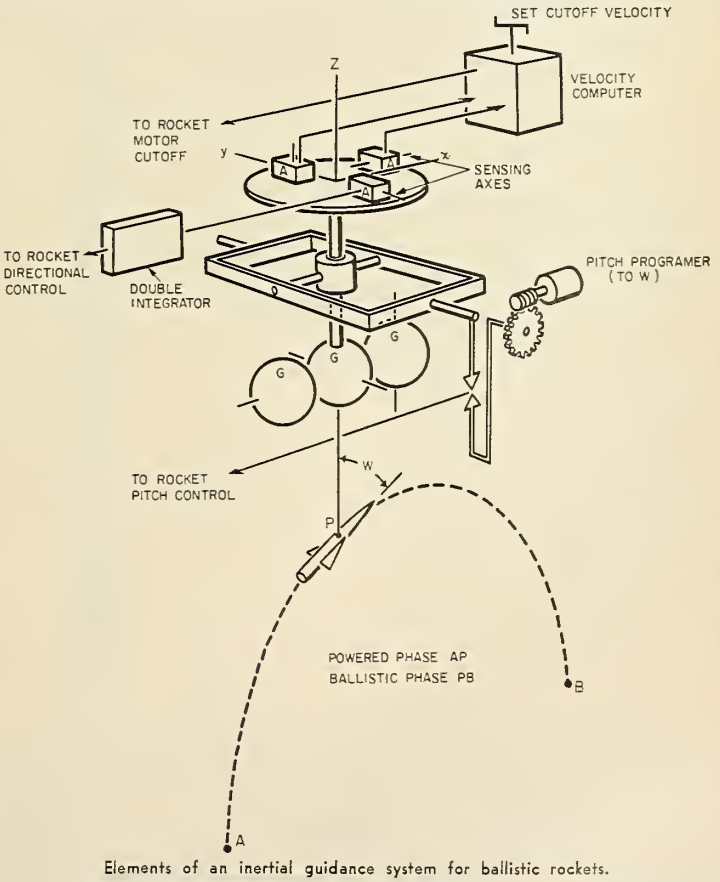
The most critical problems are associated with the gyroscopes and the acceleration-sensing devices. This follows from the very nature of the method. Thus, the gyroscopes are used, not as mere magnetic-direction or gravity-signal integrators or as rate detectors, but as a fixed or basic sort of reference.

In aircraft navigation systems, drift (angular wander) of the gyroscopes can give a position error substantially equal to the drift angle multiplied by the radius of the earth. Gyroscope drift is caused by stray torques acting on the gyroscopic element proper. A typical gyroscope of size suitable for use in air-borne equipment might have an angular momentum of, say, one million gram-centimeter-squared-radian-per-second. Now the torque corresponding to a drift rate of one minute of arc per hour (approximately equivalent to one nautical mile per hour error buildup in an inertial navigator) is only 0.08 dyne-cm.

This torque is equivalent to the gravity moment exerted by the weight of he paper *within* this letter (o), cut out and stuck on the gyroscope gimbal at a half-inch radius from the axis.

The acceleration-sensing devices have much the same quantitative requirement as the gyroscopes, in regard to allowable disturbing torque levels, i.e., a fraction of a dyne-cm, typically. The problem here is relieved to the extent that mechanically simpler constructions are possible for accelerometers. But on the other hand the requirement for exceedingly linear integration over a wide range often necessitates incorporation of at least one stage of integration into the accelerometer, as in the gyroscopic-pendulum type, for example.

The fact that inertial methods of velocity and position finding have been carried to their present level of accuracy and reliability is a tribute to the foresight of the national defense authorities for initiating, subsidizing, and maintaining the requisite intensive development programs. It is also a tribute to the scientific, engineering, and manual skills of the personnel involved in such programs.★



Elements of an inertial guidance system for ballistic rockets.

Fig. 2

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"TOM THUMB" TELEMETERING FILTERS

Designed and tested to specification #MIL-T 26985

Supplied in two principal case sizes:

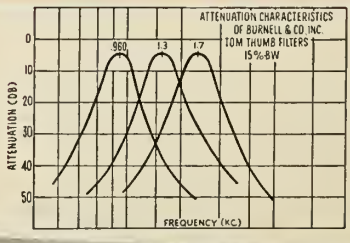
1. For RDB channels 1 through 6, case size is ¾ x 1½ x 2¼ inches high; weight: 4 ounces.
2. For channels 7 and up, case size is ¾ inches square and 1⅜ inches high; weight: 1¼ ounces.

These cases are generally equipped with a 4-pin plug to match the small Winchester socket.

ATTENUATION CHARACTERISTICS

Impedance: 100 K ohms in and out.
Insertion loss: less than 6 db.
At ± 7.5% band width is less than 3 db.
At ± 25% band width is greater than 15 db.
At 1.75 f attenuation is 40 db or more.
At .57 f attenuation is 40 db or more.

CHAN. #	FREQ.	IMP. 100K P/N	B. W.	SIZE	WT.
1	400 cps.	S-60001	±7½%	¾ x 1½ x 2¼ H	4 oz.
2	560 cps.	S-60002	±7½%	¾ x 1½ x 2¼ H	4 oz.
3	730 cps.	S-60003	±7½%	¾ x 1½ x 2¼ H	4 oz.
4	960 cps.	S-60004	±7½%	¾ x 1½ x 2¼ H	4 oz.
5	1300 cps.	S-60005	±7½%	¾ x 1½ x 2¼ H	4 oz.
6	1700 cps.	S-60006	±7½%	¾ x 1½ x 2¼ H	4 oz.
7	2300 cps.	S-60007	±7½%	¾ x ¾ x 1⅜ H	1¼ oz.
8	3 KC	S-60008	±7½%	¾ x ¾ x 1⅜ H	1¼ oz.
9	3.9 KC	S-60009	±7½%	¾ x ¾ x 1⅜ H	1¼ oz.
10	5.4 KC	S-60010	±7½%	¾ x ¾ x 1⅜ H	1¼ oz.
11	7.35 KC	S-60011	±7½%	¾ x ¾ x 1⅜ H	1¼ oz.
12	10.5 KC	S-60012	±7½%	¾ x ¾ x 1⅜ H	1¼ oz.
13	14.5 KC	S-60013	±7½%	¾ x ¾ x 1⅜ H	1¼ oz.
14	22 KC	S-60014	±7½%	¾ x ¾ x 1⅜ H	1¼ oz.
15	30 KC	S-60015	±7½%	¾ x ¾ x 1⅜ H	1¼ oz.
16	40 KC	S-60016	±7½%	¾ x ¾ x 1⅜ H	1¼ oz.
17	52.5 KC	S-60017	±7½%	¾ x ¾ x 1⅜ H	1¼ oz.
18	70 KC	S-60018	±7½%	¾ x ¾ x 1⅜ H	1¼ oz.
A	22 KC	S-60019	±15%	¾ x ¾ x 1⅜ H	1¼ oz.
B	30 KC	S-60020	±15%	¾ x ¾ x 1⅜ H	1¼ oz.
C	40 KC	S-60021	±15%	¾ x ¾ x 1⅜ H	1¼ oz.
D	52.5 KC	S-60022	±15%	¾ x ¾ x 1⅜ H	1¼ oz.
E	70 KC	S-60023	±15%	¾ x ¾ x 1⅜ H	1¼ oz.



Human Engineering in Weapon System Development

by David W. Atkins,[1] David M. Piatt,[2] Albert Shapero[3]

IN THE DEVELOPMENT of a weapon system, the role of human engineering is to optimize the man-to-man and man-to-machine relationships within the system. This has developed from a growing realization in the weapon system field that inadequate consideration of the human components in the system (operators, maintenance men, etc.) can mean marginal operations or failure of the system.

The human engineer's tasks are based on his specialized knowledge of the characteristics, capabilities, and limitations of the human as a component. Basically, these tasks are:

1 Determining the best distribution of functions between man and machines according to their respective inherent capacities and capabilities.

2 Assuring the optimum communication between man and man, and man and machine by the proper selecting, positioning, and linking of the men, equipments, and environments.

3. Assuring equipment designs which are optimized for ease of installation, maintenance, and operation.

4. Determining manpower and training requirements and evaluating human performance in the over-all system operation.

These tasks begin with the earliest phase of the weapon system development program and continue into its final evaluation stage. A fuller understanding of what the tasks are, what is involved in their implementation and their possible effects upon the program is of value to all who are connected with the management and implementation of weapon system development and operation.

Distributing Functions Between Men and Machines

Ordinarily design decisions are made on the basis of materials, components, and "state-of-the-art" electromechanical design techniques without any regard to the characteristics and capabilities of the human components of the weapon system. This failure to properly assay the role of the human component results in what can be called the accidental distribution of functions between men and machines.

Optimum as opposed to accidental distribution of functions between men and machines requires full consideration of which functions are inherently performed better by either men or machines, the economics of this distribution, and safety as well as the mission, electro-mechanical data, hardware availability, design limitations, and the other usual considerations. When men and machines are considered together there is a direct payoff in increased system operability and effectiveness which minimizes expensive design changes, operating errors, and operating and maintenance costs.

Psychological and physiological data, which make up the bulk of the human engineer's working material are utilized in making decisions in assigning functions to men or mechanisms. For example, by using this data the following general statements can be made:

SENSORY ABILITY: Except for the most complex instrumentation, human audio and visual sensing capacities surpass those of machines.

PERCEPTUAL ABILITY: Man excels at comprehending complex data.

ATTENTION: By being alert for changes, human beings can often anticipate undesirable conditions.

FLEXIBILITY: Humans are characterized by a flexibility of action which provides insurance against complete equipment system failure.

MEMORY: Man is more efficient in tasks requiring long-term memory.

JUDGMENT AND REASONING: Men are needed to make judgments when it becomes impossible to reduce operations to logical preset procedures.

SPEED AND POWER: Machines can make movements more smoothly, quickly, and powerfully than man.

REPETITIVE OPERATIONS: Machines excel in repetitive and routine tasks; unlike humans, machines do not become bored or inattentive.

COMPUTATIONS: Machines designed to perform specific computing operations are more efficient than man.

SIMULTANEOUS ACTIONS: Machines can be devised to carry on a greater number of simultaneous jobs than man.

There are two aspects to the economics of distributing functions to men or machines which demand consideration. First, there is the initial cost of the system. Secondly, there is the continuing or operating costs in the field. Building into machines functions that are normally associated with human abilities usually involves design complexity that increases the design and production cost. This must be balanced against the savings this design can effect in the operating costs in the field. Consideration of the economics involved in simplifying operations at the cost of increasing the maintenance burden can strongly influence design decisions as to whether a function should be performed by man or mechanism. For example, the decision to make a piece of equipment self checking has resulted in the ludicrous situation where the complex self maintenance features of the equipment required as much maintenance as the operating features of the equipment.

Safety and Cultural Considerations

Every society imposes conditions and limitations upon treatment of human beings. These are a function of the culture and must be taken into account by the human engineer during the design of the weapon system. Often this is done by designers without conscious examination of the problem. Among these conditions and limitations are those associated with safety, body usage, and instrument design.

During World War II, Russian fighter pilots extensively employed aircraft ramming tactics in combat. In addition, the Russian Air Force had the armor plate removed from American aircraft delivered to them to increase the aircraft performance at the expense of pilot safety. In both cases, American attitudes toward the value of the individual significantly affected flight tactics and consequently aircraft design. The deliberate expenditure of a pilot's life as part of weapon system design was also employed by the Japanese in World War II. The use of man as this type of guidance system would be unacceptable to all Western cultures despite the calculated payoff.

Cultural reading habits would dictate that the typical Western nation instruments arrangement should probably be from left to right and top to bottom. However, such a scheme would not be optimum for Chinese, Arabic,

[1] *Supervisor, Human Factors Group, Radioplane Co.*
[2] *Litton Industries*
[3] *Supervisor, Weapons System Operations Section, Radioplane Co.*

or Israeli operators whose lifelong reading habits condition them to reading and writing (and thus scanning) in different directions.

The use of the human body for operating or sensing tasks also is limited by the taboos and practices of the society. For instance, our culture would not accept the use of radical surgery or prolonged and habitual use of dangerous drugs to increase the utility value of a human component.

Linkage Between Man and Machine

In the past it has been a rather common belief that a man could operate almost any kind of equipment. Little thought was given to the physiological and psychological capacities and limitations of the humans charged with the operation and maintenance of complex systems. As a result the operator is generally provided with displays and controls designed primarily to engineering criteria which ignore his limitations.

When men and machines are required to work together it is important that the machines provide required information in such a way that the human operator can make an exact interpretation. The information transmitted by the machine to the operator must permit him to make required judgments and to act quickly, decisively, and correctly. This means that the design and placement of indicators and controls must be on the basis of the real capabilities of the operator rather than on theoretical capabilities. Some data can be much more readily accepted than others. Humans are also capable of producing a wide variety of control outputs, but again, they perform some much more rapidly and accurately than others.

In dealing with the complex tasks involved in operating weapon systems, it is obvious that even if the human operator could correct an error, there might not be time for secondary actions. The sequence of many operations is complex, precise, and in its final steps, irreversible. Thus, it is of prime importance that judgment errors are minimized by designs requiring only those human decisions which can be made correctly and within the required time limits. Good human engineering makes it possible for the operator to act decisively, selectively, accurately, and quickly. It further assures design of the human requirements with regard to the learning capability of the personnel who are to operate and support the weapon system. Thus the operator is only required to do things that he can be taught to do reliably.

It is probable that in most weapon systems of the foreseeable future, control functions will be performed primarily by humans or there will be semi-automatic control supplemented by human performance of certain critical functions. In either case the linkages between man and machine will be rather complex. These man-machine linkages have two main forms—displays which communicate data from the machine to the man, and controls which communicate instructions from man to machine.

The Human Element

In a man-machine system displays are used to present information to the human element. Usually, this is done through either the visual, auditory, or tactual senses, or some combination of the three. The best type of information display is the one which cuts the lag in perception to a practical minimum. That is, the data inputs to the human operator must be such that they can be readily accepted and interpreted.

Once the necessity of presenting certain information content to the operator has been established, the human engineer is guided in the selection of the type of display by many considerations. For example, in deciding whether to present information visually or auditorily the human engineer knows that, in general, the eyes are a better medium when it is necessary to present relational or other complex information. On the other hand, the ears are a better sensory medium when dealing with (1) alarm signals, (2) displays where reaction time is important, and (3) where information input is low but continuous.

Auditory Radar

In the past, most information has been displayed visually for equipment operators. In many cases this has resulted in an overloading of the visual senses. Further, some of the more recent investigations indicate that some information now presented visually could just as well be presented auditorily. For example, techniques have been developed at the Air Force Cambridge Research Center for effectively presenting certain types of radar return information through earphones rather than displaying it on a scope.

The human operator directly affects the weapon system through the operation of controls. The best controls are those which minimize the probability of operator error and which permit the operator to transmit the proper action with ease and speed. Hence, in fulfilling his role of optimizing human performance, the human engineer must insure that equipment controls are designed so that they most effectively transmit the operator's intentions.

Considerable work has been done in the past on such problems as the design and arrangement of visual displays controls, designing control systems in which non-linear relations between controls and displays are used to meet wide variations in speed and accuracy requirements and coding of controls to facilitate identification.

For example, it has been found possible to code controls by shape so that even with gloves on, an operator can immediately tell which knob he is touching without having visual access to it. Efforts are now under way to standardize certain of these shape codings for various functions on different pieces of equipment.

Usually it is necessary to consider display and control problems concurrently, since equipment operators customarily receive information from displays, process it, and respond by initiating control movements. In maximizing this behavior cycle the human engineer applies his knowledge of human perception, higher integrative mental processes, and characteristics of motor behavior.

Man-Man Linkage

To fully utilize the human component and integrate him into the weapon system it is necessary to consider not only the interrelationships between man and machine but also those between man and man. When men perform as a team or when information is transmitted and received directly from man to man within the system operations, it is the human engineer's task to see that the design is such that these operations are designed with regard to man's capabilities.

Optimum Design for Maintenance

Maintenance problems demand consideration during initial equipment design. It is both possible and desirable to engineer equipment for maximum usefulness and minimum maintenance. Human engineering's aim is to achieve a design that is optimized not only for operability but maintainability also.

In discussing the assignment of functions to men and machines earlier in this article, the importance of maintainability factors was mentioned. It is recognized that when human functions are mechanized, the complexity and maintenance requirements may be increased. Similarly, in determining test requirements for equipment, a balance is struck between mechanizing of test and self-test functions, and the burden of tester maintenance imposed by the complexity of its own functions.

On the other hand, the capabilities and limitations of the human are essential considerations in determining maintenance tasks, component accessibility tools, techniques, test equipment.

Maintenance involves a certain amount of decision making, such as: What unit is malfunctioning? What should be done to correct this malfunction. Can the required operation be successfully completed despite the malfunction? The factors involved in making such decisions are so complex and unpreditcable that at the present time humans are generally much better able to make them than are machines.

Manpower and The Basic Training Requirements

The human engineer is directly concerned with the determination of the requirements for weapon system manpower in terms of types, skills, numbers, and training.

While the ability of human beings to accept data, make decisions, and manipulate controls can be modified by training, lengthy and expensive training programs are not the proper or economical method to compensate for poorly designed controls and displays. However, the design of displays and controls together with many other factors determine training requirements for bringing operators and mechanics to the desired level of performance.

In establishing training requirements, the human engineer considers every task to be performed in the installation, operation, and maintenance of the weapon system. The tasks are then grouped and positions or jobs are defined. On the basis of previous knowledge and assumptions about the capabilities of the personnel who will fill these positions, training requirements can then be established. Here the human engineer utilizes his general psychological background and his specific knowledge of learning theory.

In the area of training methods and devices the human engineer determines what parts of complex tasks must be trained realistically rather than by simulation methods, and how training devices can be simplified by eliminating hardware which is not needed for efficient training.

Machines can be designed to be simple to operate regardless of their inherent complexity. The tasks of men and machines can be analyzed and properly separated to reduce the error exhibited by either. Malfunctions can be minimized by considering the malfunction problems from the beginning rather than at the end of the development of a piece of equipment. ★

LEARN and EARN

. . . Air Force looks to Systems Labs for unique program to keep the U.S. supplied with rocket engineers

by Fred S. Hunter

SYSTEMS LABORATORIES CORP., incorporated only last May, already is a million-dollar-a-year business, and the work load on the president's desk keeps increasing.

This may mean that its president, Dr. John L. Barnes, who teaches two engineering classes at the University of California at Los Angeles, will have to cut—reluctantly—to one.

But no matter how great the flow of papers across his desk at Systems Labs, Dr. Barnes will devote some portion of his time to the classroom.

"Continuing to teach is a way to keep in touch with your engineering," said Dr. Barnes. "Otherwise, next thing you know, you are 100% management." Dr. Barnes wants to be sure to retain his identity as a scientist.

Systems Labs has a number of distinguishing features: it is the first scientific corporation of its kind to specialize in interplanetary space travel, research and development; it is owned and managed by the scientists and engineers who comprise its staff; a scholastic atmosphere pervades throughout its operation.

It probably has a higher percentage of Ph.D's on its payroll than any comparable institution in the country. It also has a graduate honors program that puts the company in something of a class by itself.

A number of large aircraft corporations are offering scholarships and other educational assistance to graduate engineering students to pursue advanced degrees—and as an inducement in personnel recruiting—but no small companies have felt able to undertake the expense until Systems Labs came along. It's indicative of the imaginative characteristics of Systems Labs' activities that close to 500 applications were received by the company from graduate students in the U.S. and abroad within a month after Dr. Barnes announced the fellowship program.

Systems Labs' scholarship program provide full tuition, books and supplies at one of the three graduate schools in the Los Angeles area, the University of Southern California, the University of California at Los Angeles and California Institute of Technology. It is open to graduate students in the physical sciences, mathematics and engineering, who are in the top 10% of their class. Science bachelors working for masters and masters seeking doctorates are eligible. A graduating senior may continue his education right through to a Ph.D. under the program.

Candidates are put on salary as soon as they arrive and work full time at Systems Labs during the summer. During the first semester, 80% of their time is devoted to study, 20% to work; during the second, 40% to work and during the third 75%. Starting salary is stepped up four times during the full course of the training program.

Each student is assigned to a "staff mentor"—one of Systems Labs' top scientists or engineers, and works closely with him during the training program. Upon completion, the candidate is free to continue on Systems Labs' professional staff or seek a position with another company.

One of the world's leading authorities in electrical engineering, and co-author of "Transients in Linear Systems," the standard text in the field, Dr. Barnes is especially aware of the importance of "feed-back" in the complex circuit of human relations in scientific research and advancement. "Top quality people in an optimum environment turn out the best research," he explains. "You can't keep people unless you learn what they want."

Systems Labs' can be described as a small company with big objectives. "We don't want to get too big," says

President J. L. Barnes briefs Systems Labs staff members on moon rocketry. Left to right: R. H. De Lano, Electronic Weapons Systems Coordinator; Dr. Lewis Larmore, Superfrequency Sensors Director; Dr. Barnes and Dr. J. A. Marsh, Radiofrequency Sensors Director.

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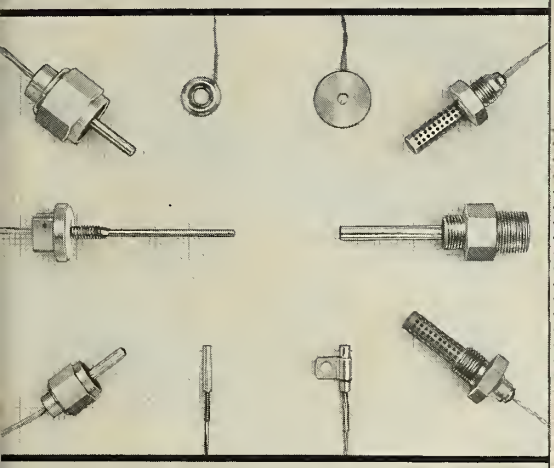

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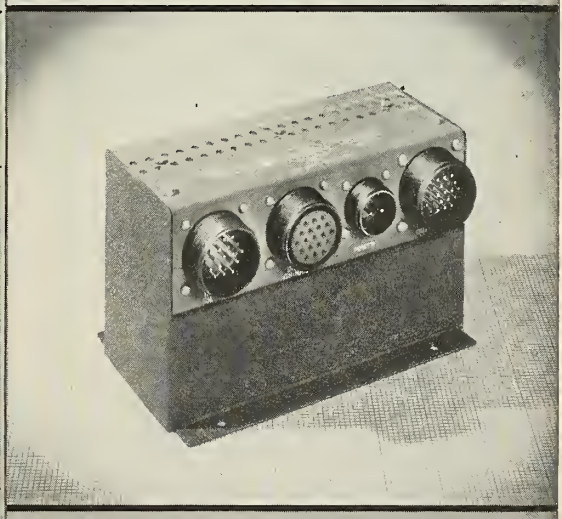

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L. K. Edwards (center), head of the Advanced Design and Systems Analysis Department, discusses atmosphere effects on missile guidance with W. F. Wright (right), head of the Analysis, Plans & Reports Section, and A. L. Lowell, Advanced Design Staff Engine

MISSILE SYSTEMS ANALYSIS—*a field of varied assignmen*

Engineers and scientists seeking a wide range of assignments will be interested in Lockheed Missile Systems Division's concept of systems analysis. For at Lockheed, systems analysis responsibilities involve virtually every phase of missile preliminary design and development. Essentially, engineers and scientists in this department formulate overall analytical treatment; perform original analyses when problems defy conventional handling; coordinate analytical activities among different departments.

Present openings are in areas related to inertial guidance, functional systems, power plants, control systems and overall weapon configuration. Openings are at Sunnyvale and Van Nuys Engineering Centers.

Inquiries are invited from engineers and scientists whose ability and aptitude demand a wide range of assignments.

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Dr. Barnes, even though he admits bigness is of itself often an advantage. "You can get contracts on bigness alone," he points out.

It will take $15 billion to circle the moon—one of Systems Labs' big objectives. This means, of course, that no agency other than the government can finance it. But, as Dr. Barnes points out, this is not the kind of project you undertake in one chunk. It is something to be done a few millions—or billions—at a time.

Systems Labs charter states that the corporation was organized primarily to work on interplanetary travel. Meanwhile, it is bringing in its revenues from sub-contracts. At this writing it has 15 of these, all scientific projects. Included in the first sub-contracts obtained by Systems Labs were four from Republic Aviation to solve problems in guided missiles and aircraft fire-control.

Systems Labs expects to begin getting some prime contracts very soon. They may even be in the interplanetary field. Dr. Barnes hints that more than one government agency is beginning to look in this direction.

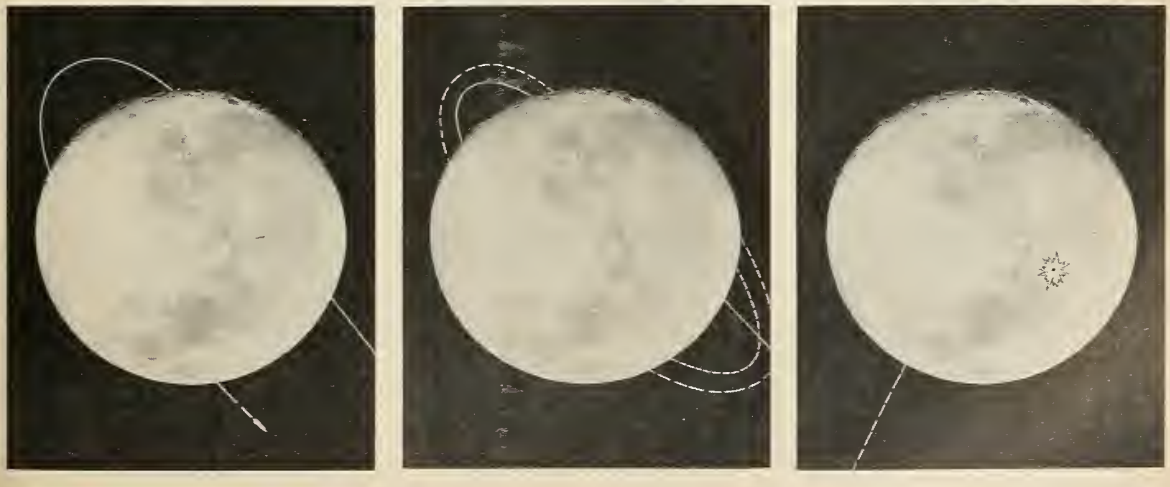
As Systems Labs' grows, Dr. Barnes plans to partition it off into semi-autonomous sections. He envisions a number of separate laboratories at various points on the west coast, Santa Barbara, LaJolla, Corona del Mar, perhaps even in other sections of the country. Dr. Barnes wants a ceiling of 100 employes in any one section. Better communications and better work are the twin accomplishments of groups held to a maximum of 100, he believes.

The first separate laboratory probably will be a radar antenna laboratory. This is logical because he has the man to head it up, Dr. James A. Marsh, who, says Dr. Barnes, is a good scientist and also a good administrator. Formerly head of North American Aviation's radar group at Downey, Dr. Marsh is one of the founders of Systems Labs. Another is Richard H. De Lano, one of the co-holders of the *Falcon* missile.

Dr. Barnes and his associates believe interplanetary travel will actually be easier than generally expected. The numbers, they say, are all coming out right in Systems Labs' initial studies of the various phases. They're watching nuclear power developments closely and unless there are unexpected throwbacks here Dr. Barnes doesn't think it at all optimistic to say that the next few years will see the development of a practical moon rocket project. ★

Dr. John L. Barnes, President of Systems Labs which weans students slowly from the classroom to the laboratory working up from a 20 per cent work-day to 75 per cent in the last year.

Three methods man may employ in trying to get his first closer look at the moon—around and back; up and orbit; and a visible impact on the moon's surface. Any one of these is the kind of project Systems Labs was set up to develop. It is also the kind of a project AF's Western Development Division is preparing to launch.



international briefs

ICBM Won't Replace Manned Bombers

Air Chief Marshal Sir Dermont Boyle, the Royal Air Force's Chief of the Air Staff, stated in Australia last month that intercontinental ballistic missiles would never completely replace the manned strategic bomber. The primary problem of all modern aerial planning centered on the change from manned aircraft to guided missiles, he declared. Some authorities thought the change would take place overnight, others that it would never take place.

Meanwhile the Chairman of Bristol Aircraft Ltd. and President of the Society of British Aircraft Constructors, C. F. Uwins, who was also visiting Australia, urged in an interview that some of the secrecy surrounding British guided missile development should be lifted. He said this would have a very good effect on the morale of guided missile workers.

Uwins revealed that more than 400 British companies are now working on guided weapons, including long-range ballistic missile.

Oil Spraying Rocket For Mercy Missions

From Bremen, Germany comes news of rocket development for mercy missions. The Deutschen Arbeitsgemeinschaft fuer Raketentechnik has designed two models of an "oil-spraying" rocket for reducing the heights of waves around a vessel in distress. In principle, the rescue ship (Coast Guard) would fire a series of these rockets up wind of the disabled vessel to lay down an oil slick prior to rescue. The rockets are designed to be fired from the standard rescue-line throwers. Only prototypes have been manufactured so far and tests are anticipated.

French Determine Fuel Erosion Constants

The French have come up with novel ways to determine the erosion constants of solid propellants. One method used two nozzles with a progressive burning grain—a large steel nozzle to maintain pressure and a smaller nozzle to test the propellant. Another method uses an erosion bomb which compares two grains.

Yet another French work tackled an old propellant—black powder for rockets. The exponent of burning rate was about 0.62 at pressures up to 800 mm Hg. At atmospheric pressures, the fastest propellant had a burning rate of 0.46 in/sec and consisted of 5% S and 20% C. For smoother low pressure operation, the best composition was found to be about 25% S and 20% C.

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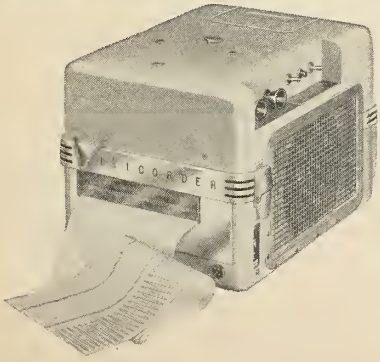

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HEILAND INSTRUMENTS

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International Scene

By Anthony Vandyk

Naval minesweeping techniques are used in a missile recovery system developed at Australia's Woomera range. Designed to protect valuable test missiles and their delicate instruments from damage, it employs a long cable attached to and reeled out from an aircraft. At the far end of the cable is a winged paravane which flows like a kite 400 to 500 ft. from the side of the aircraft. The missile is equipped with a small parachute which is automatically or electronically released at the end of its run. This parachute is not big enough to support the missile in the air but it checks its falling speed. The aircraft then closes in and sweeps the cable of the aerial paravane across the cable of the parachute. The parachute cable slides along it until grappled by the paravane. The recovery point is another cable slung at the top of a ravine or between two towers. It collects the missile from the paravane as the aircraft flies past. m/r's Australian correspondent comments: "This development calls for rather tricky flying!"

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Rolls-Royce is building the North American Aviation rocket motor under license for use in Britain's IRBM. Work on this project has been in progress for some four years. Meanwhile the British Army is putting final touches for plans for the use of its U.S.-supplied *Corporals*. Present indications are that the English Electric Company will handle the overhaul of the Corporal in the U.K.

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It's no secret that the Royal Air Force thinks very highly of infra-red missiles and is counting on the de Havilland AAM of this type to play a major role in the air defense of Great Britain. One reason that infra-red missiles are preferred to radar-guided types is that the former are less susceptible to jamming.

•

"World-wide circulation" is being given to a notice by de Havilland Propellers Ltd. that this company is responsible for the de Havilland guided weapons program—not the de Havilland Aircraft Company. The propeller company is one of three operating companies (Aircraft, Engine and Propellers) within de Havilland Holdings Ltd. in Great Britain. In Australia the propeller company has set up facilities at Salisbury and Woomera with administrative assistance from de Havilland's Australian subsidiary, de Havilland Aircraft Proprietary Ltd. De Havilland-Canada has established its own Guided Weapons Division with the assistance of de Havilland Propellers Ltd.

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The Royal Air Force has formed special units to conduct service acceptance trials of missiles under the control of the Ministry of Supply. RAF men for these units are attached to manufacturers during the development stage. After acceptance trials they will carry out the service trials of the weapons in the RAF. In another phase of missile work the RAF has formed its first guided weapons training station. A simulator is being built at this facility (location secret) which can synthetically reproduce attacks by enemy aircraft and enable interceptions to be practiced under realistic conditions.

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The Paris International Air Show May 24-June 2 will be used to unveil a lot of new French developments in the missile field. It is probable that SNECMA will be able to reveal some details of its work on ramjets. SNCA du Nord is likely to have plenty of missile hardware on show. The show is held at Le Bourget airport and has representation not only from French manufacturers but from nearly every European country plus Canada and the U.S. Several of the East European countries are planning to participate.

MICROWAVE AND ANTENNA ENGINEERS

Experienced microwave engineers are required to perform research, development, and design on antennas, radomes, and microwave components. System engineers are needed for system development related to microwave receivers, Electronic Reconnaissance, Countermeasures, Radar and Transponder Systems. The work will be accomplished in the Radiation Laboratory in relation to prime missile and airframe contracts.

AUTOMATIC CONTROL SYSTEM DESIGN ENGINEERS

Engineers are required with experience in closed loop stability analysis and synthesis of automatic control systems. System engineers are needed for design and development of servomechanism, memory circuitry, digitalanalogue techniques, and numerous other control equipment for fulfilling the requirement as specified by system analysis design studies. These engineers will perform research, development and design of stabilization and control systems for guided missiles and high performance aircraft prime contracts.

AIRCRAFT ELECTRONICS ENGINEER

Engineers with experience in transistor applications, pulse and video circuits, servomechanisms, general circuit design, guidance and radar system analysis, audio circuits, electro-optical transducers and optics are needed to perform system and detailed circuit design on guidance, radar, and television systems for guided missiles and high performance aircraft.

TELEMETRY ENGINEERS

Electronic Engineers having design capabilities and experience with present airborne and ground telemetry equipments, system design requirements, and detailed familiarity with data reduction techniques, calibration of end instruments, converter techniques, and intervalometers are needed in relation to prime missile and airframe contracts. Ground floor opportunities exist for competent personnel in this field.

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World Astronautics

By Frederick C. Durant III

For the next 5-10 years the unfolding of satellite vehicle research programs will represent the next major step in the development of astronautics. Soon the first handful of 20 in. NRL telemetering spheres will be flung into satellite orbit around the earth as part of the U.S. IGY program. The USSR, too, will launch IGY satellites of size and orbits still to be announced. As discussed previously in this column these initial programs will be followed by satellites of increasing dimensions. Eventually, man will travel in satellite flight.

To report clearly to the public on these events will require a depth of perception that is not common in news agencies today. Understanding and appreciating the satellite program's significance will be necessary to properly tell the story to the public.

Executive elements of our news and communications media must become educated to the fact that space flight can no longer be treated in a tongue-in-cheek manner. This approach, widespread until recently, masked a lack of understanding of what space flight was all about. But astronautics has now reached the age of respectability. Industry and Defense Department attendance of the Convair-OSR symposium last February significantly underlines this fact.

The problem of lucid commonsense reporting and interpreting such news events as the *Vanguard* test launchings and subsequent live firings is facing all news editors. To meet this challenge every major radio and TV network, wire news service, newspaper chain and news periodical should be undergoing self-education. At least one or more responsible staff members should now be charged with the responsibility of learning the basic facts of astronautics.

The public is understandably confused about space flight. There is deep interest but there are many misconceptions about the relative size of the problems and probable time table of realization. Above all, they want to know the *why* of space flight. What will astronautics mean directly and eventually to the man in the street, to scientific research, and to industry? When, and how, will astronautics affect our economy?

The rocket and guided missile industry and the professional societies have a major responsibility in providing facts and understanding through popular lectures, brochures, films, and consultancy. There have already been excellent examples of these such as Martin's booklet, "A Moon is Born" or their film "Horizon Unlimited," or G.E.'s "Rocket Facts." However, the quantity of such material is still far too small in the face of the rate of rocketry progress.

In the course of talks on rocket power which your columnist regularly gives to professional society gatherings it is still startling to find that discouragingly few persons know what the letters IGY represent. Still fewer can tell you why the e.s.v. program is revolutionary, or what it portends. As for the man in the street, the level of knowledge is still lower. And yet the subject relates to the most exciting adventure and exploration expedition to be undertaken by civilized man. The majority of people now alive will witness manned space flight and, at least, lunar expeditions in their lifetimes.

The communications media have the opportunity to provide the public with a sound understanding of the next basic steps in satellite flight achievement. More than an opportunity, it is a responsibility.

The Ballistic Missile Challenge

. . . as seen by Major General Bernard A. Schriever

Chief, Western Development Division of ARDC

Q. *General Schriever, does the management organization here at WDD function as one team?*

A. Yes you can't really distinguish organizational lines between WDD, R-W and BMO. It's one integrated operation. We work as one management team. Not that we don't have problems from time to time, we do; but to all intents and purposes we function as a closely knit team. I have more problems internally within my own staff than I do in keeping the R-W, BMO, and WDD all working together.

Q. *I notice everyone wears civilian clothes. Why is that?*

A. There are really two reasons for it. The first one has to do with security. When we first came out here we felt that to enter into a civilian community and have a lot of officers running around would immediately create speculation which we felt not in the best interests of security of the program of the Air Force. That was reason number one.

Reason number two is that we feel that everyone working in civilian clothes actually creates just a little better spirit of harmony or establishes conditions where you can work in better harmony. If I were sitting here with two stars on every day, I think the people coming into my office would be just a little bit more apt to be formal and stiff than if I'm sitting with a sports jacket on and a pair of brown trousers.

Q. *Is it true that $470 million have been spent on test facilities since the program was accelerated in August 1954?*

A. Well, not just test facilities, this includes plant expansion, too. Let's take the North American Rocketdyne plant at Canoga Park as an example. The plant that was built in Denver by Martin is another. So is the plant that is being built right now by Convair. However, the largest percentage of this total of $470 million has been for test facilities—major test facilities—and also test equipment which you never see.

It's an environmental type of test equipment; shake tables, centrifuges, furnaces of different types, shock tubes and things of that nature which are small but expensive. They are the kind of things that we have to have to start testing the reliability of the components before they are assembled into a subsystem. Then, of course, facilities get larger when you start testing subsystems. When you start testing the entire missile with the subsystem assembled then they become quite large.

I think a comment on the test facilities and their possible use for follow-on program would probably be an interesting point as well. You take the North American test stands that we have at Santa Susana; I don't remember how many stands were there when our program started, but in 1954 when we started the accelerated program there were something like four or five, I think. They have quite a few more than that now and they were all built in support of the Ballistic Missile program. All of the stands built at Aerojet in Sacramento, for example, were built for our Ballistic Missile program.

Q. *Will these stands have continued utilization for future development?*

A. Yes. For example, a stand at Edwards which we're just activating now—Stand 1-A—will take a million pounds of thrust. Actually, when you get the safety factors in there you will probably be able to go up to a million and a half pounds. Of course, we don't propose to test anything in this program that has thrust of that magnitude.

Q. *Then, you don't rule out expanded tests in the future, for space flight, for example?*

A. Resources in manpower and facilities and the knowhow in fabrication and techniques that have been established to date and are still on the build-up, are of such a magnitude that the business of space flight is just a matter of whether or not you want to do it and want to spend the money on it. It's no longer a matter of technology or a

The business of space flight . . . a matter of whether or not you want to do it . . .

matter of resources in terms of the facilities and know-how. It's a matter of the funds and the need for doing it, either in terms of military requirement or in terms of national prestige.

Q. *Do you think there is a military requirement for spaceflight?*

A. Certainly, military requirements can be formulated—just one in terms of reconnaissance, that relate to other phenomenon; that relate to matters of the earth's gravitational field, cosmic rays and that sort of thing—these can all be applied to the military. But if you want to be more specific in terms of having space vehicles out there trying to shoot each other down or delivering weapons by space vehicles this is something that I am not able to comprehend in terms of specifics yet.

As we move out into space, I think first it will be to get scientific data. From there, once you get moved out into space, you're going to start identifying specific things that will relate to a specific military mission. I'm sure of this. I think this is an evolutionary thing, and I'd certainly not try at this point to lay out a blueprint as to what this might look like.

Q. *Going back to the $470 million which was spent on facilities, and test stands and what not, does that amount include the scientific study contracts that have been let in the same period?*

A. No, this covers only the actual facilities.

Q. *How much money has industry put in?*

A. When you add up all of the industry facility investments, they total slightly over $100 million. This is industry money out of that total of $470. But here again, like the Martin construction, all of the construction isn't quite complete yet. Neither is the Convair construction program. The Aerojet facility construction is almost complete. So is the North American Rocketdyne facility in terms of their investment.

Q. *What can you say about the progress of the program since you took it over?*

A. Well, actually, I divide the program into four phases and perhaps I should discuss very briefly each one of these phases. The first phase really was a study and organizational phase. After the von Neuman committee made its recommendations to the Air Force that we should accelerate the ICBM program they didn't say take the program that the Air Force had in being then and accelerate it. They said that we should conduct very detailed technical studies and systems analysis to bring about a reoriented program within one year's time. This was to assume maximum benefit from the thermonuclear breakthrough that had occurred. This actually changed the nature of the weapon system in terms of its military characteristics.

First we conducted very exhaustive technical studies and system analysis. At the same time we established this management complex—the administrative actions required to set up the management establishment to clarify procedures, get personnel into place and so forth.

Next we made the major technical decisions that launched the development program that followed. I mean the reorientation of the *Atlas* and a number of other things of a technical nature. That ended phase one. Phase two was relatively short and involved the selection of our industry team. We had to select the total contractor team-guidance contractors, which included both radio-inertial and all-inertial; the computer contractors that went into the radio-inertial guidance contractors; another large liquid rocket development and production agency; the nose cone contractors of which we selected two.

Then we introduced a second approach, a second or alternate ICBM approach which was very, very strongly recommended by the scientific advisory group which kept in being with Dr. von Nueman as chairman. We had frequent meetings with that group.

Q. *Was the von Nueman committee organized strictly to monitor the Ballistic Missiles?*

A. Correct. It was during the second phase then that I considered the selection of the industry team. We of course kept the program going and accelerated both contractors that we had in being. At North American we had to put a great deal more money there during '54 to expand the facilities. We kept Convair more or less at the same level until we made a decision on what changes we wanted in their particular configuration.

When we had completed, for all practical purposes, the selection of our contractor team, the IRBM was not yet in the picture. Next would be what I consider the third phase, which I call the development, fabrication and test phase, which covers, you might say, the real development effort. This of course, had associated with it the vast facility program we've just discussed. Schedules are all paced on getting facilities in being on time, if you want to carry out a crash program. I think, from the standpoint of accomplishment, that getting this facility program accomplished essentially on time was a major accomplishment of our first two years of operation. There have been minor slippages here and there in activating a launch stand here or an engine test facility there, but for practical purposes you could say that we met the scheduled target dates that we laid down for ourselves in this over-all facilities program.

Now that the end of it is in sight it looks as though we will not have any slippages because facilities were not available on time. I don't mean to say that everything has been milk and honey, because it hasn't, and we have not gotten as much testing in some areas as we would like because a facility was a little bit late, but it doesn't appear

I happen to disagree with you . . . a national agency for ballistic missiles won't do . . . would be complicated, I think . . .

that we'll be able to blame facilities for any slippage that might occur in the future.

The fourth phase is the operational phase.

WDD is responsible for all four of these phases. We step out of the operation phase at such time when we have an operation capability. When this operation capability has been established the missile is in fact operationally ready, then it reverts to Strategic Air Command control.

Q. *Are you working closely with SAC?*

A. Yes, but the Command jurisdiction rests with me until such time as it is turned over to SAC, which will be some date in the future. Then we would drop out of the operational side of it entirely and revert back to a normal research and development type organization.

Q. *As far as the long-range missiles are concerned, you're carrying out not only the conventional R & D phase but the training of personnel and the production phase of it and even the operational phase of it before SAC takes over?*

A. Right.

Q. *Isn't that unique in the history of ARDC?*

A. It's unique in the history of the Air Force! I think it's very easy to explain why this is the wise thing to do. We are introducing here a type of weapon which required a rather new operational environment. It isn't another airplane that's going to be operating from a standard aircraft base. The manner in which it is going to be operated is considerably different from the manner in which you operate an airplane. The establishment of the actual facilities—the operational facilities—is in itself a development job which is dictated to a very large extent by the characteristics of the weapon to be employed.

You have got to have very, very close tie-in between the characteristics of the weapon and the characteristics of the facilities from which the weapon is going to operate. You have to marry the two. You can't do it any other way. In order to conserve time, this is the main thing that we are trying to do here. The Air Force felt, that by giving one organization the total responsibility for integrating all of these things it wouldn't be necessary to get everybody's blessing and then call in an umpire if there is a disagreement. I personally feel that in this case because of the uniqueness of this weapon, that this type of an approach is sound.

Q. *Could this concept be employed in any R&D program?*

A. I would not recommend this type of organizational approach, say if we were developing a new airplane like the B-58. It's an advanced jet bomber with better performance characteristics, but you're going to introduce it in exactly the same operational environment as other jet bombers. The manner in which you're going to operate that weapon—the command structure; the communication structure—is going to be very similar to the one you used for the B-47 and the B-52 so you shouldn't depart from standard method for the B-58.

Now, I might comment at this point, I've noticed in the past where your magazine has advanced a national agency of some kind to carry on the development of ballistic missiles. I think everybody is entitled to their own opinion on this. I happen to disagree pretty violently with this philosophy simply because of what I've just been talking about—the necessity for a total program being under the direction of a single agency. If you have a separate national agency somewhere developing the hardware, I'm not saying you couldn't get a very fine agency for the development of the hardware. But the problem of introducing this hardware into a military organization where it becomes a useful weapon, I think, would be complicated to a much greater extent than any benefits that you might derive by having a national agency.

I'd even grant you that maybe you could have one that has a better capability and confidence than we have. But I'd still say that it wouldn't be the right thing to do, unless the differences in confidence were so great that there was a question about our ability to get the job done, as against the other agency's certainty of being able to get the job done.

Q. *How about the scope of testing at the Patrick facility? It seems to be getting sort of crowded with the Army, Navy and Air Force all wanting to schedule tests at the same time. Will this interfere with the testing of the long-range missiles?*

A. Well, I don't know if I can really answer that for security reasons but I think I can say this: the Patrick test facility has never really been called upon to accommodate a large-scale test program. All of the testing down there has been sort of on an individual basis. Procedures that apply to that kind of testing would not be very satisfactory to a large-scale test program such as we envision. We have done a lot of studies with Patrick on the streamlining of procedures to accommodate the larger volume of testing, such things as range safety provisions.

Possibilities of a three-shift operation, in other words, working around the clock on a standard three shift operation instead of calling upon an extra crew that might be required from time to time. We have concluded that there doesn't appear to be any reason why we can't accommodate our test program at Patrick. For the expansion of facilities, from our standpoint, I think we see the end of our major facilities requirement on the horizon. And within a relatively short period of time we will have our facilities, except for minor extensions which are always of course to be expected.

Q. *What does the top national priority that the program has been given actually involve?*

A. I think the best way to put it is that it has generated a streamlining of procedures, primarily within Washington, and it has provided contractors with a priority for materials. It also has resulted in the relative rapidity of decisions from the top level, plus support economy-wise as far as the contractors are concerned in getting their materials, parts and components ahead of any other requirements on the list.

It also, of course, resulted in our getting a very high priority in availability of key people—qualified people. It resulted in our being given the funds required to do the job. I would say the funds plus streamlined procedures for decision making are perhaps the two most important results of the national priority. I think it's fair to say that we have been proceeding at the fastest rate that technology permits.

Q. *Ever since 1954, you mean?*

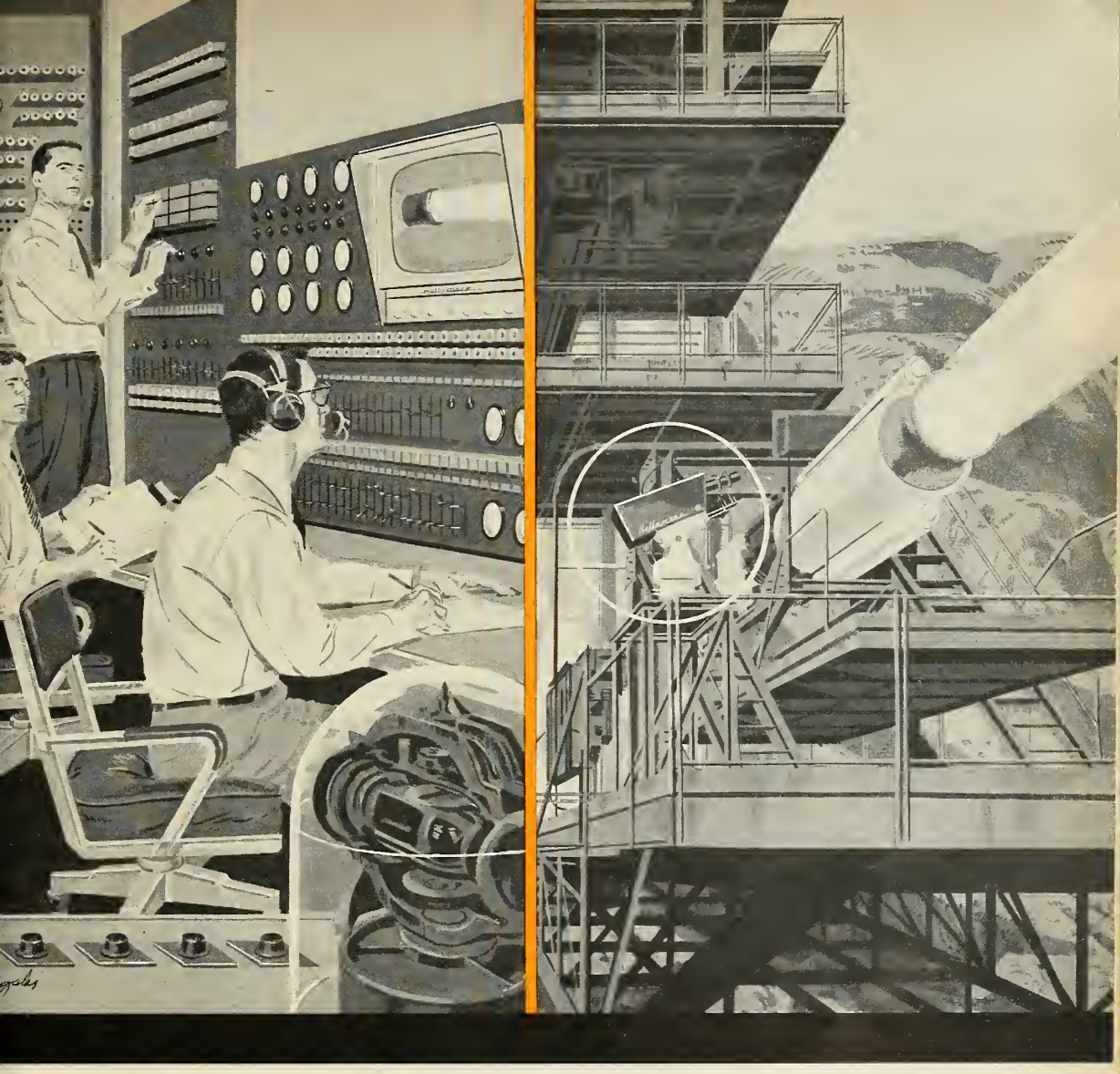
A. Ever since 1954. During the first year or so of the program the fund requirements were such that it did not require that a national look, you might say, at the funds was necessary and we were able with an Air Force priority to meet the needs of the program at that time. But by the time we had hit the middle of '55 the Air Force no longer could swing it on their own. I mean if we had not gotten a national priority about then we could not have carried on the program at the rate we have.

Q. *Are there any other military projects in existence that involve so much support from industry and science as the ballistic missile program?*

A. No.

Q. *Then, this is the biggest project the Air Force has ever attempted?*

A. To the best of my knowledge that's true if you add up the systems, the *Thor*, the *Titan*, and the *Atlas*. As a total the Air Force Ballistic Missile program is the biggest weapons system project we've attempted. I think that's a fair statement.



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The Ballistic Missile Procurement Problem

. . . as seen by Brigadier General Ben I. Funk

Deputy Director of Ballistic Missiles, AMC
Chief of the Ballistic Missiles Office, WDD

Q. *General Funk, you deal with all of the ballistic missile contractors?*

A. Yes, the contractors are as deeply involved as we in this management effort and in the ballistic missile program—more than any other weapon system program that I know of. They have been around AMC for many, many years, and they have been working on other management problems as well. What we're doing here is asking industry very early in the program to begin gathering what we call "failure rate and consumption data" on the components that are tested. In other words, the WDD people in coordination with R-W set up the tests to be followed by the contractor. The contractor begins getting failure. Normally in an R&D program you're not in such a hurry to know instantly which part failed and how many of these are consumed over a period of time. But here again we need to compress time to meet this priority program. We already have a format that we're implementing which will insure that we do get it—and get it when we need it. Now at Convair, they have more work in process, and they are turning out more work than the rest of the contractors on the *Atlas* because they have a systems integration responsibility in addition to the airframe fabrication. On the basis of the information we get from them we can begin the process of provisioning the spares requirements. Provisioning the spares for not only the missiles themselves, but the ground support equipment. It is extremely important in this program.

Q. *Ground support is one of the things that we'd like to know about. We have an idea that you are now pretty deeply involved in the planning of the actual launching facilities.*

A. Well, we are all involved of course in trying to firm up what ground equipment is going to be required, and what levels of spares are going to be required so that we can budget and buy in time. I'm speaking of the lead time requirements to get all the things into Camp Cooke necessary to make it function as a missile training base. We must be thinking now about what ground support equipment and what spares we're going to need.

When we think of spare parts not only do we have the spare parts problems for the missiles themselves, but ground support equipment has to have spare parts. Let me make an anology particularly applicable in this weapon system. With a gun, you of course think of the gun and the bullet. Well, we have a lot of guidance equipment and a lot of support equipment must stand on the ground. Your missile's the bullet, and your gun costs a lot of money, and this is where the uniqueness comes into this program; whereas most ground support equipment percentage-wise, would run, anywhere up to 35% depending upon which weapons system you are talking about.

In this program it may run as high as 50% of the total cost for ground support equipment alone. So you can see the importance of making certain that we are selecting the right kind of ground support equipment and that we're not duplicating anything that is already in the inventory.

Q. *How do you go about implementing your long-range planning objectives?*

A. We visualize the use of electronic data processing means to actually manage all of the assets to support a weapon system. By that I mean we have our common Air Force items; then we have the design procurement items which the contractors themselves are responsible for; certain government furnished equipment and certain contractor furnished equipment. We would use the large computers that industry is now turning out to compute and determine levels that would be required, say at a support base, launch complex or at a contractor's facility. Now, at least initially, we feel that in order to buy time (and this is a phrase we often use here too) we need to have the contractors provide us with the depot level of supply and maintenance for their procurement items. Under our AMC depot system, usually the depots themselves do the whole depot level job to support the weapon system in the field.

In this program we may run as high as 50% for ground equipment . . . we're taking a calculated risk . . . we may make some changes . . .

Here we would bring in the contractors. We've got to contract with him to not only build this weapon, but to support this weapon. We are actually in the initial stages of working this out with the contractors now. This is during the initial operational capability phase that I'm talking about now, and my weapon system manager responsibility would implement that type of a logistics plan.

Q. *How does your job differ from a normal AMC job? Is it normal for AMC to get into the act of producing weapons at this early date, and is it an advantage?*

A. It is not usual for AMC to get into the act of producing weapons at such an early date. Here again though, if you're going to buy this time that we keep talking about, there's no other way to do it than to accomplish the R&D, and production-operational phases on a parallel basis. Obviously, we're taking a calculated risk that maybe we're going to make some major changes. We don't think we will. We think that the necessary changes will be minor. In effect, this is not "business as usual"; this is pioneering. We have to deviate from the old established hand-driven methods, and we do this whenever we feel it buys us time.

Q. *Does your office get involved in choosing personnel for the project, or do you leave that to the contractors?*

A. We provide a surveillance function with the contractor to be sure that he is getting proper quality and quantity of manpower to do the job. If we're dissatisfied with the number of engineers and technicians that he has—for example, if he is late on his engineering work order releases; if he's out of station on his production line based on lack of engineering effort, we're to take action and tell the contractor he needs more qualified engineers or whatever. He gives us a forecast of his manpower buildup by category of manpower, manufacturing, engineering and so forth, and we monitor this very carefully and look at it in a monthly management meeting we have here.

Q. *How do you go about determining contractor specifications on something you've never built?*

A. Well, there are no specifications, in the main, in this program because we're doing something brand new—new fabrication techniques, new types of weapons. So we have to deviate from the normal acceptance procedures for Air Force materiel. Where you'd normally inspect to a certain set of specifications, we don't have them so we have to use our best judgment here as to whether we do or do not accept something.

Q. *What about problems you don't anticipate, such as the contingency factor?*

A. We're realists, let's put it that way. We have had enough experience that we can generally anticipate the areas where we're not going to have difficulty and where major testing is being accomplished. We do a lot of testing on the ground to insure a reasonable degree of certainty that we won't have any delays due to a particular new fabrication technique or new metal or something like that. The degree of reliability required in this program is unique. It's higher than any other weapon system program simply because you launch unmanned missiles, whereas when you launch a bomber if it doesn't work, you just fly back home.

When you launch a missile it's gone. In this business you must build in a very high degree of reliability, and this reliability is not only in the weapon system itself, it's in the systems which stay on the ground and in the ground support equipment. Reliability is here again unique, and it's highly important.

Q. *What about storage? Can you store the missiles for four or five years and then take them out and make them work?*

A. Well, the missiles won't be around for four or five years. Obviously you must have a degree of readiness at all times. I'm not going to go into the degree of readiness because it is classified. But it does require the rotation of operational inventories for example.

Q. *Well, isn't it safe to assume that when you reach the production stage, you will have a certain production output of these missiles at all times, because you will obviously have to launch some of them for training purposes?*

A. Definitely. We're not going to build just so many and then quit!

Q. *You're going to shoot the missiles as part of your crew training program?*

A. Of course, you're absolutely right. So provided a contractor performs well under the contract terms it is reasonable that he would still continue to be in business for some time to come. You not only have this problem of production in the missiles, but here again the ground support equipment and the spares must be programmed for. It's not a one shot deal in any sense of the word, but a continuing program. It's the one thing that I think a lot of people misunderstand.

There is a tremendous amount of planning that has to go into this weapons system to make it a useable programmed weapons system—not only is it a program for the procurement, production, logistics, logistical support, training, base selection, base building, you're also building the installations, you're building communications systems; you're building electronic data processing systems; you're building contractor capability to do supply and maintenance of the weapons, as well as getting an Air Force capability to the degree that it can supplement the manned bomber force.

This is not business as usual, this is pioneering . . . we're not going to build just so many and then quit!

The Ballistic Missile Management Problem

. . . as seen by Dr. Simon Ramo

Vice President, Ramo Wooldridge Corp.

Q. *Dr. Ramo, how are the financial aspects of the ballistic missile program handled?*

A. R-W does not have any connection with monetary phases of the program. No money passes through R-W. We do laboratory work, we simulate the whole system, we do regular dynamic analysis, we do certain kinds of laboratory explorations on any fundamental point that is basic to a decision that has to be made. We supervise the final system tests. We decentralize to the airframe manufacturer what you might call the physical integration and system test operation. We do not attempt for example, to design hardware details.

Q. *What is the size of your staff?*

A. Well, I can't give you the precise number, which is classified, but there are some hundreds of engineers and scientists. These experts are assisted by certain non-technical, administrative, clerical and other help. Our principal group is composed of some forty people, average age 40, who have 15 to 20 years experience, and who are graduates of programs of this general kind. You'll find that many of our key people have associated with other successful complex programs, extending from World War II to missiles of the last ten years to other weapon systems, including Manhattan project assignments.

Q. *Will you expand the GMRD as the program goes along?*

A. Well, the program has not yet hit its peak personnel requirements but it is very close to it. Obviously, we do not anticipate any need for expanding indefinitely. Nor do we plan to ever go into production in this general area of ballistic missiles. This is of course a key point. We have felt it's rather important in taking on the systems engineering work for this project, to be sure that every one of our decisions are based on the most objective thinking possible. Thus we have no production contract and engage in no production in connection with the ICBM program.

Q. *How about the need for more missile engineers for this particular program, say, during the next 15 and 20 years?*

A. Well, of course, what has to be decided is what rate is essential. The number of engineers and scientists that we have will partially determine how fast we go in this highly technical society of ours. Most of the time in connection with most of the things that are happening today, I do not believe that there is a shortage of engineers and scientists. But, rather it's a problem of how we utilize the available scientific personnel.

Q. *We have noted that the locations of the contractors engaged in the Air Force Ballistic Missile Program are spread over the whole country. Does the dispersal aspect of National Defense play any role in this?*

A. It did to some extent during initial stages of the program. It is not easy to talk inquantitative terms as to the decisive step. For example, North American was the major developer and supplier of large rocket engines. And Aerojet was another. We notice that both of those are California companies. And we notice that both of those have had a very great deal of expansion from the standpoint of facilities. We also notice some things, however, in the Mid-West in support of these companies. Convair and Douglas as two airplane companies, are both located in Los Angeles with expansions of their programs and with large systems test support in their areas; such as San Diego and at Edwards Air Force Base. We also notice that while Martin is located in Baltimore, Maryland, it has a division in Denver working on this project. So, you see there is a certain amount of dispersal.

Q. *The Martin Division in Denver was actually set up for this program?*

A. The Division in Denver was set up after they came into this program.

Q. *So it might be safe to assume this move was dictated more by the ICBM program than by the dispersal aspect?*

The number of engineers . . . will partially determine how fast we go in this highly technical society of ours . . .

"ARCTIC STARS," latest in a series of paintings by Simpson-Middleman, painters of the meanings of science. They describe this interpretation as "an expression of entropy in the cosmos. Starlight, clear and cold, contrasts with the warm color of autumn leaves. Behind both, the undulating field of the celestial wall." Painting courtesy of John Heller Gallery Inc.

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A. Well, at any rate, I think this is a conjecture that you yourself have to make. Let me point this out, certainly it is true that companies have been expanding and seeking other locations. In our case, the Denver plant of the Ramo-Wooldridge Corp. is intended for larger scale production than we will do here in Los Angeles. A major reason for our going to Denver was the dispersal policy. However, there are some advantages in our locating ourselves partially out of Los Angeles in any case. Thus we also have offices in Dayton, Washington, D.C., Boston and Cocoa Beach, Florida.

Q. *Did you say R-W was a production facility?*

A. Yes, this applies to our five other divisions but not to the GMRD, which works only on the Ballistic Missile Program.

Q. *What do your other divisions do?*

A. Well, to make it very short and simple, the Ramo-Wooldridge Corporation was set up with a number of divisions emphasizing electronics work; not only the systems engineering aspects of electronics projects but the actual development and production of equipment right through to spares and maintenance. We were engaged in these activities when the Air Force asked us to take on the ICBM systems engineering and technical direction assignment. To do this job we set up our Guided Missile Research Division solely devoted to ICBM. The Guided Missile Research Division is only concerned with systems engineering and technical direction for the Air Force's Ballistic Missile Program. It does not do any production nor will that division do any production on follow-on jobs.

Q. *Does the R-W Denver plant have anything to do with the fact that Martin also has a plant there which is doing ICBM work?*

A. There is no connection whatsoever. As a matter of fact, we had acquired the Denver land before Martin was in the ICBM program.

Q. *But Dr. Ramo, hasn't R-W been involved in aiding the Air Force in selecting companies for the Ballistic Missile Program?*

A. We are involved indirectly in a sense that we propose the R & D plan which tends to define the nature of the needed contractors. The Air Force alone chooses a candidate list. We brief those candidates during the short competition period which is always held by the Air Force. In general, all the contractors have been chosen by competition and by the Air Force. We do evaluations on both their oral presentations and on their written presentations, but only from the technical standpoint, and finally we withdraw and are not part of the final deciding team.

Q. *Do you provide some of the contractors with assistance from your expert engineers and scientists?*

A. Yes, the reason this happens is this: Though we try very hard to decentralize the detail, design and development, things will arise in which the interaction between one part and other parts is the key point of importance and we are in a position to see it most rapidly. It is natural that we try to help when we can. But we don't attempt to, and it would be absurd to imagine that we could try to fix it so that whatever every contractor can do, we also have the capability of doing.

Q. *Do the various contractors have representatives here in Los Angeles?*

A. Some of them do.

Q. *On a permanent basis?*

A. Some of them do and some of them do not. But you must remember that there is a tremendous amount of interaction to technical meetings so if you look at any given time you will find WDD/RW buildings full of contractors' representatives. This makes for excellent inter-communication between RW and all major contractors. Basically, we were a little surprised to see how well it worked out ourselves.

Q. *Is there a good deal of travel involved?*

A. Yes, there is a great deal of travel, but this is unavoidable. There is an attempt to arrange meetings and other communications for efficiency. We have perhaps made advances in communications on large projects. It is a problem—always will be when things have to be large and spread out. We have the best organizations in the country and their top technical management are good at communications. These people are developing unusual skill at this; the teamwork is almost exciting to watch.

Q. *Do you anticipate that in the future you might go to closed circuit television conferences?*

A. Actually the communication of words and numbers is much more important than the communication on a visual channel in our work. So that while I have no doubt that years from today, in setting up a major project that is widespread and of an urgent crash nature, one would probably employ television nationally to an elaborate extent. I don't think we are going to take time off to inject it into our system now.

Q. *Do you consider this responsibility to be a great personal challenge?*

A. You see I feel that we are part of a large team getting a big job done. I would guess in other words that each man in his own way, here and with the various contractors and in the military; each one of them finds what he has to do on the job is a challenge. And each one of them is quite cognizant of the fact that he needs to get his job done or it can be a significant blow to the project.★

...I feel we are part of a large team getting a big job done... get the job done or it can be a very significant blow to the project...

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Astrionics

By Henry P. Steier

SAN FRANCISCO—Fastest growing area for the electronics industry lays within a 100 mile radius of this hilly city. Single level, "California style" buildings for small electronics firms, and for Eastern firms opening branches in the area are being put up at a great rate for leasing. Together with the leased buildings many firms also lease the electronics test gear and machine tools for R&D and manufacturing.

Old established firms in the area like the Hewlett-Packard Co., Eitel-McCullough and Ampex Corp. which are noted for the high quality and flexibility of their manufacturing operations are expanding rapidly. Admirably suited to meet demands on the electronic industry, many firms are planning complete moves of entire facilities to new and bigger buildings or additions to existing ones.

Ampex Instrumentation Division business has jumped from $12 million in fiscal 1955 to $19½ in 1956. Big percentage of tape recorder instrumentation business is in the missile field. Tape systems for aircraft flight evaluation and engine tests have been growing in use, and for missile telemetry uses promises to be even greater.

Operating without any competition in its specific field the company has doubled its personnel in the past year. One reason is new use of Ampex tape systems in hypersonic missiles. Range and radio transmission problems in ICBM test vehicles are being met by recording the data on vehicle-carried tape recorders. Ampex officials will not say how tape is recovered or *if it is.*

One theory is that data is played back during slowest moving part of the missile re-entry flight period. In any event, the firm's laboratories are swarming with ICBM "brass" these days.

•

IRE NATIONAL CONVENTION, 1957—The big show and convention drew 50,000 registrants this year. With 800 exhibitors showing their wares in the New York Coliseum for the first time everyone agreed it was the most pleasant, informative and comfortable show ever.

Everything was new, from the booth displays to the people manning them. Especially noticed was the high technical competence of company personnel who answered questions about the companies' products. Complaints, mounting over past years, that booth personnel were apparently only there to guard the booths were not heard.

Something else new was a complete morning and afternoon session on astrionics. Recognizing the new problems being faced in telemetry and remote control for long range missiles, and space ships a symposium on this subject was a feature of the Convention. The other session was a symposium on techniques for data acquisition and handling in the missile field which emphasized that newest hope for rapid missile data handling-digital systems.

Latest look in booth displays was RCA's calm-looking reflection pool around one corner of the display. The pool soon turned into a "wishing well." Passing engineers soon had the bottom of the pool covered with shiny copper pennies tossed in for who knows why. One joker, however, had tossed in a General Electric Co. medallion which looked like a silver dollar at first glance.

AiResearch servo-controller for a pilotless guidance system

Simple servo-amplifier...actuator system achieves maximum speed of response with high stability

Because most missiles and drones are self-destructive, it is important that the components in their guidance systems be both highly accurate and dependable and be producible in quantity at low cost. The AiResearch servo-controller meets the above requirements.

It operates as follows: an AiResearch servo-amplifier weighing less than .7 of a pound amplifies electric signals from an inertial guidance source and converts them to command signals. These in turn are transmitted to an AiResearch electrically-powered light weight linear actuator which adjusts control surfaces of missile or drone to maintain a predetermined course.

The servo-controller can operate from either a DC or AC power supply. It can also be designed to take signals from celestial, telemetering or pre-programming sources to maintain or readjust the course of its pilotless air vehicle. It is another example of the AiResearch Manufacturing Division's capability in the missile field.

Inquiries are invited regarding missile components and sub-systems relating to air data, heat transfer, electro-mechanical, auxiliary power, valves, controls, and instruments.

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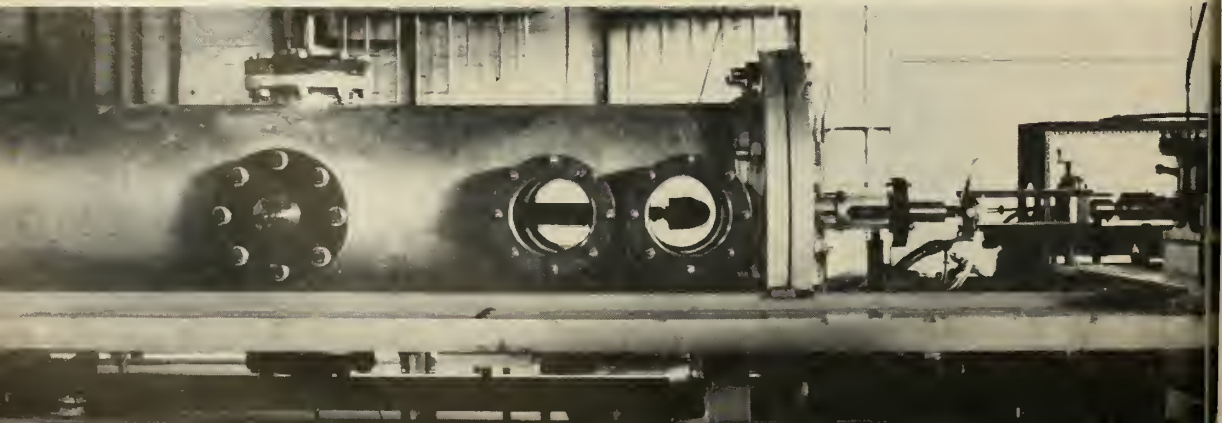
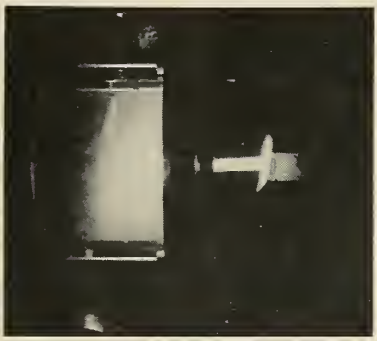
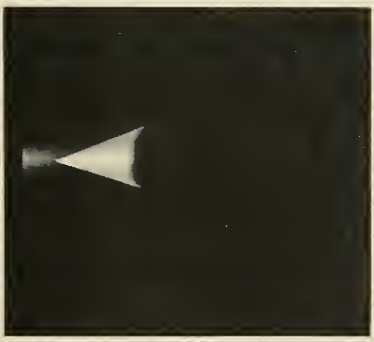
To Put the Sun to Shad

The melting, spalling test cone above provides a vivid demonstration of the problem of high-speed reentry into the earth's atmosphere. Operating in vacuum chamber this water stabilized arc produces a flow of atomic vapor with temperatures exceeding those of the sun's surface. Developed jointly by General Electric Company's Missiles and Ordnance Systems Department and the University of Chicago, this unit using a one-quarter-inch graphite electrode is at MOSD's Philadelphia Aerophysics Laboratory. Below, a medium drag-to-weight ratio nose cone is ready for test. Note equipment's small size, simplicity.



o the right are a variety of test shapes and aterials under test. With the exception of vo in the block of four (pointed cone and bolie hat) all of the runs on this page are air. Notice the tendency to burn as well as elt, sublime and spall. This unit is powered y four electric welding arc generators shown the picture immediately below. Larger units ow being built will produce temperatures of 0,000°K, and will require 10,000 volts d.c.





ne photograph at the bottom right of this age shows MOSD's water stabilized arc, or lasma jet as it's sometimes called, at about alf its actual size. A major advantage of his equipment is that testing conditions can e maintained for several minutes consecuvely. Heating rates from 2000 to 6000 BTU er square foot per second have been atained with much higher rates in prospect. or further information see Aerophysics, this sue, and the news section of m/r for March.

U. S. TIME GYROS IN CONTROL

The development and production of sub-miniature precision gyroscopic type instruments are exacting problems. These problems can only be solved by combining the skills of creative, seasoned research development and production engineers within the framework of an organization long experienced in the problems of precision instrumentation.

Important example of U. S. Time's present role in the gyroscopic field has been the volume production of sub-miniature precision rate gyros. More than seven thousand of these precision-built rate gyros are currently being used in guided missiles, antenna stabilization systems, autopilots, damper systems and stable platforms. The performance characteristics of these rate gyros can be modified to suit your specific requirements.

U. S. Time's new enlarged research staff and facilities are engaged in research, design and development of miniature precision instruments—instruments to withstand and perform under the severe environment of supersonic aircraft and missile flight.

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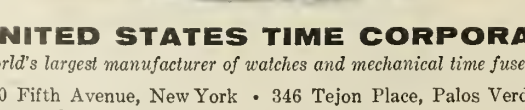

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Aerophysics

By Seabrook Hull

A new science—heliodynamics—may result from tools now being developed for studying ICBM heat transfer rates.

Within 12 months so-called plasma jets will be in operation capable of producing temperatures on the order of 50,000°K and stream flow velocities of Mach 15 and up. Inherent in these devices will be heat transfer rates in the range of 10,000 BTU per square foot per second and an ionized gaseous environment "seen" heretofore only through celestial spectrographic analysis. The equivalent black body surface temperature of the sun is about 6,000°K, 50,000°K would be found 600 miles below the sun's surface.

ICBM reentry ballpark figures are 6,500°K and 1,000-to-3,000 BTU, depending on nose cone design and construction. On the same dependence, reentry speeds range up and down from Mach 20.

Both Giannini Research Laboratory and GE's Missiles and Ordnance Systems Department, in cooperation with the University of Chicago have recently announced successful plasma jets. Using relatively small electrodes and "moderate" power sources, temperatures over 14,000°K and heating rates of 6,000 BTU have been achieved. Flow rates have ranged from subsonic to moderately supersonic. In both cases, arcs have been water stabilized.

MOSD, however, plans to complete construction by year's end of a 10,000 Kw arc using a three-inch electrode. Plans are also under way to use liquid air stabilization. Extreme temperatures and flow rates are anticipated. In addition liquid air, when vaporized and ionized by the arc into a plasma, will more closely duplicate actual reentry environment. The 10-to-15% carbon vapor concentration that results from electrode disintegration is not considered to be particularly troublesome.

The plasma jet is still a little-known device. One problem is how to reduce temperature without cutting Mach No. Others involve selection of components to withstand temperatures for protracted running times—several minutes. In one case a graphite electrode drooped; the brass fitting dripped away. These problems, however, are not considered troublesome since peak temperatures occur at the nozzle or beyond.

Similarly, plasma jet potentials have only been suggested. Consisting of charged particles they can be affected by magnetic and electric fields. A study plan is under way to appraise it as the driver section of a hypersonic wind tunnel. Its real benefit, however, may lay in its yet-to-be-developed usefulness in the basic study of matter. In part it duplicates conditions within the sun, results in material states, such as $C_3 7$, never before found on earth. As a basic research tool its redevelopment at this time amounts to a major technological break-through.

•

For aerodynamic study of ICBM reentry problems, GE-MOSD has constructed an expansion throat at the end of the six-inch shock tube at its Philadelphia Aerophysics Laboratory. This device will permit study and optical observation under what amounts to full-scale conditions—with large enough models that the scale effect of the atmosphere no longer need be taken into account.

A check of the state of the reentry nose cone art reveals: (a) it's still highly classified; (b) research may be producing as much new confusion as new answers and (c) though there's still a lot to be desired, it won't be the nose cone that holds up production of operational ballistic missiles. One problem is that some materials that show promise in one test device, pack in in another. Thus the usefulness of plastics, for example, still remains somewhat in doubt. Another problem appears to be how to prevent the reentering warhead from tumbling. Meanwhile, current designs still heavily favor the high drag-to-weight ratio concept.

Career News for Engineers!

Flight Tests are under way on one of America's most important defense projects:

The Navaho Strategic Missile

Artwork based on Official U.S. Navy Photograph

The results are secret—but this much can be told. A test vehicle designated the X-10 has gathered new aerodynamic and electronic information which will help to speed progress on the SM-64 Intercontinental Strategic Guided Missile.

The opportunity—and the privilege—to implement this revolutionary data is yours.

Twenty-eight-year-old Army vet **WILLIAM T. SCHLEICH** was graduated from Georgia Tech in 1952 with a BSAE. He joined North American as a junior engineer the same year. Seven months later Bill was promoted to aerodynamics engineer for the Navaho missile program. He was appointed Supervisor, Stability and Control Unit in October of last year. With the help of North American's Educational Refund Plan, he received his MSAE from USC. Bill and his wife are hi-fi enthusiasts and have a sound system built into their Whittier, California home.

If you accept this challenge you'll be solving tomorrow's problems—today. Here facts are collected fresh daily. If yesterday's yield proves inconclusive you'll approach the problem from a new direction. You'll travel new paths and develop new inventiveness. And you'll be guided to each breakthrough by the world's best-informed missile authorities—your own associates.

One example of the new hardware evolving from this creative engineering effort is a fully transistorized electronic commutator. This instrument increases the information-relaying capabilities of the missile's telemetering system by commutating 27 outputs at speeds of approximately 100 cycles per second. It was developed by the Flight Test Instrumentation Group.

North American's Missile Development Division is a major center of missile activity—and a pioneer in the field. As far back as 1948 its first test instrument vehicle was fired from a launching platform. Today North American has complete weapons system responsibility for the Navaho—and its test program is being conducted at the Air Force's long-range missile proving ground which stretches more than 5000 miles across the Caribbean and far into the South Atlantic.

LYLE C. BJORN has lived aviation all of his life. As a high school boy he built a glider modeled after the Wright Bros.' first flying machine—flew it from ski jumps near his Utah home. He studied engineering at Utah State and earned his BSME degree from the U of Wyoming. Lyle joined North American in 1951 and is now Group Leader, Field Test Operations at the Missile Test Facility, Patrick Air Force Base, Florida. He lives with his wife and three children near Cape Canaveral where he is an active leader in Cub Scouts.

If this sounds like the kind of career-opportunity you've been looking for—write us today. We promise you a working climate that stimulates personal growth and rewards it with responsibility, professional recognition and material benefits limited only by your own ability. Further, you can continue to grow academically with the aid of our Educational Refund Plan—and some of the nation's finest universities are nearby.

Let us know what kind of creative engineering interests you. (Please include highlights of your education and experience).

CONTACT: Mr. R. L. Cunningham, Engineering Personnel Manager, Dept. 495-MAR-42
Missile Development Division, 12214 Lakewood Blvd., Downey, California.

NORTH AMERICAN AVIATION, INC.

A Boom Town Bursts Its Seams

. . . nothing adequate but bars and jobs in COCOA

by Don MacDonald

WHEN THE DEFENSE Department in 1947 chose to reactivate a dormant Naval air station now known as Patrick Air Force Base for potential use as a guided missile test center, it displayed excellent geographical logic. There was no better spot on Florida's East coast from which to pepper the Atlantic with untried rockets sure to be occasionally erratic.

However, as was true so often during World War II, military practicality overshadowed the inevitable need for housing thousands of scientists, engineers, technicians, and their families recruited for the program. The result, 10 years later, is Alamogordo number two—a bleak little boom city called Cocoa.

The initiative of its grocer founder, a man named Willard, can be judged from the fact that when postal authorities in 1822 rejected his first choice of names—Indian River City—as too long, he glanced around his shop, spotted a case of newly arrived beverage, and so the town was born.

Until the advent of Patrick, Mr. Willard's inertia carried through to his descendants. Even judged by Florida standards where a potential alligator farm can be sold for $500 an acre, Cocoa could not claim its fair share of tourists or retired folk, much less entrepreneurs who could contribute more solidly to the area's economy. Major private industry was and still is citrus farming, although breeding Brahman cattle—which thrive where other types fail—is fast becoming a local specialty.

None of this is Cocoa's fault as such. The scenery is like any other part of East coast Florida—flat, palmetto-studded sand, moss-hung live oak, and an occasional palm. The beach is one of the best for swimming. Fishing, especially for salt water trout, is tops. Being roughly at Florida's coastal midpoint, Cocoa's climate is never too hot, and seldom chilly. January averages a comfortable 62 while August is shirt-sleeve moderate at 82 degrees.

As all m/r readers know, jobs go begging in Cocoa. Any engineer who can define ICBM just about has his choice of the Air Force or the numerous aircraft and components manufacturers of the area. Pay scales for scientists, engineers, and technicians are well above normal Florida levels in non-critical industries, just as they are for the trades. Permanent residents within a 100-mile radius complain that no one will fix their leaky faucets nowadays—all the plumbers went to Cocoa.

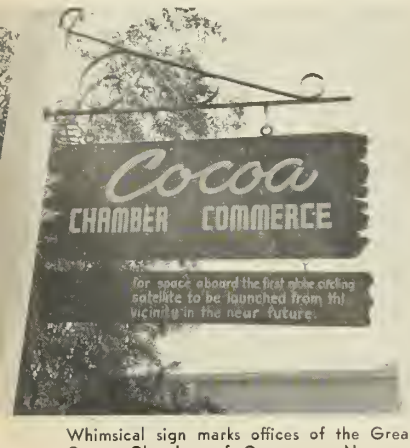
Anyone accepting a Cocoa job should insist on per diem payments until he settles his family. Typical arrangement now being offered by major employers includes seven cents per car mile from point of hiring plus $7.50 per travel day (350 miles) for the employee, $5.00 for his wife, and $3.50 for each child. Upon arrival, the daily payments are continued up to a usual maximum of 30 days, during which period the employee is supposed to be hunting for permanent housing.

Local motels are well aware of this scale. One newcomer interviewed reported paying $93 a week for a one-bedroom and kitchenette unit to temporarily put a clean but certainly not AAA rated roof over the heads of his small family. Another older hand stated that if he had it to do over again, he would insist on an expense account covering the cost of feeding and sheltering his family over and above a deductible $200 per month. "This," he snapped, "should continue indefinitely until a family finds acceptable perma-

Waterfront development is one of many planned by Gus C. Edwards, local real estate mogul. This picture, taken in February 1957, does not indicate much progress towards solving Greater Cocoa's housing problem.

Enlightened solution by Convair benefits only its own employees, will ultimately give 350 families waterfront homes on easy payments.

New Central Brevard National Bank, locally built and capitalized, is one of few signs of Cocoa's sense of industrial responsibility.



Whimsical sign marks offices of the Greater Cocoa Chamber of Commerce. Newcomers would like less whimsy and more action.

nent housing at a cost bearing some logical relationship to its income."

"We've been here nearly a year," he continued, "and look at this place I had to rush into buying!" He pointed to his nondescript three-bedroom home standing in a row of dozens like it and went on: "It isn't even CBS [stands for 'cement block stuccoed,' a kind of construction unpopular with Florida's voracious termites], the lumber is green, and nothing fits. It cost me twice the $7,000 I could duplicate it for in Oklahoma City."

The most unfortunate Cocoites are those who must rent. If anything is available, which is not usually the case, a minimum rental for the home described above would be $150 per month without utilities or furniture.

Surprisingly, some of the worst gougers can be found in the ranks of fellow employees. Those who had been through the experience of Alamogordo and the like saved their money, came to Cocoa, purchased at least a duplex and in some cases a whole block of homes, and now make more money as spare time realtors than at rocketry.

The Daytona Beach News Journal, 80 miles up the coast, recently featured a series of interviews between one of its newshens and would-be Cocoa residents temporarily lodged in 36-inch conduits, thousands of which line the roads waiting to be installed as part of a new $7 million water system for the area. She found these people reluctant to respond to her questions in a civil manner, and unfortunately portrayed their plight as typical of the housing situation.

m/r's correspondent inspected many such pipes and could locate no one inside. Whether or not they had ever been occupied by humans is no true measure of the area's problem and how natives as well as newcomers are banding together to meet it.

There are those who claim that finding a house is easy compared to driving into Cocoa for Saturday morning's shopping. All traffic from the peninsulas funnels into a two-lane causeway, not even adequate in 1950 when the area's permanent population was 12,000. Now it is triple that.

All businesses except the numerous bars are geared to the past, although the inconvenience of trading with the local merchants is greatly softened by generally low prices for staple items. The one unfortunate exception is groceries. Chain super markets have, up until now, found land too expensive to move in in force.

The crowded condition, reminding transplanted New Yorkers of Macy's Basement on bargain day, is typified by the lone bank whose patrons have trouble finding elbow room in which to fill out their deposit slips. Fortunately, a new and more spacious bank has just opened.

No group in Cocoa is more aware of these detriments to happy living than the city fathers, led by Mayor Garry Bennett, an affable fish merchant and long-time resident. Bennett says: "Good housing and better business facilities are going up just as fast as local capital can provide the wherewithal. Greater Cocoa today is no different than any other boom area."

Bennett points proudly to his newly opened Central Brevard National Bank, an all-new institution located on land reclaimed from the inland waterway and fronted by a highway cloverleaf that will do much to relieve the congestion of traffic pouring into town from the peninsulas.

He cites the newly awakened social consciences of industries in the area. Convair, for example, has purchased waterfront property for an employee housing development that will ultimately take 350 families off the private real estate market by offering them fairly priced dwellings and even spreading the small down payment out in a company-carried second mortgage. Fairchild is planning a similar venture, and others will undoubtedly follow suit. On-base military housing for Patrick is already considered adequate.

Bennett has a right to point to a bright future. Even local entrepreneurs, such as Gus C. Edwards, are finally waking up and hocking their souls to put up decent dwellings to ease the strain as well as turn a legitimate profit. Building permits taken out in Cocoa alone jumped 10 times in value in the last two years. Somewhere in this number will be more and better places to live.

It could fairly be asked that since Patrick is not new, especially when time is measured at rocket pace, why hasn't something been done before? The answer lays partly in local inertia but mostly on the shoulders of the Defense Department, which has a habit of moving into peaceful backwaters and deserts around the globe without planning beyond its immediate needs. When satellite civilian industry follows, housing and attendant problems inevitably develop.

Their solution is too large and immediate a job to be practical for private capital. Cocoa could have long since been an oasis for its dedicated newcomers if Uncle Sam had seen fit to exchange just one B-52 for cinder block and stucco. ★

For a Hot Return

Three-stage reentry test vehicle as it leaves launching rail at NACA's Wallops Island, Va. First stage is an HONEST JOHN while second stage is a NIKE booster—both proven components and NACA favorites in high-rate heating studies. The missile's third stage is a solid propellant T-40 and is programmed to fire in a downward direction. Note the extreme low-drag-to-weight ratio configuration. This cone would be useful in studying the heating gradient back along the missile body, as when, for example, disassociation occurs at the vertex of the cone and reassociation near the tail.

Lockheed Aircraft Corp's. X-17 test vehicle cuts a grotesque figure in the still, moist predawn Florida air as it's readied for firing from Patrick Air Force Base's Cape Canaveral launching site. The job of the X-17 has been to approximate long-range ballistic missile reentry conditions. Velocities on the order of Mach 15 are accomplished by firing the final stage in a downward direction. Data thus gained will contribute to development by Lockheed of the Navy's Fleet Ballistic Missile, POLARIS, as well as to the Air Force's two ICBM projects.

Consisting of a modified SERGEANT first stage, three encased RECRUITS as a second stage and a single RECRUIT third stage, the X-17 from a propulsion viewpoint is a Thiokol product.

Over 40 feet high and weighing six tons, the Air Force X-17 Reentry Test Vehicle is tilted into firing position by a device nicknamed "strongback." Note the telemetry tower and antenna in the foreground. Ideally, the X-17 is fired in such a way that its third stage hits the Atlantic while over the continental shelf, enabling the test nose cone to be recovered.

The Spectacular X-17

The spin stabilizers fire for only a brief moment before they burn out and are flung free (see picture to far right). The X-17 test program is being conducted by Lockheed as part of the Air Force ballistic missile program under the supervision of the Air Research and Development Command's Western Development Division. The knowhow cannot but be helpful in working with the General Electric Co's. Missiles and Ordnance Systems Department to whom Lockheed has given a contract for POLARIS nose cone development.

NACA's 8000 MPH Rocket

Carefully protected from the weather by a polythene bag, a blunt high-drag-to-weight ratio nose cone awaits launching for 8000 mph reentry test. This rocket test vehicle consisting of an HONEST JOHN first stage, NIKE booster second and third stages, RECRUIT fourth stage and a Thiokol T-55 fifth stage is the latest of NACA's hypersonic reentry rockets. It is shown about to be launched from NACA's Pilotless Aircraft Research Station, Wallops Island, Va. The vehicle attains its record speed by firing the last three stages after the rocket has "gone over the top." In previous similar work, an NACA four-stage rocket attained a speed of Mach 10.4 (6864 mph) and an altitude of almost 200 miles. The speed of this five-stage vehicle has never been officially announced. Aside from telemetered data, the missile's performance is monitored by visual, electronic and special photographic aids. From the first through the fifth, companies responsible for the various stages include Douglas Aircraft and Emerson Electric (HONEST JOHN); Ingersoll Div., Borg-Warner Corp. and Goodyear Aircraft (NIKE boosters); and Thiokol (RECRUIT and T-55).

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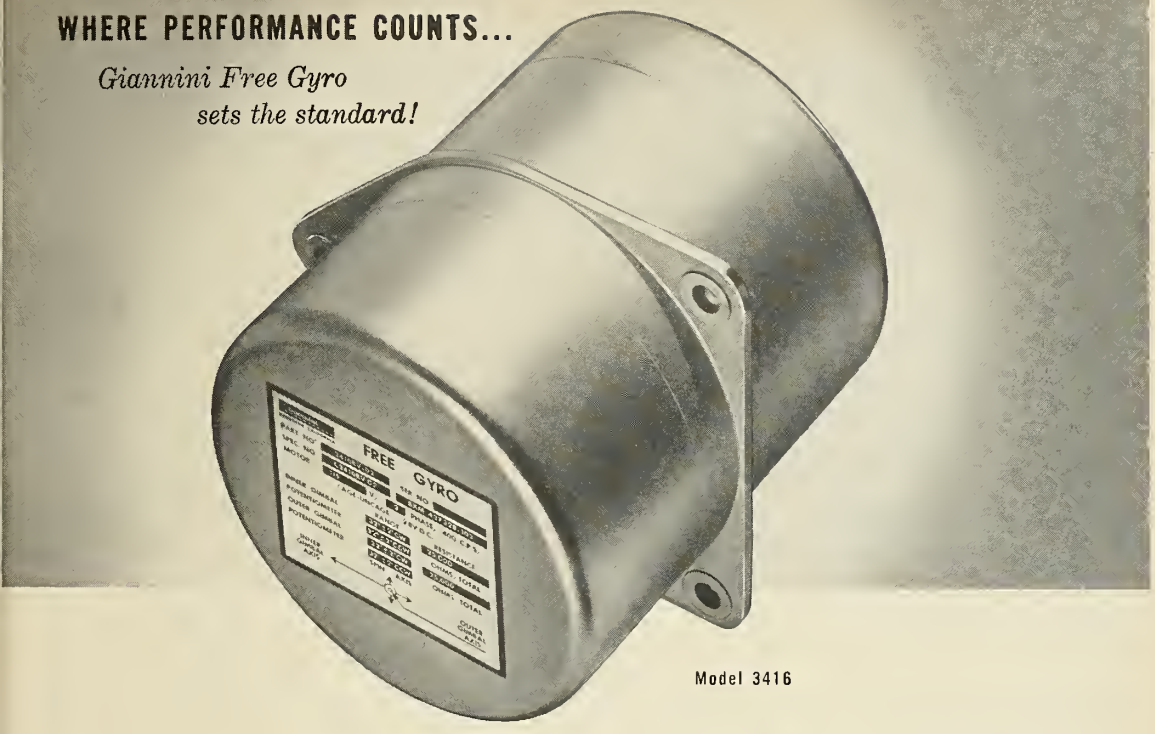

Model 3416

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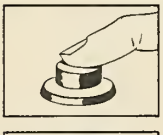

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Circle No. 28 on Subscriber Service Card.

Propulsion Notes

By Alfred J. Zaehringer

Ionization as the result of the combustion of fuels at simulated altitudes in oxygen was studied by the Naval Research Lab. At an instrument frequency of 24 x 10^9 no attenuation was found for hydrogen sulfide, carbon disulfide, or hydrogen. Ionized fractions: about 10^{-4} for acetylene, ethanol, and gasoline; and 10^{-5} for ammonia. These figures were about 6 times greater than predicted.

Aerojet has been granted a patent (US 2,771,739) for suspensions of lithium, beryllium, boron, aluminum, magnesium, phosphorous, potassium, or sodium in liquid hydrocarbons such as gasoline. Oxidants are WFNA and RFNA. Use is for hypergolic bipropellant rocket systems.

Burning rates of solid propellants are said to be increased 100-200% by addition of hydroxylamine perchlorate in a new patent (US 2,768,874). The crystalline compound is hygroscopic, decomposes at 120°C, and can be initiated by impact of a 2 kg weight falling 15 cm.

NACA has released its findings of research on nitric acid systems. Lewis Flight Propulsion Lab has found that RFNA with 19% N_2O_4 and 3% water gave the best low freezing point and short ignition delays. Some 17 acids were tested. Triethylamine made for the best blend of aromatic fuels down to —76°F. At lower temperatures, 30% ortho-toluidine in triethylamine gave the shortest ignition delay with RFNA. In general, it was found that ignition delay decreased with increased oxygen content and decreased with temperature increase.

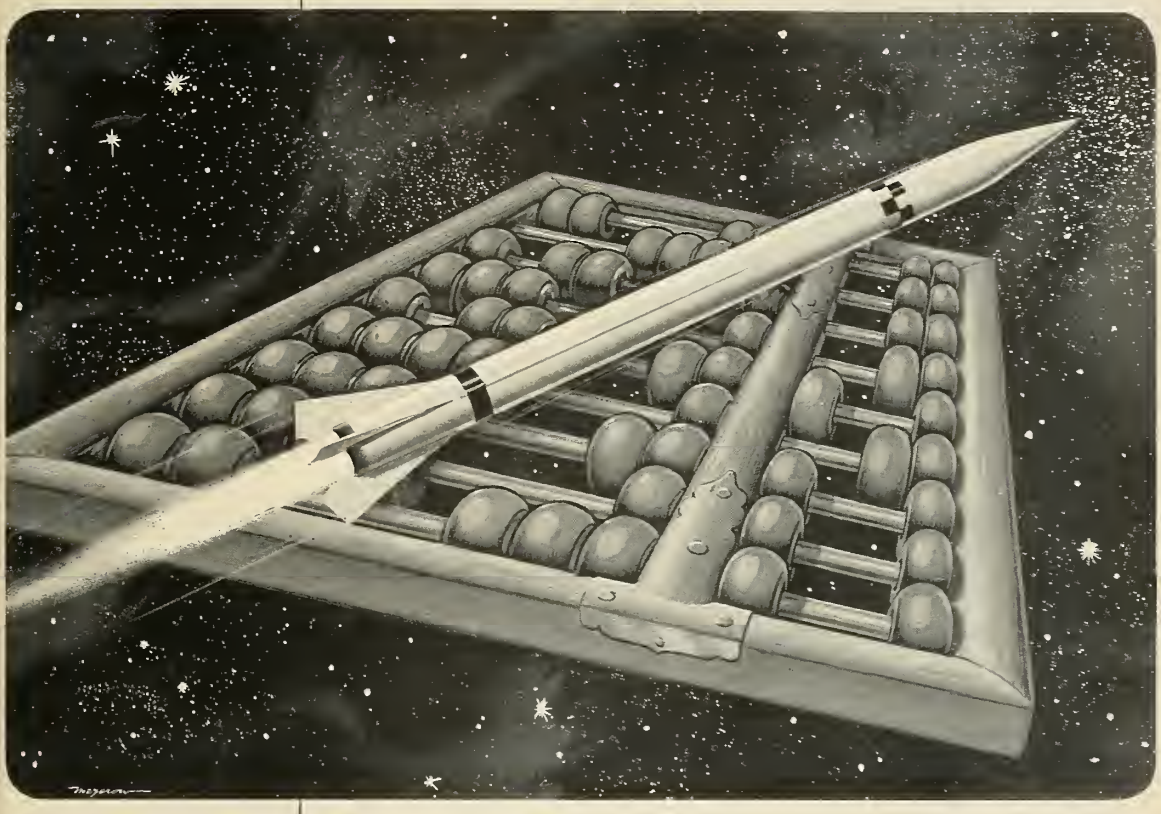
High energy Aeroplex solid propellant (Aerojet) has an exponent of burning rate only slightly greater than ammonium nitrate-base propellant. Typical burning rates (in/sec) over a chamber pressure range of 500-2,000 psia: ammonium perchlorate, 0.6-1.4; potassium perchlorate, 0.4-1.2; mixed ammonium nitrate and ammonium perchlorate, 0.1-0.18; ammonium nitrate, 0.04-0.08. Aerojet also reports a "medium energy" ammonium perchlorate propellant that plateaus at about 0.3 in/sec. The burning rate is constant from 1,000-2,000 psia.

Hydrogenation of unsaturated polycyclic hydrocarbons gives jet fuels with higher heats of combustion than conventional fuels (US 2,765,617). Monsanto claims a typical heat of combustion of 136,800 BTU/gal.

Patents were granted to Phillips Petroleum for fuels in liquid propellant systems. Piperidine and substituted piperidines are claimed to be hypergolic with acids, peroxide, nitrogen tetroxide, oxygen, or ozone (US 2,771,737). Another (US 2,769,304) is concerned with hypergolic fuels of low freezing point and short ignition delay. The fuels are composed of 10-87% volume pyrrole and 13-90% volume of ethylenimine and other oxidizers. Combustion stabilizers are chlorides and naphthenates of iron, zinc, or cobalt.

Sign of the times: Olin Mathieson made its first tank car shipment of hydrazine recently from its Lake Charles, La. plant. Commercially available since 1953, deliveries have all been in small lots.

American Rocket Co. is entering the liquid propellant field with the introduction of a new-type, high-energy monopropellant. It is a liquid with very low freezing point and high boiling point. Other features: very high density, ease in handling, low cost. The new material has been under development since late 1956.



Computers for Missile Guidance

The Jet Propulsion Laboratory is a stable research and development center located north of Pasadena in the foothills of the San Gabriel mountains. Covering an 80 acre area and employing 1700 people, it is close to attractive residential areas.

The Laboratory is staffed by the California Institute of Technology and develops its many projects in basic research under contract with the U.S. Government.

Opportunities open to qualified engineers of U.S. citizenship. Inquiries now invited.

The abacus is a very ancient and useful computing device in the hands of a person versed in its use. However, the requirements for speed and accuracy in computing the functions necessary for modern missile guidance have obsoleted all man-operated devices, creating a need for computing systems previously considered impossible.

The Jet Propulsion Laboratory pioneered in the application of analog computing techniques to missile guidance systems and, to maintain its leadership in this field, constantly searches for new techniques that will make optimum use of magnetics, transistors and other modern computing components.

The successful application of these techniques to missile systems under development requires designs that will perform properly under the adverse environments found in today's guided missile. A degree of accuracy and extreme reliability, previously thought possible only under controlled laboratory conditions, is now a reality because of improved instrumentation techniques and development of highly accurate instrumentation equipment. This has been successfully applied to development of special purpose equipment for missile guidance.

The JPL guidance computer group, now engaged in research and development work encompassing electronic, mechanical, electromechanical and servo computing systems and their application to missile guidance and control, now offers attractive opportunities for truly creative engineers interested in advancing the state of computer art.

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Moving Averages Police Solid Rocket Output

At Air Force Plant 66, McGregor, Texas, Phillips Petroleum Company, through its Rocket Fuels Division, is engaged in the development and manufacture of solid propellant rockets of various kinds and sizes. Several rocket types are nearing the qualification stage. The M15 has progressed through the stages of laboratory experimentation, pilot plant production, and qualification, and is now in large scale manufacture for service use. This unit is powered by a rubber-base, extruded, solid propellant grain.

Statistically sound sampling plans are in use for the acceptance of incoming chemicals and metal parts. A relatively small variation in a chemical material from specifications may result in either expensive difficulties in processing or rejection of propellant. A change of source in certain materials may require process alterations. Quality control in processing is equally essential since even such variations as mixer-to-mixer differences in intensity of mixing must be considered. Wherever sampling or testing is expensive or destructive, inspection by variables rather than by attributes plans reduces cost.

Attributes inspection is, of course, inspection for the presence or absence of a certain characteristic or attribute.

Variables inspection is the actual measurement and recording of a quantitative value, such as 2.93 inches. This inspection yields data telling not simply whether a dimension or quantitative characteristic is within specification, but also how far it is inside or outside of the specified limits. Equal assurance can be attained with a much smaller sample through the use of variables sampling plans than through the use of attributes plans.

For ballistic acceptance of the M15 JATO, consideration was first given to lot-by-lot acceptance using variables sampling plans. A lot, for purposes of this paper, is a group of consecutively manufactured rockets produced under the same set of processing procedures from materials having no significant changes affecting end performance. Such a lot may be considered as homogeneous in nature, with no abnormal variations in any performance characteristic from the lot average for that characteristic. Ordinary lot acceptance would require that each lot be completely manufactured prior to selection of random samples to be fired. This requirement led to one of two alternatives:

Either lots had to be kept to a minimum size (100 to 300 JATO units), to allow for minimum storage and delay prior to acceptance, with the disadvantage that variables sampling would lose much of its sensitivity and require more destructive testing, or larger lot sizes and more storage were required. Disadvantages would be the cost of storage facilities and the increase in delay in information from acceptance firings.

Neither alternative was very satisfactory. After a study of the problem, it was decided that maximum sensitivity to trend changes in ballistic parameters, greatest economy, and minimum delay of information to manufacturing personnel could be achieved by adapting a variables fractional continuous sampling plan for ballistic parameters, as explained in the following paragraphs. The basis for this type of sampling plan was presented by Harry G. Romig in a paper entitled "New Statistical Approaches in Aviation and Allied Fields," presented at the Aircraft Quality Control Conference at Dayton, Ohio, in November, 1953.

The plan as adapted for M15 JATO calls for a lot to be one month's production, unless some change in the process occurs requiring a change of lot designation. For acceptance and identification purposes, a one-month production lot is broken into sublots representing the production of one eight-hour shift. Ballistic acceptance sample units are chosen from these sublots. Every precaution is taken to insure a completely random choice. Control is maintained of the calibration of the instruments and test equipment used in firing the sample units, and of the conditioning temperature of the units prior to firing.

Acceptance sampling is carried out on a fractional continuous basis through the use of a three-point moving average for each ballistic parameter. In other words, the ballistic parameters resulting from every acceptance firing are respectively averaged with the same parameters from the preceding and succeeding firing. Firings are made in equal numbers of units conditioned to the three required temperatures, hot, cold, and normal; and all ballistic parameters are adjusted to represent the firing of a unit conditioned at normal temperature. Acceptance or rejection is on the following basis:

1. From the production of the first sublot under this plan, three production units are selected at random and fired, one at each of the three temperatures. Adjusted values of all ballistic parameters must individually meet the limits specified and fall within upper and/or lower reject limits.

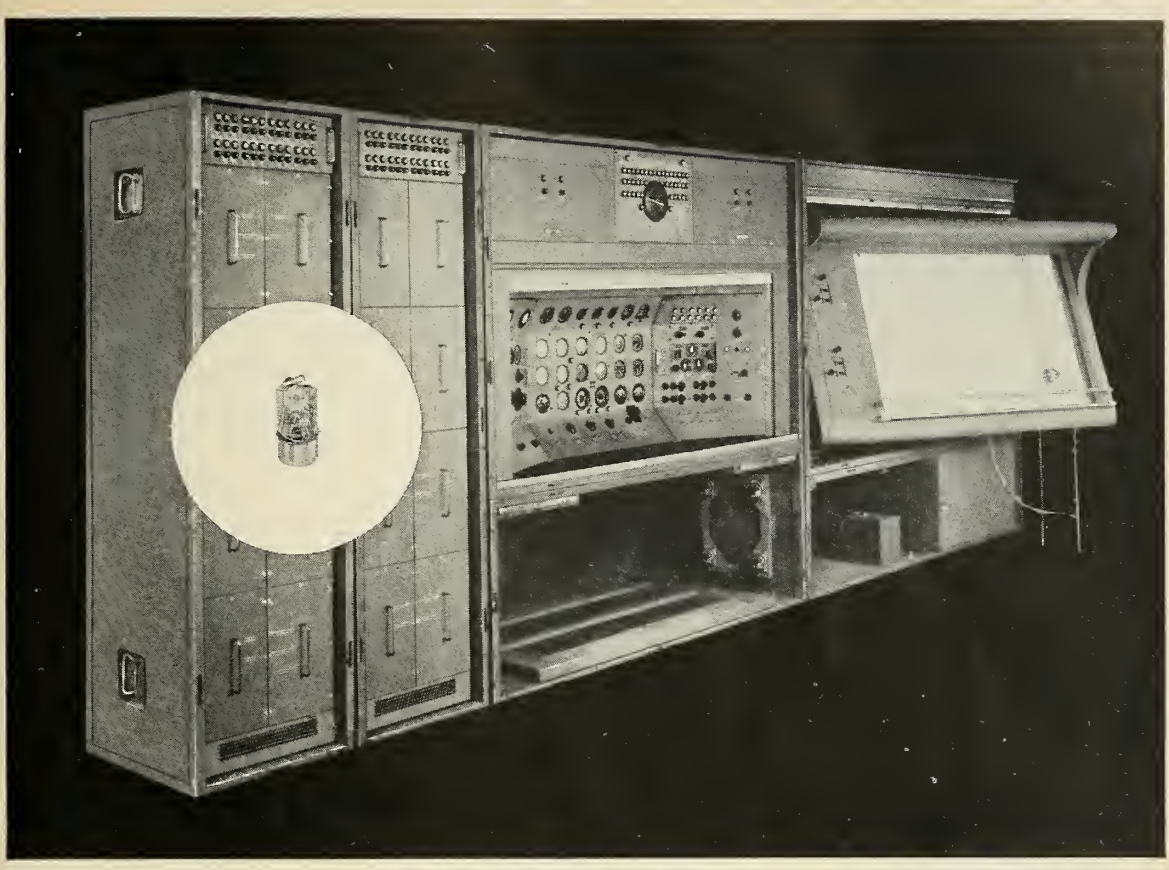
2. If Paragraph 1 is met, then one per cent of units produced (and not less than one unit), randomly selected from each sublot, are fired, and a moving average maintained of the results of the last three firings. This moving average must remain within limits for averages, and individual parameter values for the last firing must also remain within acceptable limits.

3. If an individual firing of a sample unit yields any ballistic result which fails to meet limits for individual units, then the sublot represented by that unit is rejected. If the moving average for any parameter fails to meet limits for averages, then the three sublots represented by that average are rejected.

4. Alteration of firing temperatures is done in such a manner that units from any one eight-hour shift will not always be fired at the same temperature.

It has been apparent from the results to date that the fractional continuous variables acceptance sampling plan for ballistic parameters of M15 JATO has been much more feasible than lot-by-lot variables sampling. It has been more economical, since it has resulted in much less than half the number of firings necessary to yield the same assurance using a small lot variables sampling plan and has made unnecessary any provision for additional storage capacity for large lots. It has been more rapid in furnishing usable information and more sensitive to defective material than would lot-by-lot acceptance of small lots of units.

One area of caution regarding the use of this plan concerns the greater degree of sensitivity afforded by the moving average for the various parameters. It is quite possible, due to a slight shift in the mean for any certain parameter, for one or more sublots occasionally to be rejected when in actuality all units in the sublot are within individual limits. This problem cannot be considered a defect in the sampling plan, since the sensitivity of the moving average is desirable. However, it does necessitate the recognition by the procuring agency, as well as the manufacturer, that sublots which are rejected by a moving average found slightly outside limits, should be evaluated through additional firings.★



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Reinforced Plastics for Rocket Applications

Reinforced plastics are being used not only in secondary, but in primary rocket structures as well where successful performance is essential. For short, one-shot operations their temperature tolerance often exceeds that of their metallic counterparts. The unique service conditions for rocket-motor hardware often necessitate a search for unconventional materials or the adaptation of existing materials to an unconventional use. Adiabatic flame temperatures of several thousand degrees fahrenheit for relatively long exposure periods, are routine requirements for rocket-motor and missile manufacturers. High gas velocities at these elevated temperatures often are encountered. The thermal properties of reinforced plastics make these materials desirable when compared to metallic structures. Furthermore, combinations of reinforced plastics and metals can effect significant weight reductions.

Here are just a few of the rockets and missiles shapes capable of being fabricated of reinforced plastics, which promise increased flexibility and economy.

Founded in 1942 by Dr. Theodore von Karman, the Aerojet-General Corp. has expanded its activities to include almost all possible applications of rocket power. Recognizing the potential of reinforced plastics in producing lighter weight, more efficient, or otherwise more suitable structures, Aerojet management encourages continuing activities in development of novel designs involving reinforced plastics. Some of these developments are finding their way into non-rocket applications.

George Epstein, J. W. Ederhardt, Jack Goldberg and H. A. King of Aerojet recently presented a paper, "Reinforced Plastics for Rocket Applications," at the Annual Conference of the Society of the Plastics Industry. This article extracts that paper.

Glass reinforcements are used primarily in conjunction with polyester, epoxy, elevated-temperature-resistant phenolic, and silicone resins. Asbestos reinforcements, refractory powders, and other filler materials are also used. Fabrication techniques include layup, matched-die molding, filament winding, casting and adhesive bonding.

The advantages of reinforced plastics in rockets include: high strength-to-weight ratio; desirable thermal insulating properties; ease of fabrication into complex configurations; use of non-critical materials; wide versatility in selection and formulation of resin-curative-filler (reinforcement) systems; low-cost tooling and fabrication techniques; resistance to various environments, e.g., moisture, sea water, weather, fungi, solvents and fuels, acids and alkalies; non-magnetic properties; excellent electrical properties.

Reinforced plastic structures are employed in rocket applications for various temperature exposures. Polyester and epoxy resins usually are used for service at low temperatures (between −65 and + 200°F). For service at intermediate temperature ranges (200 to 500°F), and at high tempera-

tures (500 to 1000°F), heat-resistant epoxy, phenolic, triallylcyanurate-modified polyester, and silicone resins are employed, with silicones usually limited to long-duration or repeated exposures. Reinforced plastics also are used when exposure is required for extremely short durations (several seconds or less) to temperatures of over many thousands of degrees.

Aerojet developed the modified-epoxy-resin formulation employed in glass-reinforced-plastic liners for insulating nozzle adapters in rocket motors during operation of a safety device. Service conditions require exposure to temperatures of over 3000°F for several seconds in a high-velocity gas stream. Fabrication costs of this structure are approximately one-half those for a "conventional" heat-resistant phenolic resin.

A JATO unit contains several reinforced-plastic components. The Tee baffle is subjected to gas temperatures of approximately 3800°F and gas velocities up to several hundred feet per second for a duration of approximately 15 seconds. In addition to providing a thermal barrier, this phenolic-resin, glass-fabric-reinforced structure suppresses instability which might occur during combustion of the solid propellant. A reinforced-plastic cone is also used in this rocket, serving as a safety-diaphragm deflector. An external exhaust deflector of glass-reinforced-phenolic-plastic employed with the JATO in order to confine the high-velocity exhaust jet and deflect it from adjacent aircraft surfaces. In a normal firing, the high-velocity exhaust gases

Cross-section of a rocket motor showing the increasingly important role being played by reinforced plastics.

are confined by the plastic part, which is capable of being used for several normal firings.

Honeycomb plastic sandwich was fabricated for a stabilizing-control-surface part on an advanced *Aerobee* sounding rocket. Elevated-temperature-resistant, reinforced-plastic skins, core, and attachment edges are joined with a heat-resistant structural adhesive. The leading edge of this sandwich part has a herring-bone pattern designed to provide optimum resistance to erosion during high-speed flight.

A number of the guided-missile warheads have made extensive use of glass-reinforced-plastic structures to take advantage of minimum parasitic weight and increased strength-to-weight ratio, and to provide versatility in design. Warheads using reinforced-plastic structures and adhesive-bonded-metal components have successfully withstood the most severe military environmental tests and, in many cases, warheads subjected to these tests have been completely usable when their metal counterparts would have been rendered completely useless.

Filament winding provides a means for obtaining the maximum strength-to-weight ratio in reinforced plastics by locating each strengthening filament of glass at its optimum position. Thus, if the structure is to be stressed in one direction only, all (or nearly all) of the filaments can be applied in such a direction as to counteract this force. Pressure spheres made this way have been produced in diameters from 1½ to 21 inches and varying in design burst pressure from less than 100 to over 10,000 psi.

Such spheres are used as pressure tanks in aircraft hydraulic systems, in missiles and rockets to pressurize liquid propellants, and high-pressure containers in general. Two 12 inch filament-wound spheres mounted in an *Aerobee* sounding rocket. This type of installation was employed in the widely-publicized "Firefly" project of the Air Force. Nitric oxide gas was contained at a pressure of 3000 psi and released at an altitude of 56 miles during upper atmosphere research investigations.

Plastics engineers in the rocket industry are pioneering in the areas of high temperature and high-pressure applications of reinforced plastics. Many of the accomplishments to date have been achieved primarily as a result of close cooperation between material suppliers, engineers, and fabricators. It is expected that continuing cooperation in the development of new materials and techniques will promote rapid expansion in the utilization of reinforced plastics in the rocket industry.

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Type	Input		Rated Output			Max. Altitude at Rated Output	Approx. Wt. Lbs.	Designed to Gov't. Part No.
	Volts	Amps.	Volts	Phase	VA Rating			
12128	27.5	1	26	1	6	35,000	2.2	AN3496
12126	27.5	2	26	3	10	35,000	2.3	E1615
32B21	27.5	3	115	1	20	50,000	5	—
MG-93	27.5	12	115/200	1 3	100 100	65,000	10	E5134
MG-54	27.5	22	115/200	1 3	250 250	50,000	17	E5109
12142	27.5	22	115	1 3	250 250	35,000	13	E1617
12143-1	27.5	22	115	3	250	35,000	13	—
12143-2	27.5	22	115	1	250	35,000	13	—
*32B15	27.5	22	115	3	300	50,000	14	—
32E01	27.5	35	115	3	500	50,000	26	AN-3533-1
32E00	27.5	51	115	1 3	500 750	50,000	34	AN-3534-1
MG-65	27.5	52	115/200	1 3	750 750	50,000	35	E52805-2
MG-61	27.5	126	115	1	1750	50,000	54	53C6767
1518	27.5	126	115	1 3	1500 1800	20,000	37	—
32E06	27.5	160	115/200	1 3	2000 2250	50,000	56	E1725
32E03-3	27.5	150	115	1	2500	50,000	58	53B6227
*32E03-8	27.5	160	115	1	2500	50,000	65	53B6227
*MG-77	27.5	150	115/200	3	2500	50,000	65	—
*32B49	27.5	160	115/200	1 3	2500 2500	50,000	65	E54807
MG-81	27.5	160	115/200	1 3	2500 3000	50,000	61	E1725
MG-95	27.5	160	115/200	1 3	2500 3000	50,000	58	E54807
32E09	27.5	160	115	1 3	2500 3000	50,000	60	—
32B27	27.5	285	115/200	1 3	3500 4000	50,000	76	—

*These inverters have magnetic amplifier "static" type voltage and frequency regulators.
NOTE: D.C. Input Voltage shown is nominal value of 27.5 volts, but all units are designed for 26 to 29 volt operation. Input amperes shown are rated at 27.5 volts input.

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engineering briefs

Expanding exotics: Callery Chemicals has broken ground on a $38 million plant that will grind out high energy boron fuels for the Navy. By 1958 the facility will produce a compound called "Hi-Cal" which was developed by Armour Research Foundation. Olin Mathieson is starting construction on a $36 million facility at Model City near Niagara Falls for the production of "Zip" chemical fuels for USAF and a smaller plant at the same site for the Navy. Meanwhile, tank car quantities of boron trichloride will be available by Stauffer Chemical at its Niagara Falls plant. Stauffer is also planning to produce other metal chlorides in a new $1 million expansion.

*

Marriage of propulsion and guidance looks near for Thiokol. The propellant firm recently acquired National Electronics Labs of Washington, D. C. Recently, Aerojet expanded its electronics operations (Avionics Div.) under an $880,000 program. Another propellant firm—Atlantic Research—is also in electronics and is marketing a line of transducers, amplifiers, and even a solid propellant strand burner.

*

Position of normal propyl nitrate is uncertain. After a recent accident, one service is considering abandoning its use. AMF is still said to be doing work on NPN and GE has come out with a pump to handle the nitrate. AMF is said to be going great guns on use of ethylene oxide—mostly APU's for the ICBM program.

*

Studies in the controlled thermal decomposition of cellulose nitrate may lead to clues in the complex combustion mechanism of double base solid propellants. Work at Aberdeen Proving Ground is being carried on with propellant type cellulose nitrate. In ignition and combustion at low pressures, a solid nitrated oxycellulose low polymer is obtained. At somewhat higher pressures a whole line of organic fragments resulted. Some HCN was also found at all pressures and is believed to come from residual solvent.

*

Developments in aircraft nuclear power plants and power reactors may usher in a new age of steam power for conventional aircraft. One firm is replacing the pile with a modern fuel combustor and uses compound vapor systems to run a closed cycle turbine. Now being investigated are water, ammonia, and isopropyl biphenyl.

Where do you belong in IBM Military Products?

Systems Design Engineer: Before his recent promotion, this man planned electronic digital computers through development and evaluation of logical configurations and electronic circuits. He used linear and pulse circuits employing transistors and other semi-conductors; evaluated test data from development models for speed, reliability, data processing capabilities. *Could you handle his responsibilities?*

Transistor Logic and Circuit Designer: Also promoted recently, this man formerly planned, tested and evaluated advanced electronic digital computer circuitry. He guided the building of original circuits through the development model stage. Other assignments in associated fields: advanced component development, specialized projects in ferromagnetics, optics. *Could you handle his responsibilities?*

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At the new plant and laboratory in Owego, N. Y., IBM designs and manufactures advanced airborne analog and digital computers for Air Force bombing-navigational equipment. At the new Kingston, N. Y. facilities, IBM builds the world's largest electronic computers for Project SAGE, part of our nation's giant defense net.

The electronic computer field offers one of the best ground-floor career opportunities today. Economic experts rank the electronic computer in importance with automation and nucleonics in growth potential. Sales at IBM, the recognized leader in the field, have doubled, on the average, every 5 years since 1930. Engineering laboratory personnel quintupled in the past five years. Future expansion plans offer even better opportunities.

As a member of IBM Military Products, you enjoy the stability and security of the IBM Corporation, plus the opportunity to progress in any other IBM division. Promotions open up frequently from continuous growth. The "small group" approach assures recognition of individual merit. Salaries are excellent and company-paid benefits set standards for industry.

Where would you like to work for IBM?

This map points out key IBM plants and laboratories, including the Military Products facilities at Owego and Kingston, N. Y. Limited openings are available at many flight test bases and SAGE computer sites across the nation.

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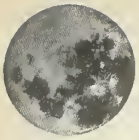

Missile Miscellany

From a combat soldier who should know, this capsule appraisal of a missile family: Redstone—a monstrosity, payload too big for range; Corporal—a misfit, range, complexity and logistics too much for tactical requirement; Honest John—the soldier's pal, highly mobile, designed for the job; Lacrosse—a precision pillbox getter with five-yard maximum error per mile range, truck transportation with go-nogo box the size of TV creepy-peepy; Little John—designed to cut out need for AF close support; Dart—Army nearly did to a good French design what Martin and AF did to the Canberra.

And while this page is apparently picking on other people's pet projects, developing preference for Nike over Talos may be due to the fact that Talos electronic gear requires over 250 "wall cabinets." Nike takes much less.

A telephoned warning this page respects, quoted by a Government man of science from University of Chicago bio-chemist Jaques Loeb: "If a man claims there is a gaseous verterbrate floating around the atmosphere, it is clearly his duty to prove it and not the duty of every other scientist to disprove. Otherwise we'd spend our lives disputing the claims of every charlatan and crackpot."

In contrast, this from a physicist turned editor: "Einstein's was an unfettered mind. He ignored the dogmas of ages past and hypothesized solely on the basis of observed phenomena and, thus, was able to provide a wholly new approach to man's universal environment. Now there's danger this product of a free mind will be used by men of science as an excuse for restricting their own thinking."

Basic Army strategy in the AF-Army squabble is aimed at keeping ABMA in the Army and in one piece. Reasoning is that roles and missions decision denying Army the right to use IRBM weapons will sooner or later be reversed, and Army wants to have its hotshot weapons development group intact when that happens.

And a tip to missile peddlers: It's odds on the recent U.S.-U.K. Bermuda deal will give Britain choice of Thor or Jupiter: Nike or Talos. Same for France. These prototype agreements will set pattern for other NATO powers where U.S. will supply hardware but not manpower for manning European missile bases.

Now quick and fast across the spectrum—Unstable subatomic particles accelerated to near-light velocities decay more slowly than they do at rest, which may be first man-made evidence of Relativistic time-lengthening . . . will close observation of Saturn's spinning rings give similar support to Relativity's length-velocity relationship? . . . Wernher von Braun's back to his jig-saw puzzles, dreaming up a super-Jupiter-C, maybe? . . . a future m r contributor tells of a BBIM, Buoyant Ballistic Inertial Missile that doesn't require any propulsion to go hundreds of miles . . . AF has fixed the external configuration of the Thor; anything to be changed will be internal—a Jupiter in Thor's clothing, maybe . . . lest we forget, the same fuel that smoked up grampa's lampshades will power man's first venture into outer space . . . from NACA director Dr. Hugh Dryden out of context at Congressional hearing: "There is no doubt missiles are coming." . . . while a Regulus with extra fuel tanks has made a successful RATO launch, word seeps through that air-to-surface-ship Petrel will be phased out to make way (and money) for higher priority projects . . . brief word of work at Aerojet on underwater pulsejets recalls Dr. Fritz Zwicky's earlier claim that ramjets can run through earth as well . . . a proprietary-minded technical salesman wonders about the system whereby an overall missiles system monitor also designs and manufactures products in competition with contractors whose latest developments he monitors . . . NACA's A. M. Rothrock says turbojets are good to Mach 3; ramjets, from Mach 3 to Mach 6; and rockets, from Mach 6 to Mach 25 . . . and to the right appears a good replica of how results of years of effort and many dollars expended sometimes turn out . . .

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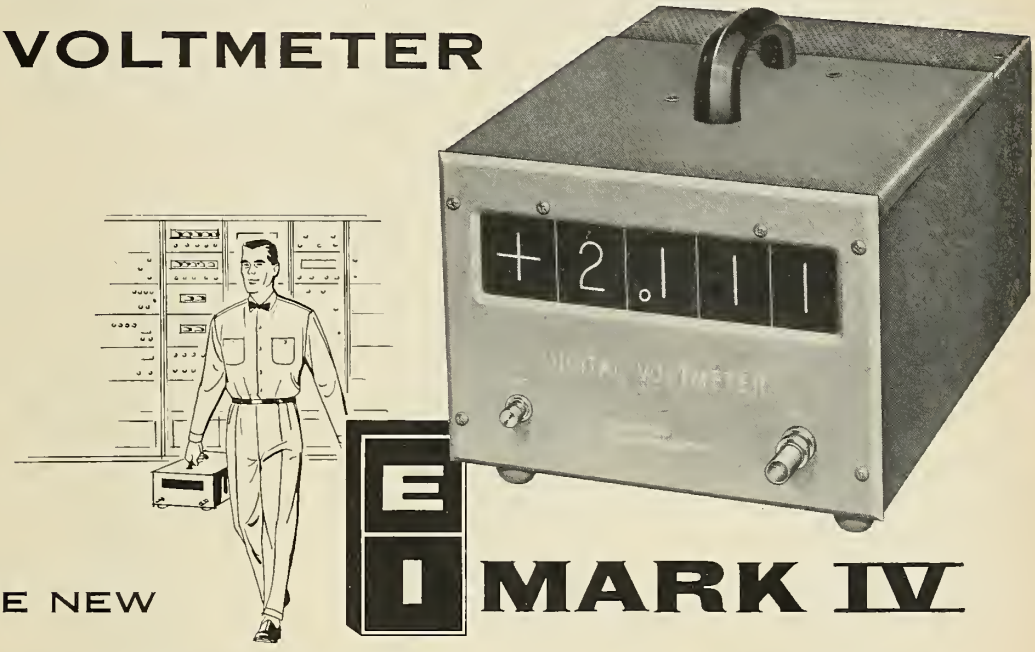

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A new electronic amplifier design (reducing the number of tubes to only eight!) and advanced miniaturization techniques have reduced the overall size of the new Mark IV to only 7½"x9"x11", and cut the weight to 28 pounds.

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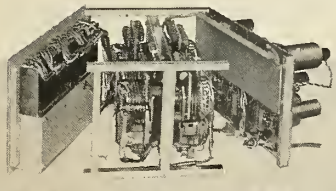

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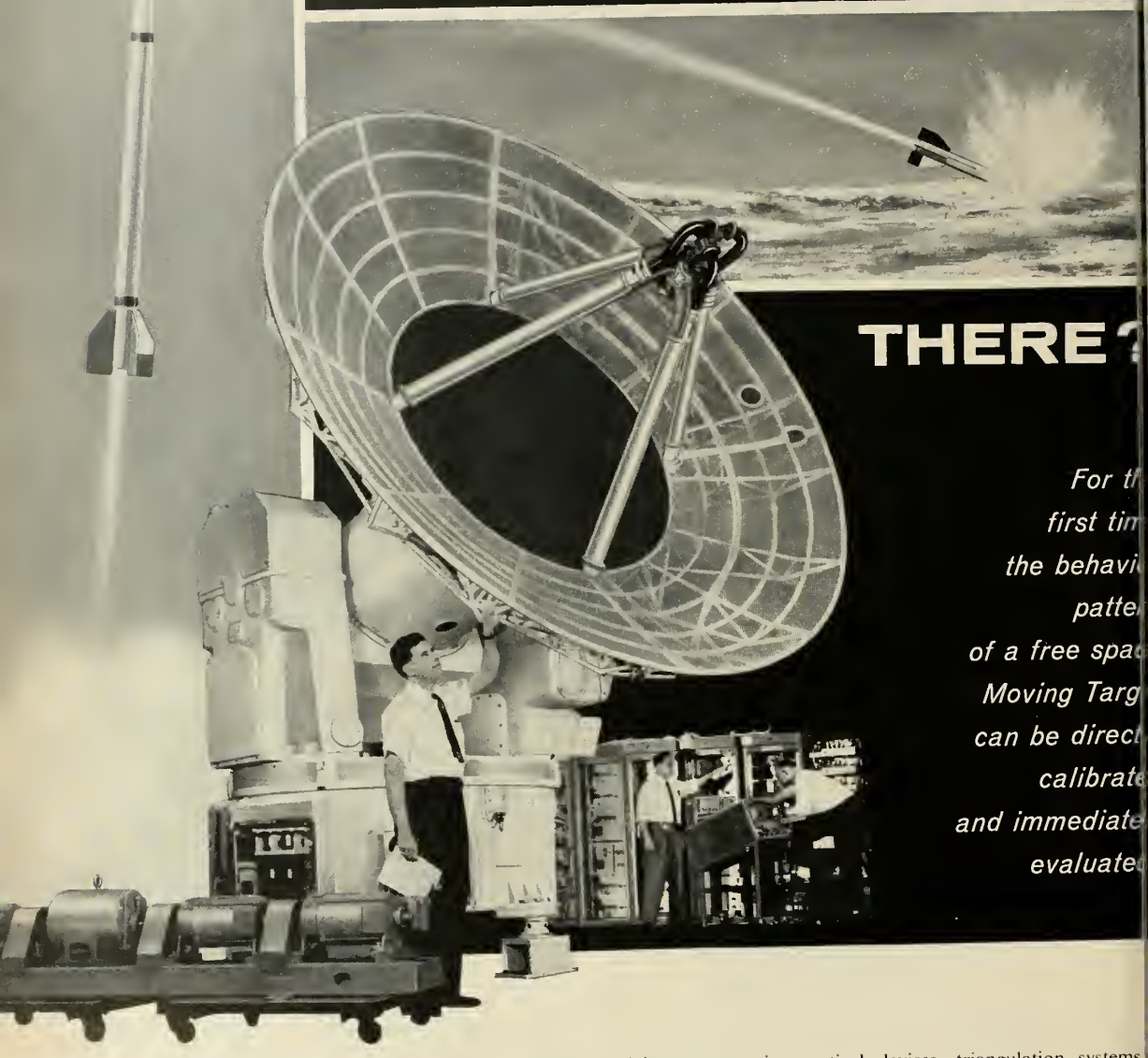

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and immediate
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The proof of any guided missile is its performance. Not only is it necessary to provide accurate trajectory data in order to determine its effectiveness, but this must be made immediately available.

To meet both requirements is the purpose of the AN/FPS-16 instrumentation radar. This is the first radar developed specifically for Range Instrumentation. It has demonstrated its ability to track with accuracy in darkness, through clouds—under any atmospheric conditions—over extended ranges, and to yield data that can be reduced almost instantaneously to final form. This unit can also be assigned to plot performance of missile, satellite, drone and other free space moving targets.

In the past, this data has depended upon optical devices, triangulation systems with long base lines and precision limitations, modified radar equipment and data reduction methods often requiring months for computation. The immediate availability of data evaluation provided by the AN/FPS-16, now being built by RCA under cognizance of the Navy Bureau of Aeronautics for all services, is a great forward step in Range Instrumentation.

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NEW MISSILE PRODUCTS

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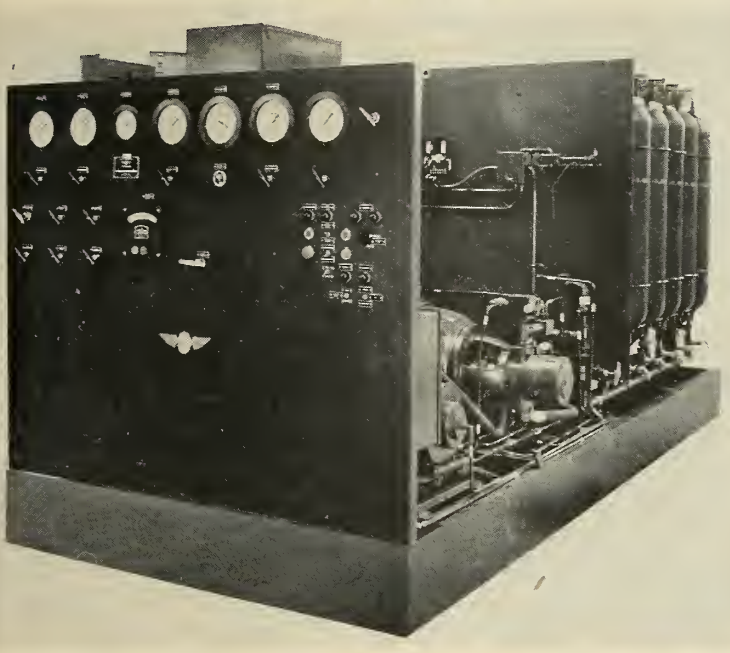

A new high pressure gas booster developed by Greer Hydraulics, Inc. for testing rocket engines and components is capable of boosting pressures up to 10,000 psi at nominal flows up to 10,000 scfh.

The Greer unit, designed to deliver uncontaminated boosted gas, is proposed for a variety of missile and rocket uses. According to Greer, portable and stationary large-capacity units can be remotely controlled for charging a missile receiver before launching. A smaller stand is adapted to checking missile components, gases and pressure switches.

For dynamic check of missile components, large-capacity stands will supply large continuous flows and can be supplied with gas-recovery features to conserve helium. Other portable, low-capacity models can be used to supply uncontaminated gas pressurization to missiles or components at launching sites.

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MISSILE FAN

A new landmark in miniaturization is the claim of Rotron Manufacturing Co. for its 2 in. diameter, 1½ in. long Aximax fan to cool missile electronic equipment.

Of vaneaxial design, the Aximax II features inside-out motor construction wherein the electrical rotor and air-moving impeller are integrally cast in one piece. Unit weighs only four ounces and is rated to move 62 cubic feet per minute of air at free delivery and 43 cfm at 2 in. static pressure.

New fan operates at 20,000 rpm, is wound for 400 cycle a-c, either 200 volt, three phase or 115 volt, single phase.

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VIBRATION TESTER

New "economy" vibration test machine introduced by The Ahrendt Instrument Co., subsidiary of Litton Industries, weighs only 30 lbs. and will handle testing of small items up to five pounds.

The Model 14-28 test machine conforms to frequency and amplitude requirements of MIL Standard No. 202 and is said to be extremely valuable for interim testing during development as well as for final test or production line quality checks.

Variable-speed drive and 1/15 hp split-phase induction motor of the Model 14-28 are housed in a cast aluminum base. Linear sinusoidal motion is carried to a flex-mounted table via a connecting rod driven by a ball bearing mounted eccentric cam.

Frequency adjustment is infinitely variable between 10 and 55 cycles per second while the machine is running and frequencies down to 2 cps are available at extra cost. Amplitude setting from zero to 0.040 in. (double amplitude maximum is 0.080 in.) is provided by means of an eccentric adjustment. Literature available.

Circle No. 201 on Subscriber Service Card.

CANNON CONNECTORS

Two new connectors—a high speed, high altitude design and an AN quick-disconnect type—have been unveiled by Cannon Electric Co.

The former, a rack/panel pressurized connector, is intended for high-altitude and high vibration applications and features use of a special rubber seal about its insert faces upon mating.

The quick-disconnect unit is basically an accessory made up of an adapter and coupler designed for standard AN connectors. Adapter is designed to screw over coupling threads of AN receptacle and contains an external locking groove which receives the formed ends of the coupler latch when fully engaged.

Cannon coupler is a special spring latching assembly designed to replace coupling nuts on standard AN3106 and AN3108B plugs.

Circle No. 215 on Subscriber Service Card.

FRACTIONAL HP MOTORS

New 400-cycle, 200 volt, three-phase, two-speed, constant torque motors introduced by Western Gear Corp. operate at speeds of 7,200 and 1,200 rpm and are available at ¼ hp and 1/24 hp respectively.

Western Gear's Model 1H58ML1 is "pancake" shaped, weighs 6.5 lbs. and measures 2½ in. deep by 3¾ in. in diameter. Output speeds are said to be plus or minus 5% with controlled acceleration and deceleration.

Circle No. 213 on Subscriber Service Card.

MINIATURE VIBRATOR

P. R. Mallory & Co., Inc. is marketing a new miniaturized vibrator that weighs only 1.5 oz. and measures 1¼ in. high by ¾ in. diameter. The Mallory 1900 series was developed for use in missile power supplies, primarily for guidance system applications.

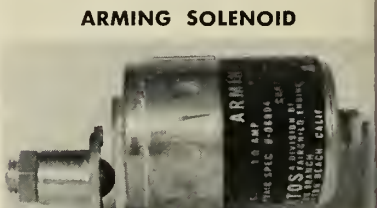
New vibrator is rated for shock loads of 9,000 g's and above and is said to have performed satisfactorily after a shock exceeding 17,000 g's. It was not affected by spin test accelerations from

standstill to 13,000 rpm, according to Mallory.

Designed for intermittent service, new vibrator is a 400 cycle, full-wave interrupter type that will deliver up to 20 watts for short periods.

Circle No. 217 on Subscriber Service Card.

ARMING SOLENOID



An 11-ounce arming solenoid introduced by Stratos Division, Western Branch, is designed to arm missiles in high performance fighters, but can be adapted to other high-altitude applications according to its producer.

Unit operates unpressurized and, although qualified to 80,000 ft., has been tested successfully to 115,000 ft. Solenoid operates down to 18 volts and normal power drain is .7 amperes.

Circle No. 205 on Subscriber Service Card

MINIATURE PLUGS

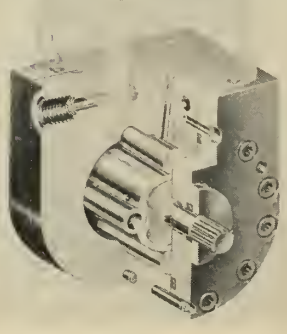
Microdot, Inc. has unveiled two new miniature coaxial plugs, series 32-66 and 32-68, designed for use with Teflon RG-195U miniature coaxial cable having a maximum outside diameter of 0.155 in.

New plugs feature assembly without special tools and adaptability to use with existing Microdot S-93 receptacles. Series 32-66 plug has a guarded center pin.

Circle No. 219 on Subscriber Service Card.

ROTARY HYDRAULIC ACTUATOR

Aviation Division of Kelsey-Hayes Co. has unveiled a new rotary hydraulic actuator intended for use in precision control servo systems using fluid supply pressures in the 3,000 to 4,500 psi range.



New actuator ranges in size from 100 lb. in. to 6,000 lb. in. stall torque based on a 3,000-psi supply pressure rating. Static breakaway friction is said to be less than 6 lb. in.; internal leakage

50 x 10-6 in. 5/lb. sec. and total angular travel 125°. Actuator has a static breakaway friction of less than 1% maximum stall torque, according to K-H.

Circle No. 211 on Subscriber Service Card.

COOLANT PUMP

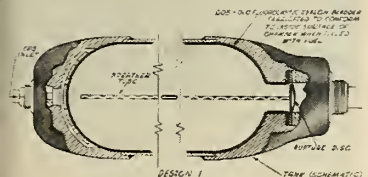
New lightweight coolant pump introduced by Applied Dynamics Corp. weighs about three pounds and is designed for such applications as coolant circulation in missile guidance systems.

The ADC pump, in a typical 3-pound model, measures 8 in. long and 3 in. diameter and operates from 400 cycle power source. Design feature is leakproof construction utilizing a "canned" motor that requires no seals or stuffing boxes. Available designs are of centrifugal or positive displacement types.

Circle No. 214 on Subscriber Service Card.

EXPULSION BLADDERS

Joclin Manufacturing Co. has announced development of fluorolastic Teflon seamless fuel bladders for handling fuels and oxidizers in missile propellant systems. Units are of the expulsion type in which gas is introduced at one end of cell to propel fuel from the other.



According to Joclin officials, the new container and fuel bladder combination is the result of two years of research to develop equipment that would cope with the 1,000-degree spread between —450° and 550° temperatures experienced in high altitude missile, ramjet, rocket engines.

Circle No. 206 on Subscriber Service Card

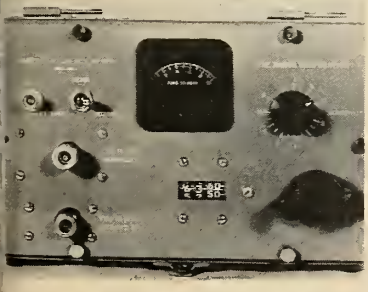
TEMPERATURE PROBE

Total temperature probe developed by Aero Research Instrument Co. for missile use is available with a choice of resistance thermistor of thermocouple sensing elements. Resistance elements are designed for operating ranges up to 1,000°F; thermocouple elements to 2,800°F. Probes are said to be completely insensitive to 20-degree angle of attack or yaw.

Circle No. 208 on Subscriber Service Card

FREQUENCY METER

An improved Model 802 Narda frequency meter has a range of 2.350 to 0,500 mc. The instrument has also been



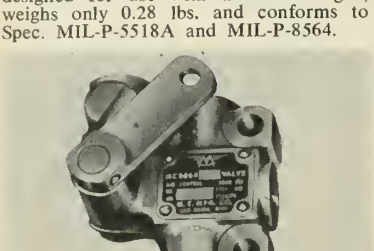
redesigned to give better accuracy and legibility. Principal change is the elimination of two micrometers and substitution of a Veeder-Root digital counter system for frequency readings.

Frequency in mc is obtained without calculations or written interpolation to a rated accuracy of 0.2%. Two tuned cavities are used. They are tuned by a precision lead screw. Both tuning shafts are driven by a single knob. Counter readings are referred to a universal nomograph-type calibration chart. The Narda Corp.

Circle No. 240 on Subscriber Service Card.

CONTROL VALVE

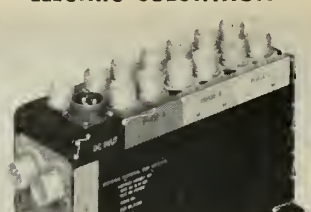
New 3-way air control valve introduced by M. C. Manufacturing Co. is designed for use with air or nitrogen, weighs only 0.28 lbs. and conforms to Spec. MIL-P-5518A and MIL-P-8564.



Valve is rated for operation at temperatures from —65° to 225°F and pressure of 3,000 psi. Internal leakage is said not to exceed one bubble in two minutes with 500 to 3,000 psi applied at pressure port.

Circle No. 200 on Subscriber Service Card.

ELECTRIC SUBSTATION



Miniature electric substation developed by Cole Electric Co. for the Northrop *Snark* missile is designed to transfer 88 electrical circuits and seven signal circuits from ground test power to airborne supply in 2½ seconds. Weighing only 28 lbs., the Cole system is remotely operated and provides instantaneous synchronization—make before break—to maintain a steady, constant power supply.

Substation draws 6.2 amperes at 28 volts for 2.5 seconds maximum. Current used totals 434 watt-seconds, instead of a continuous load as would be necessitated by a large group of relays, according to the manufacturer.

Circle No. 204 on Subscriber Service Card

TRACKING SYSTEM

New track-while-scan radar system developed by Westinghouse Electric Corp. electronic division automatically reports on 72 targets in three dimensions.

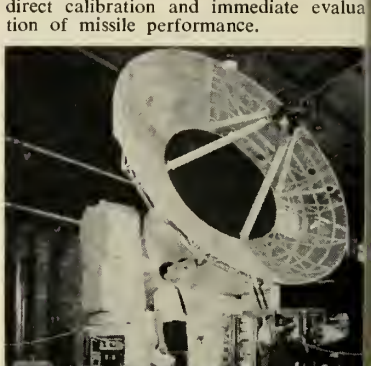
New system, is basically a hybrid digital-analog system in which error sensing is an analog function controlled by a digital computer. Latter computes, controls and displays data on all 72 tracks.

Construction features plug-in packaged unit design using printed circuits. All units are broken down into 200 lb pieces each with its individual transit case

Circle No. 216 on Subscriber Service Card.

MISSILE RANGE RADAR

Radio Corp. of America has unveiled an instrumentation radar system company officials say for the first time permit direct calibration and immediate evaluation of missile performance.



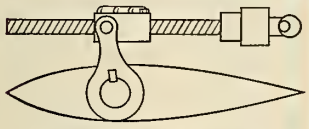
The new radar, developed to join Navy Bureau of Aeronautics and Army Signal Corps specifications, is adaptable to plotting performance of satellite, drone

TOO "HOT" TO HANDLE

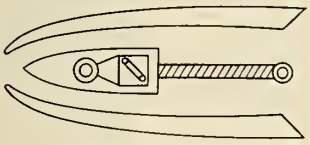
with ordinary actuators?

Saginaw b/b Screws and b/b Splines are dependably solving critical guidance and control problems for missile and rocket engineers . . .

TYPICAL APPLICATIONS

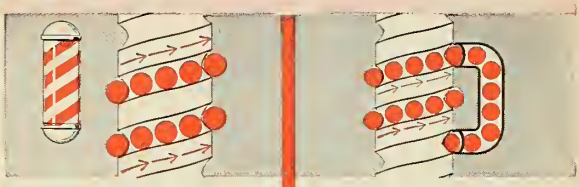


Control surface actuators



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 ⅓ 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.

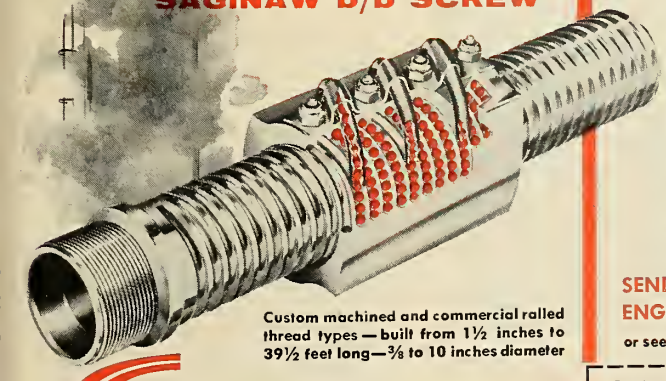
3 PRECISE POSITIONING. Machine-ground Saginaw b/b Screws offer a great advantage over hydraulics or pneumatics because a component can be positioned at a predetermined point with precision. Tolerances on position are held within .0006 in./ft. of travel.

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. For 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

Radically increases efficiency of transmitting or restraining high torque loads; built from 3 inches to 10 feet long, ⅜ to 6 inches diameter

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or other free-space moving targets.

Designated AN/FPS-16, the RCA equipment is an evolution of earlier radars it developed for the Johns Hopkins *Bumblebee* project and Army application of Navy's *Terrier* missile system.

Circle No. 209 on Subscriber Service Card

MOTOR GENERATOR

Production of a new size 10 ac motor generator for error rate damping in missile servo systems has been announced by Clifton Precision Products.

Weighing 72 grams, the Clifton unit requires an input power of 0.2 watts and has an output of 0.16 volts per 1000 rpm. No load speed is 7,000 rpm.

Circle No. 218 on Subscriber Service Card.

ROTARY ACTUATOR

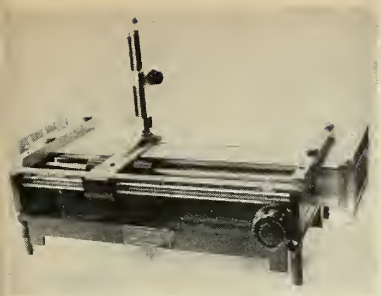
A rotary actuator marketed by Electrical Engineering and Manufacturing Corp. has a travel of 45 degrees at .625 rpm. Operating on a 320 to 480 cycle ac frequency range (compared to MIL Spec. 380 to 420 cycles), the EEMCO D-822 actuator is said to eliminate the need for a constant speed drive in aircraft or missile power generation systems. Actuator operates under 26,000 in. lb. normal load with a maximum of 52,000 in. lbs.

Circle No. 202 on Subscriber Service Card.

SLOTTED LINE KIT

A carriage and slotted line sections are available for taking standing wave measurements in several of the larger waveguide sizes. Slotted sections for 1.7 to 4.9 kmc are available in five sizes. The carriage accommodates four interchangeable slotted sections in different waveguide sizes and slow carriage travel is permitted through vernier positioning of the probe.

The unit can be adapted for remote operation by using a motor drive and limit



switches. The carriage is designed to use most standard probes without alteration. The Diamond Antenna & Microwave Corp.

Circle No. 220 on Subscriber Service Card

LOW TEMPERATURE COUPLINGS

New line of quick couplings marketed by Hofman Laboratories for use in low temperature apparatus require only ¼ turn to open or close. Design employs a mechanical cam action to provide a metal-to-metal medium-pressure contact in place of gaskets for positive sealing.

Produced from high quality bronze, the Hofman couplings are available in 1 in. to 3 in. diameters at ½ in. increments, plus a larger 4 in. diameter model. Hofman also provides armored transfer hoses with couplings installed.

Circe No. 239 on Subscriber Service Card.

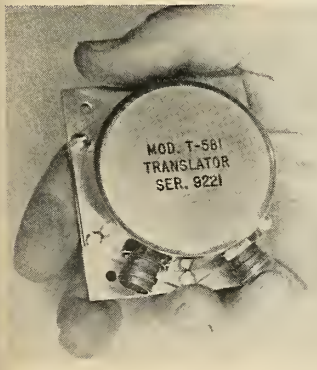
SHOCK MOUNTINGS

New series of light-weight shock mounting devices introduced by Shur-Lok Corp. are designed for use in electronics, radar and missile applications. New units include six types of electronic clamp assemblies, four of the hinged type. Another Shur-Lok device is a mating electronic equipment hook for vertical and horizontal attachment at a maximum angle of 92 degrees.

Circle No. 207 on Subscriber Service Card

INSTRUMENT TRANSLATOR

A transistorized instrument translator permits substitution of variable reluctance electro-mechanical pickoffs for potentiometers in missile systems without adding much weight and size.



The translator receives power from the system source, whether ac or dc, and when connected to a suitable ac sensing transducer produces an ac or dc signal proportional to the transducer sensed signals. Various models are available to operate motors, recorders, hydraulic valves, servo motors, etc. The unit is

potted in an anodized aluminum case. The Crescent Engineering and Research Co.

Circle No. 238 on Subscriber Service Cord

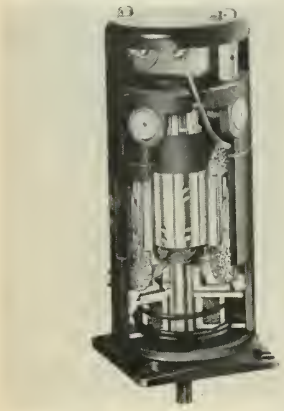
ACCELEROMETER

Genisco, Inc. is marketing an improved Model GLH accelerometer for missile flight and fire control systems. Weighing from 2 to 2.5 lbs. depending on G rating, the potentiometer-type instrument is available in ranges from ±1G to ±80G, or up to ±30G with reduced damping. Operational life is said to exceed 3 million cycles. Dimensions: 3.40 x 2.40 x 3.12 in.

Circle No. 203 on Subscriber Service Cord

LIGHTWEIGHT MOTORS

Lundy Manufacturing Co. has unveiled a series of lightweight, fractional horse-



power motors rated from 1/20th to 1/8th hp and weighing from 15 to 22.5 oz. Designed for 26-volt operation, the Lundy motors feature an electromechanical brake, integral radio noise filter and nearly flat brush pressure characteristics made possible by use of a new brush rig construction.

Circle No. 234 on Subscriber Service Cord.

MANIFOLD VALVES

Robbins Aviation has developed an aluminum three-valve housing having five ports for use in air distribution boxes. It is adaptable to applications over a range extending from high vacuum to pressures of 3,500 psi.

Valve features finger-tip control for all pressures. Construction of manifold is such that any or all of its valves can be overhauled without disturbing the plumbing. Valves are company's standard type using plastic seats and O-rings for sealing.

Circle No. 235 on Subscriber Service Card.

HIGH TEMPERATURE MATERIALS

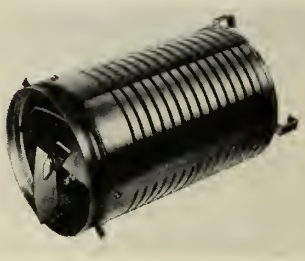
Haveg Industries, Inc. has introduced two new materials called Rocketon and Missileon for high temperature uses in rocket and missile construction. Basic make-up is a high melting silicate with an organic binder.

Among current uses cited by Haveg are: blast tubes for temperatures approaching 8,000°F; motor cases; flame reflectors and special insulating components. Company states that up to 17 parts in one rocket are of molded Rocketon.

Rocketon is said to have a compressive strength of 15,000 psi, tensile strength of 6,000 psi and ultimate shear of 9,500 psi. Respective figures for Missileon are 16,000; 6,000 and 10,500 psi. Density of both is 0.061 lbs. per cu. in.

Company states new compounds may be fabricated in parts as small as ½ in. dia. yet one-piece, field-fabricated sections have measured 205 ft. tall weighing 42,000 lbs.

Circle No. 236 on Subscriber Service Cord.



POWER ABSORBER

An electric power absorber marketed by Sun Electric Corp. and used in Army's *Redstone* and Air Force's *Snark* missile programs is said to replace 21 500-watt stick resistors while occupying only 1/25th the space they normally would require.

The power absorber is essentially a small cylinder in which air is drawn through circumferential casing slots over specially-designed, V-section ribbon resistors.

Unit operates at 13,500 watts continuous duty and weighs 1 lb. per kw absorbed. Space requirements total ½ cu. ft.

Circle No. 237 on Subscriber Service Cord.

new product briefs

GREER HYDRAULICS, INC. has developed a linear actuator test stand said to achieve an accuracy within ± 1% in testing actuators at loads ranging from 50 to 5,000 lbs. Device is equipped to time actuator travel in inches per second and, by means of a dynamometer, to measure torque of screwjacks up to 60 lb. in.

Circle No. 225 on Subscribers Service Card.

EXPANDED LINE of flexible, polyethylene "Caplugs" for protection of ports or threaded fittings on delicate valves or instruments has been introduced by Protective Closures Co. Literature available.

Circle No. 226 on Subscribers Service Card.

CLAMP LINING for aircraft and missile installations introduced by Joclin Manufacturing Co. employs an asbestos wire-reinforced strip impregnated with Teflon. Joclamp lining operates at temperatures from —300° to 500°F and is said to resist damage from hydraulic fluids, oils and corrosive fuels.

Circle No. 227 on Subscribers Service Card.

RUSSELL MANUFACTURING CO. is producing an instrumentation tape woven with Fiberfrax, a new ceramic fiber developed by The Carborundum Co. Tape is wired to signal areas of high radioactivity when applied to atomic reactors and plumbing. Special zirconium adhesive used to affix tape is said to withstand temperatures up to 3,000°F.

Circle No. 228 on Subscribers Service Card.

TASK CORPORATION is marketing a new line of lightweight, high-performance induction motors for power outputs from 10 watts to 1,000 hp. Designs feature low weight to power ratios—a typical model weighing 4.8 lbs. is rated at 6½ hp at 24,000 rpm, 3-phase, 208 volts, 400 cycle.

Circle No. 229 on Subscribers Service Card.

ENVIRONMENTAL CHAMBER. A 5-cubic foot capacity environmental test chamber marketed by Mantec, Inc. is rated to drop temperatures from ambient to —65°F in five minutes and raise to 400°F in 10 minutes. Unit has 100 lb. dry ice capacity and is said to maintain temperature within —2°F over range from —100°F to 400°F. Overall dimensions are: length—22½ in., width—32 in. and depth—24 in.

Circle No. 230 on Subscribers Service Card.

SCINTILLA CONNECTOR. New SR type rack and panel electrical connector introduced by Scintilla Division, Bendix Aviation Corp. incorporates a solid shell and resilient insert to facilitate pressurization and provide maximum protection against vibration. They are rated for operation from—0° to 250°F.

Circle No. 231 on Subscribers Service Card.

TEFLON ENCAPSULATED, color coded flat cable for aircraft and missile electronics has been introduced by Miljan, Inc. Wire sizes range from 16 to 26 gauge and cables are fabricated with any number of wires up to a maximum of two inches in width.

Circle No. 232 on Subscribers Service Card.

ENVIRONMENT RESISTANT electrical connectors announced by The Pyle-National Co. are said to be impervious to water, moisture, oil, pressure, vibration and shock. Connectors conform to Spec. MIL-C-5015B. Literature available.

Circle No. 233 on Subscribers Service Card.

INDUSTRY SPOTLIGHT

By Joseph S. Murphy

Complex Computers For Missiles

The electronic computer, virtually an inseparable ingredient in the nation's missile and rocket program since its development, is shaping a new giant in U.S. industry.

This year, according to the Assn. for Computing Machinery, total computer sales and rentals will reach the $250 million mark. And this does not include the special purpose, one-of-a-kind variety of computer that is not commercially available for lease or sale.

ACM's forecast came during the recent Western Joint Computer Conference in Los Angeles. At that session, eight of the country's leading computer producers gave this round-up report on today's equipment, tomorrow's prospects:

International Business Machines Corps.—STRETCH computer, slated for Atomic Energy Commission projects and due for completion by 1960, will be about 30 to 40 times faster than present computers. It will multiply and add numbers at rates up to one million items per second.

Remington Rand Univac and Philco Corp.—Reviewed their respective development of "desk size" computers which use magnetic amplifiers and transistors instead of vacuum tubes. Units consume no more electricity than four 100-watt light bulbs, and although now intended for scientific applications, developments for commercial use are anticipated.

National Cash Register Co.—announced its extensively transistorized computer designed for such commercial use.

Datamatic Corp.—Stated its Datamatic 1000 computer will store nearly four billion decimal digits and transfer these in the computer at a rate of 60,000 per second.

Logistics Research, Inc.—Reported its Alwac 800 can store up to six million decimal digits and gain access to groups of 12 of these digits in 40 one-millionths of a second. First Alwac 800 is slated for Federal Reserve Board in Washington.

Radio Corp. of America—Described its Bizmac II as a large-scale business data processor fitted with many forms of memory devices and especially designed for maintenance of business files. It is a modified version of Bizmac I used by Army Ordnance for inventory control. Electró Data Division, Burroughs Corp. said the Datatron computer will permit storage of 200 million decimal digits. Its system has been programmed to maintain a 200,000 item file for inventory control operations.

One of the better examples of the missile industry's efforts to get the most out of present-day computer equipment is a "do-it-yourself" program recently announced by Lockheed's Missile Systems Division.

MSD has set up a special course to qualify employes on the use of its IBM 650 computers. After 12-hours instruction, they are turned loose to use the equipment to solve mathematical problems as they arise.

The training is given on company time and the only prerequisite to the instruction is a knowledge of algebra.

Lockheed feels this approach will ease the workload of professional programmers on the staff of E. K. Fisher, head of its mathematics and computer service department at the MSD Van Nuys, Calif. plant.

Key to the "do-it-yourself" computer approach, according to Lockheed, is the development by IBM of a new simplified coding technique called SOAP (symbolic optimum assembly programming).

This technique makes it possible for the novice to write actual equations on his coding sheet, instead of the complex system of address numbers normally used to locate information within the machine.

In the Lockheed system, the engineer will first state his problem as an equation, then draw up a flow chart or analysis of the problem as a series of computer equations. He fills out a coding sheet from which a computer key punch operator takes instructions.

Next, he checks answers against a test case, for which he knows the answer, to locate possible errors. As part of the instruction course, he is taught how to diagnose answers and trace errors should they turn up. ★

Lockheed Computer Chief E. K. FISHER instructs missile engineer, MRS. FLORINE CAIN, on workings of IBM 650 computer. After 12 hours training, Missile System Division engineers program their own problems as part of "do it yourself" computer approach.

GE Gets TV Contract For Patrick AFB

General Electric Co.'s Technical Products Dept. has received an Army Signal Supply Agency contract to produce a closed-circuit color TV system for observing and tracking missiles at Patrick AFB, Fla.

A GE spokesman said the system will be used by Army observers for close-up viewing of launching operations and for tracking up to a possible 100,000 ft. altitude. Use of color TV is designed to give engineers valuable data on flight characteristics by observation and analysis of rocket motor flame characteristics at takeoff.

The new system is scheduled for delivery in May. Although the dollar value of the contract was not disclosed, it is believed to approach the high end of the estimated $25,000 to $100,000 range of price tags prevailing for color TV system ranges.

R-W Acts to Speed Test Data on ICBM

The Ramo-Wooldridge Corp., technical strategist in the Air Force's Ballistic Missile Program, has set out to speed the analytical side of missile testing to keep pace with advances.

A new facility unveiled this month by Ramo-Wooldridge is designed to do just that. Its aims—quick and accurate reduction of telemetered test data; more rapid analysis.

The R-W installation designed and built by its Electronic Instrumentation Division, will be operated by its Guided Missile Research Division.

Emphasis throughout its development was keyed to flexibility, according to R-W officials. Equipment now installed in the data reduction center can be quickly interconnected into circuits which can reduce any of a variety of input signals into forms required for engineering analysis. Provision for addition of new equipment is "built-in" should improved techniques become available.

A wide selection of equipment in the center has been united for flexibility by routing all circuits through a central "patchboard" control panel. This permits engineers to pre-wire circuits that will link together all units needed to process a specific piece of missile test data.

Output equipment is equally as flexible. It can produce graphic records for study by engineers, magnetic tape recordings for analysis in the computing center, or can feed signals directly into vibration analysis equipment in the data reduction center.

Typical of the versatility of the entire installation is the variety of equipment in the vibration analysis section alone. It includes a Davies automatic wave analyzer, a Hewlett-Packard wave analyzer, a Kay vibralizer, a specially assembled half-octave filter bank plus a special correlation function computer developed by the R-W Electronics Research Lab.

All units are assembled in modules with space and power supply provided in the overall center for 50 modules. To date 31 positions are occupied.

In the plan for the future are the addition of other devices to speed missile test data into engineering answers. They include equipment for time coding and decoding, automatic data search, pulse code modulation telemetering decommutation, data linearizing, Doppler data processing and other specialized requirements.

Douglas Divisions to Share Thor Engineering Work

Douglas-Santa Monica Division has subcontracted a portion of engineering for the Air Force *Thor* intermediate range ballistic missile to Douglas-Long Beach Division. Project coordinator on Thor at Long Beach will be W. W. Miller.

industry briefs

REACTION MOTORS, INC. paid 74% of its vendor/subcontractor dollar volume to 1,500 small business firms during last six months of 1956. Payments to small business totaled $3,082,000 of overall $4,182,000 spent by RMI.

FINN AERONAUTICAL DIVISION, Hawthorne, N. J. producer of combustion liners and flameholders of *Navaho* missile's Curtiss-Wright ramjet engines, has doubled facilities to 20,000 sq. ft.

MICRODOT, INC., builder of microminiature coaxial cables and connectors, has moved to new quarters at 220 Pasadena Ave., So. Pasadena, Calif.

SOLAR AIRCRAFT CO., San Diego, has received a $2 million contract from Hughes Aircraft Co. to produce *Falcon* missile airframes.

TUCSON INSTRUMENT CORP., new aircraft and missile electronics firm located in Tucson, Ariz. has commenced manufacture of potentiometers and electronic test equipment. President and treasurer is F. R. Perier.

G. M. GIANNINI & CO., INC. reports 1956 sales of $9,510,091, up 47% from $6,436,330 in 1955. Net earnings were $339,521 against $290,787 in 1955.

REACTION MOTORS, INC. has shifted its Los Angeles offices to larger quarters at 10835 Santa Monica Blvd. Office provides joint representation for RMI and Olin Mathieson Chemical Corp. and is headed by J. M. Rogers.

RHEEM MANUFACTURING CO. has commenced operations in an enlarged electronics research laboratory and production facility at 7777 Industry Ave., Riveria, Calif.

SPERRY RAND CORP. will build a $2 million plant at Clearwater, Fla., to specialize in research in microwave physics and the development of advanced radar and missile instrumentation. New division will be headed by E. J. Venaglia and will commence operations with a staff of 150 scientists and technicians.

BELL AIRCRAFT CORP. has received a $405,000 facilities contract from Air Materiel Command in its GAM-63 *Rascal* missile program.

GILFILLAN BROS., Los Angeles, has received a $2,877,000 contract to conduct a design improvement study of the ground guidance system for Army's Firestone *Corporal* missile.

GOODYEAR AIRCRAFT CORP. plans construction of a 20,000 sq. ft. addition to its rocket component production and development facilities at Akron.

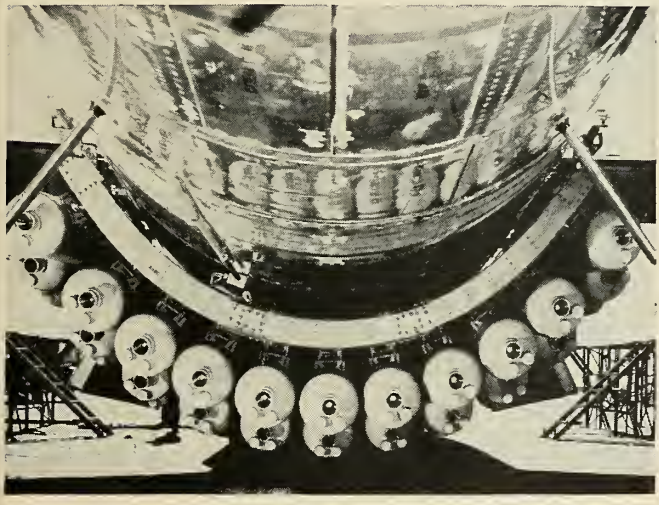
THE FIRESTONE TIRE & RUBBER CO., Los Angeles, has been awarded a $1,756,846 contract to design and build a guided missile stowage and launching system.

KAMAN AIRCRAFT CORP. is forming a Nuclear Division to engage in systems analysis and research in the fields of nuclear ordnance and propulsion. Group will be located at Albuquerque, N.M. under v.p. and general manager, Dr. K. W. Erickson, former chief of experimental weapons research for Sandia Corp.

THE EDO CORP. has received a $2,188,200 Navy Bureau of Aeronautics contract to build an undisclosed number of missile launchers and pylons.

Advantages you get with Phillips 66

SOLID ROCKET PROPELLANTS



The M15 JATO loaded on Boeing B-47 The first of its kind to meet rigid Air Force performance tests. (Boeing Airplane Company photo)

At the Phillips operated Air Force Plant 66 near McGregor, Texas, there are extensive facilities for development, testing, and manufacture of rocket propellants. Consult Phillips highly competent scientists and engineers about your specific propulsion problems.

- *LOW COST.* Phillips family of solid propellants for rockets is made from readily available petrochemical materials, such as ammonium nitrate, synthetic rubber, and carbon black.

- *VERSATILE IN APPLICATION.* Phillips family of rockets is easily modified to meet various needs.

- *WIDE TEMPERATURE RANGE.* These rockets operate successfully from –75 F to 170 F.

- *INSENSITIVE TO DETONATION* by impact or explosion. Exhaust gases are noncorrosive and relatively low in temperature.

- *STORAGE.* Phillips 66 propellants can be stored for long periods of time without deteriorating.

PHILLIPS PETROLEUM COMPANY
Bartlesville, Oklahoma

Address all inquiries to:
Rocket Fuels Division, Bartlesville, Oklahoma

Phillips 66

Industry Highlights

By Fred S. Hunter

Interesting figures—The Douglas Aircraft Co.'s annual report shows missile sales in 1956 amounted to $140 million, and adds that orders for missiles and related equipment comprised approximately 16% of its backlog at the start of fiscal 1957. This translates into something above $170 million since Douglas reported a total backlog of $2,209 million and explained this was divided almost equally between military and commercial business. The Air Force recently revealed $67 million as the amount of current *Thor* ICBM contracts, leaving something in excess of $100 million in other missile work at Douglas.

•

More interesting figures—Lockheed Aircraft Corp. reports annual sales rate of its Missile Systems division now betters $70 million, and then goes on to stagger the imagination a bit by pointing out this is 13% greater than that of the entire air industry 20 years ago. In two years time, Lockheed's missile division multiplied its sales seven times, quadrupled its work force (now approximately 5,000) and more than doubled plant area in use or under construction (almost one million square feet.)

•

Still more interesting figures—J. R. Dempsey, general manager of Convair-Astronautics, quotes numbers to show missiles make more jobs. For the ICBM *Atlas*, Convair-Astronautics is scheduling employment of 8,000 workers. These will require 18,000 more in support work. For an airframe program of comparable scope, 8,000 direct wage earners would require only 11,000 more in supporting jobs. Astronautics, last year, spent more than $10 million with 330 suppliers in the San Diego area and $30 million with 894 suppliers in the Los Angeles area. They'll get more this year.

•

Not everyone seems to have been aware North American Aviation's Air Force contract for development of the *Navaho* was a three-stage affair. First stage was the turbojet X-10 test vehicle. Second stage was the intermediate XSM-64, with ramjet engines and a booster. Third stage is the long-range XSM-64A. The recent contract termination involved the intermediate stage XSM-64, with remaining funds and materials from this project transferred to the long-range XSM-64A, which continues with 1957 funds. Speculation over ultimate fate of the missile centers around the fact no money was earmarked for it in fiscal 1958 funds. But most people think 1958 money will still be budgeted for continuation of the project, so don't be in a hurry to write it off.

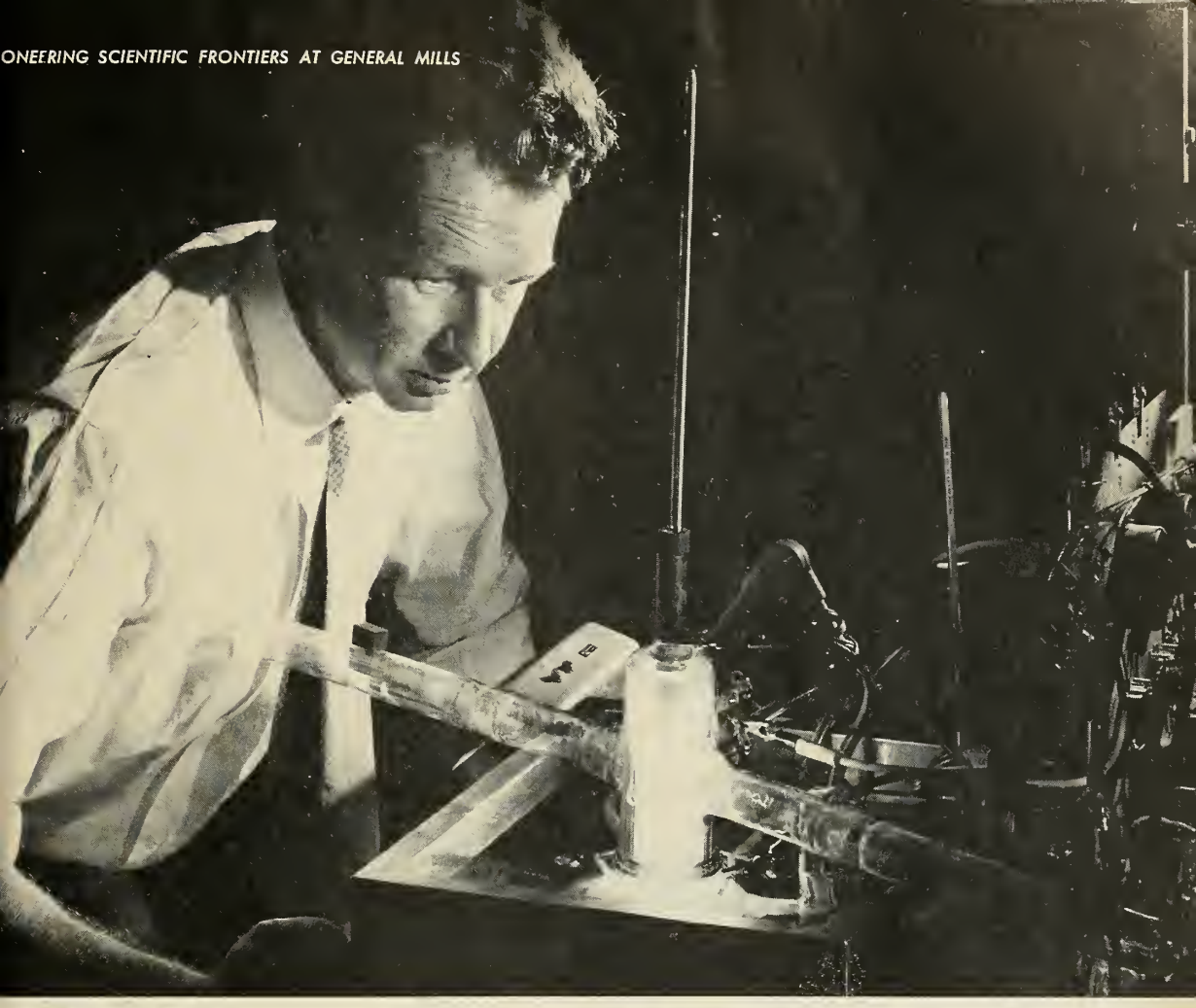
•

"Premium apparatus!" That's Lee Atwood's term for the electronics equipment the Autonetics division of North American is producing. A sample—the new CP-226 all-transistor digital computer, which weighs only 200 pounds and measures a mere six cubic feet, but will do everything, we're told, that an IBM 701 will do, only slower. Cost of the new machine is approximately $100,000. Autonetics envisions market possibilities for 3,000.

•

Berkeley division of Beckman Instruments, counting up, found 77 companies in the analog computor field in which it is active. Not all are turning out complete systems. Some make only components. But they have to be considered as possible competitors any time a request for bids is tossed out. Biggest analog plum up for grabs recently was a one-and-a-quarter-million-dollar job for the Glenn L. Martin Co.

ONEERING SCIENTIFIC FRONTIERS AT GENERAL MILLS



This scientific pioneer is Dr. G. K. Wehner, designer of the space chamber which he uses here to determine the "sputtering" or disintegration rate of molybdenum under bombardment from atoms moving at 25,000 m.p.h., 200 miles above the earth.

What happens to metals at 25,000 m.p.h. 200 miles up?

General Mills scientists are finding some of the answers to this question, which bears directly on space ships and man-made satellites.

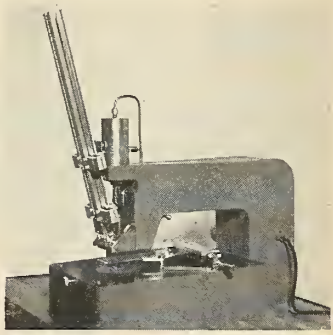
Their findings indicate that materials to be sent into space must possess properties not found in today's ores and alloys. Since few new metals remain to be discovered, they conclude that present ones must be given new properties to cope with the heat barrier and to keep vehicles from disintegrating under particle bombardment.

The study of metals in space flight represents but a single phase of General Mills' over-all program of advanced exploration in theoretical and developmental physics.

Findings in this "research for tomorrow" are being translated regularly into practical applications for industrial and military use today. If you have product or production problems, you can profit from these applications, and from our high-level production facilities.

Send for Production Facts

This interesting booklet tells the story of how you profit by giving us your difficult production problems. Write Mechanical Division, Dept. MR4, General Mills, 1620 Central Ave. N. E., Minneapolis, Minn.



AUTOFAB: ***built for the present***

From General Mills' creative research and precision manufacturing come machines for industry to use today—machines such as *Autofab*, for near-automatic assembly of electronic components on printed circuit boards.

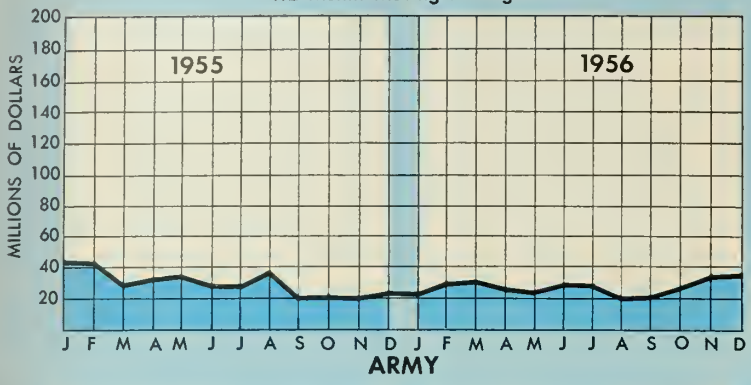
MECHANICAL DIVISION OF General Mills

CREATIVE RESEARCH AND DEVELOPMENT + PRECISION ENGINEERING AND PRODUCTION

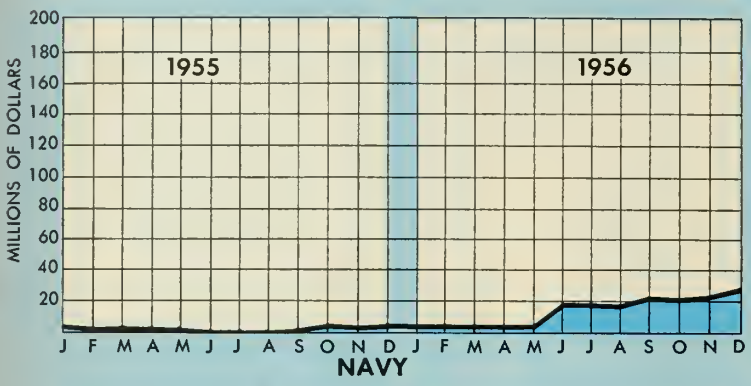
INDUSTRY BAROMETER

GUIDED MISSILE OBLIGATIONS INCURRED

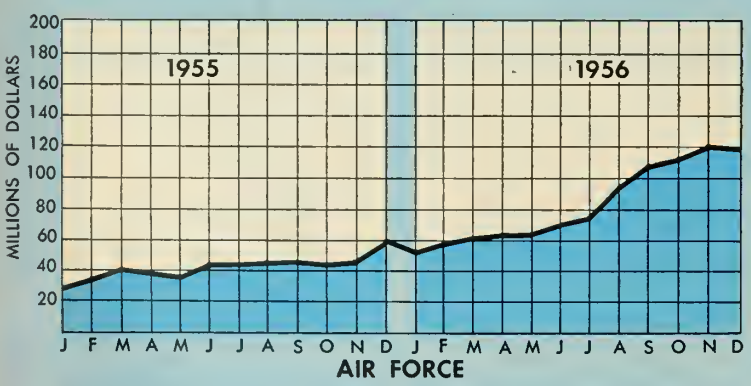
(12 Month Moving Averages)



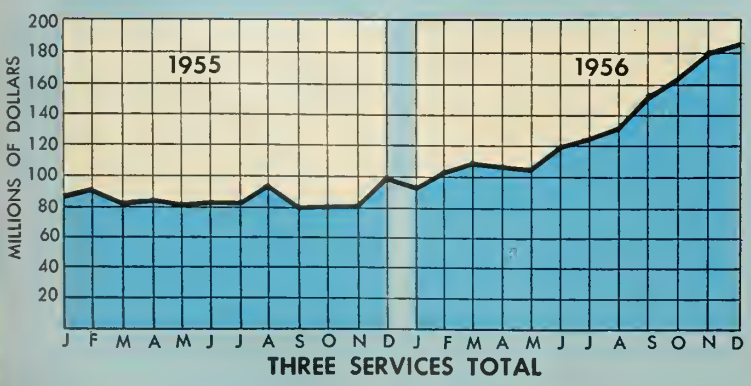
ARMY



NAVY



AIR FORCE



THREE SERVICES TOTAL

The twelve-month moving averages illustrated (see November 1956 "Industry Barometer") point out the rising rate of obligations for guided missiles during the current fiscal year.

Department of Defense average missile obligations have increased from $100,554,000 in December 1955 to $186,137,000 in December 1956, a jump of 85%.

Army guided missile obligations continue to fluctuate from month to month, but show a marked increase during November and December of 1956. The December '56 average obligations incurred ($36,251,000) represent an increase of 48% over December 1955 ($24,476,000).

Missile obligations incurred by the Navy reached a new high in December of '56 ($29,412,000). This figure is a 90% increase over December 1955 average obligations of $15,470,000.

The Air Force's average obligations show an upward trend during the first half of fiscal year 1957. December 1956 obligations ($119,940,000) increased 98% over December 1955 ($60,609,000).

Guided missile obligations incurred during the first half of fiscal year 1957 (July through December 1956) amounted to more than twice the money obligated for missiles by the Department of Defense during the first half of fiscal '56. From July through December $1,391 million were obligated, compared with $604 million in the previous year.

Direct obligations by the Department of Defense should average about $280 millions per month of the last six months of the current fiscal year (January-June 1957). This is based on the fact that total direct obligations for missiles are estimated at $3,071 million for fiscal year 1957. During the second half of FY 1957—based on current Pentagon thinking and money committed in the first half of the fiscal year, indications point to:

. . . Army missile obligations exceeding those of the first half, probably averaging about $83 million per month;

. . . Navy guided missile obligations decreasing over the first six months of fiscal '57, to an estimated $31 million per month for the six month period;

. . . Air Force obligations increasing; an average for the six month period of $166 million per month.

IBM Reports Income and Facilities Expansions

Year end report of the International Business Machines Corp. shows gross income as $734,339,780 compared to $563,548,792 for 1955. Net income after taxes was $68,784,510 which amounts to $13.10 on outstanding shares.

During the year, IBM said, the five-hundredth type 650 data processing machine, and the one-hundredth 700 series data processing machines were delivered to customers.

Facilities expansions noted were the new Kingston, N. Y. manufacturing plant for producing Sage computers, a 406,000 square foot plant and laboratory near Owego, N. Y., believed to be planned for production of Air Force BRANE navigation and bombing systems, and 96,000 more square feet of laboratory space at Poughkeepsie, N. Y.

Other new plans call for an engineering laboratory with 160,000 square feet in Kingston for work on SAGE and other defense projects.

A major new product that came out of the laboratories during the year was IBM's 305 RAMAC based on a new concept of random access accounting. Disc memory units can store 24 million digits of information.

Work is also underway on a large-scale computer being developed jointly by IBM and Los Alamos Scientific Laboratory of the AEC. The new computer will be between 100 and 200 times faster than any commercial computer in existence.

New Matador Contract

Air Materiel Command has awarded The Martin Co. a follow-on contract amounting to $1,527,981 for *Matador* TM-61B missile testing.

Talco is Building New Phoenix Facility

The Talco Engineering Co. of Hamden, Conn. has acquired a 2,000-acre plot near Phoenix, Ariz. for construction of testing and firing range facilities capable of handling cartridge-actuated and rocket devices.

F. G. Talley, Talco president, said the facilities also will be made available for evaluation of contractor-furnished and developed airborne equipment and systems.

Company plans to complete the

first phase of construction in July including a sled track, environmental testing laboratory, office, shop and storage buildings. Firm's operations in Connecticut will continue at an expanded level with the Phoenix site slated to handle qualification and production testing of the larger equipment it builds.

Among the latter is a new personnel rocket catapult developed for the Convair F-102 and TF-102. Company officials said development of versions of this system for other aircraft is currently in progress.

General Tire Nets $10.8 Million

General Tire & Rubber Co. netted $10,860,129 in 1956, a drop from $11,600,463 in 1955 despite a sharp increase in sales from $295,731,096 to $390,471,772 for the parent firm and its subsidiaries, including Aerojet-General Corp.

Although specific Aerojet sales for the year were not given in General's annual report, it was noted that they increased by 109% over 1955 and that its backlog now exceeds $500 million.

The report did, however, deal in considerable detail with the accomplishments of Aerojet during the year, highlighting these specific points:

Manufacture of more than 1,300 large solid-propellant booster rockets for guided missiles.

Production of 40,000 smokeless JATO units, 1,000 *Sparrow* missile powerplants, 3,500 *Nike* sustainer motors and several hundred large JATO units for medium bombers.

Development of a liquid propellant booster for the Boeing *Bomarc*, followed by successful *Bomarc* testing at Patrick AFB, Fla.

General Tire also noted progress on development of a solid propellant sustainer motor for the Martin *Bullpup* missile; a booster for launching the Chance Vought *Regulus* II; and, start of work on a new *Sparrow* engine using Aerothane as propellant for increased specific impulse.

In the R&D area, Aerojet developed the largest solid propellant powerplant ever used in any ballistic missile, the report disclosed. The unit was developed for the Army's Jupiter IRBM and, in October, testing began on a reduced-scale Jupiter rocket.

Also mentioned in brief was Aerojet's activity toward development of a new type of powerplant, an air-turbo-rocket. The engine was described as a high-speed, high-altitude powerplant combining the best features of rockets and ramjets.

An Announcement

OF FIRST IMPORTANCE TO EXPERIENCED ROCKET ENGINEERS AND SCIENTISTS

- *Reaction Motors initiating big new Research and Development Program*
- *Key spots offered to men who have already made a name for themselves in Rockets*

If you're one of the relatively few trained rocket men in America, your experience will pay off handsomely at Reaction Motors. The first rocket company in America, RMI is now entering its period of greatest expansion, a period that will see far-reaching developments in America's fastest-growing industry. Your participation in RMI's program during this crucial period is your best guarantee of leadership in the industry. In a job like one of those listed below you'll be strategically placed for both achievement and advancement.

1. Stress Engineer

Degree in engineering or applied mechanics. Required experience in mechanical design with emphasis on stress analysis: 3 years for an engineer, to 6 years for the senior engineer. Must be able to handle and/or supervise involved analyses—including the effects of dynamic forces, high temperature gradients and high pressure differentials—under conditions where light weight is vital.

2. Technical Planning Engineer (advance design)

Our technical planning group has an immediate opening for a qualified engineer with about 5 years' experience (mostly mechanical) in high-performance turborocket engine design. Experience with turborockets should be broad and should cover thrust chambers and turbopumps. Additional experience with turbojet engines is also desired, though not essential. Work will involve, determining future propulsion requirements, evaluating them, and creating designs for products to meet them.

3. Controls Engineers

Here, we are looking for men who will solve rocket propulsion problems by applying their knowledge of fluid flow theory, thermodynamics, servomechanism and information theory, analog simulation or statistical design techniques—The work includes designing valves and other control components; development of hydraulic, pneumatic and electrical feedback control systems and sequence control systems; analog simulation of single components and complete systems, including computer set-up and problem formulation; application of statistical design techniques to control situations.

4. Applications Engineer

Work involves technical liaison with military agencies and airframe industry to discuss requirements and determine applications for aircraft pumps, valves, ignition systems and related products. Must have sufficient technical experience to understand construction, operation and performance of power plants and be able to integrate with requirements of airframe engineers. Knowledge of military contracts and airframe industry desirable. This is a responsible opportunity in the aviation industry for a mature, ambitious man to age 45 who possesses imagination, initiative and ability to organize.

RMI'S 6 MAIN PROJECT AREAS INCLUDE:

MISSILES • PILOTED AIRCRAFT • LAUNCHING DEVICES • GROUND SUPPORT EQUIPMENT • LIQUID AND SOLID PROPELLANT CHEMISTRY • NUCLEAR ROCKETS

For additional information on these or any other positions, drop a note or send complete resume in strict confidence to:

SUPERVISOR OF TECHNICAL PLACEMENT

Power for Progress

RMI®

REACTION MOTORS, INC.

A MEMBER OF THE OMAR TEAM

50 FORD ROAD • DENVILLE, N. J.

GE Dedicates IBM-704 Facility

First computer installation of its kind has been inaugurated by the General Electric Co.'s Computer Department on the Campus of Arizona State College.

The center is equipped with an International Business Machines Corp. 704 computer that will be jointly used by GE and the College.

H. R. Oldfield, general manager of GE's computer department predicted at the opening ceremonies that present computer sales of $450 million annually would rise to over $1 billion by 1966.

Martin To Expand Denver Facility

Recently completed $10-million plant of The Martin Co. in Denver will undergo further expansion at a cost of $2 million. Plan calls for addition of an engineering laboratory, extension of the administration building and of the plant cafeteria.

Martin now employs 2,500 at the facility and expects this figure to double in 1958.

Ryan Sales Increase, Net Drops in 1956

Ryan Aeronautical Co., producer of the Firebee jet-powered target drone, showed a 19% decrease in net profit last year despite an increase from $41,527,770 to $46,998,925 in sales for fiscal year ended October 31.

Declining profit was attributed to high "make-ready" costs in early phases of new items production.

Ryan backlog, however, increased $17 million and now stands at $92 million. In addition to the Firebee production, president T. Claude Ryan cited missile guidance as one of three phases of aviation electronics work being carried forward by the company.

Boeing Gets New Plant For *Bomarc* Manufacture

Boeing Airplane Co. will take over a former Army Corps of Engineers plant for *Bomarc* missile and B-52 bomber production under a recent Army-USAF agreement.

Some 100,000 sq. ft. of the new plant will be used for Bomarc work along with 200,000 sq. ft. of its new Development Center now in the construction stage. Balance of the 347,000 sq. ft. Army plant will be allocated to B-52 manufacturing and will be fitted with eight spar and two skin mills.

Convair Astronautics Move to Begin in June

Convair Astronautics Division expects to begin shifting personnel into its new $40 million Kearny Mesa plant late in June. First building up will be the engineering laboratory.

Plan is to transfer employes as space and facilities become available, with the overall shift extending from June through December.

In July, Convair will partially occupy two office buildings, one for engineering and the other administration. Cafeteria, power and security buildings will also be completed about the same time.

Last building slated for occupancy will be the manufacturing plant expected to be completed in November.

Missile Sales Up At Lockheed

Missile Systems Division of Lockheed Aircraft Corp., in the two years since its formation, has increased its sales seven-fold, quadrupled its work force and more than doubled its laboratory, office and production space, according to Lockheed president Robert E. Gross.

Gross places present sales at about a $70-million annual rate. MSD now has 1,000,000 sq. ft. at facilities in Van Nuys, Palo Alto and Sunnyvale, Calif. and has started construction of a 3,200-acre test center in the Santa Cruz mountains.

Two Contracts Let For New Fuels Plant

Air Force and Navy last month awarded contracts totaling $71.5 million for construction of facilities to produce high energy fuels.

AF contract, issued by Air Materiel Command, went to Olin Mathieson Chemical Co. in the amount of $33.5 million for a plant to be located at Niagara Falls, N. Y.

Navy's award to Callery Chemical Co. is further advanced than that of USAF. Ground was broken early last month on a $38-million facility at Muskogee, Okla. and output of HiCal, a boron compounded high-energy fuel, is expected late next year.

Bomarc Contract In The Making

The Air Force and Boeing began negotiations early last month for the first volume production contract for the IM-99 *Bomarc* pilotless interceptor missile. Weapon will be manufactured principally in Seattle with support from

Wichita. Boeing will utilize 100,000 square feet of an Army Corps of Engineers facility in the Seattle area for *Bomarc* work. The government-owned facility was made available by the Air Force after working out an agreement with the Army.

Hughes Adopts Work-Study Plan

Hughes Aircraft Co. has launched an engineer work-study program with three universities designed to provide full payment of college tuition and related expenses for undergraduate engineers it employs.

Hughes officials said the plan is expected to increase to 950 the number of part-time or full-time employes studying for degrees at company expense. The new plan extends the program outside of the company for the first time.

Schools associated with the program are Loyola Univ. of Los Angeles; Univ. of Southern California and Univ. of California at Los Angeles.

Temco Names Plant For Missile Work

Temco Aircraft Corp., known recipient of a Navy contract to design and develop the *Corvus* missile, has designated its Garland, Tex. plant for missile and drone production.

Before the *Corvus* award, Temco won a Navy competition to build the XKDT-1 rocket-powered missile target drone.

ACF-Erco To Build Missile Arming Units

Contracts for design and development of safety and arming devices for Air Force's Boeing *Bomarc* and Army's Chrysler *Redstone* missiles have been awarded by the Army to Erco Division of ACF Industries, Inc.

Three Missile Firms Get Rapid Writeoffs

Three rocket and missile firms—Aerojet-General Corp., Propulsion Research Corp. and Convair were on the most recent list of firms receiving rapid tax amortization of new facilities.

Aerojet was allowed 60% by Office of Defense Mobilization in certifying $417,740 for research and development facilities.

Accelerated tax amortization to Propulsion Research Corp., also for R&D facilities, amounted to $88,359 at 70%. The Convair certificate for R&D facilities: $17,022,000 at 60%.

Fruehauf Converts Missile Capacity

Fruehauf Trailer Co. is planning to convert the entire capacity of its Delphos, Ohio plant to handle increasing defense contract work, primarily missile ground handling and support equipment.

Company reports it now builds such equipment for six major missile types and is in design and prototype phases for a number of others.

Current projects are *Redstone, Regulus, Thor, Nike Matador* and *Ding Dong.*

Anadite Opens Plant at Hurst, Tex.

Anadite, Inc. of South Gate, Calif., specialist in chemical milling and finishing of aluminum, magnesium and steel, opened a new 20,000 sq. ft. plant at Hurst, Tex. on April 1. Firm will be called Anadite, Inc. of Texas and will employ more than 100.

New facility is situated on a 3-acre site and represents an investment of more thain $500,000.

Republic Gets ICBM Subcontract from GE

Republic Aviation Corp. Guided Missiles Division will build an undisclosed number of Convair ATLAS ICBM nose cone structural units under a $500,000-plus contract from General Electric.

Republic plans to handle tooling and heavy machining for the contract at its plant at Farmingdale, N. Y.

M-H Nets $22 Million Report Sales Up 18%

Minneapolis-Honeywell Regulator Co. reports an 18% increase in sales during 1956 to a record $287,944,462, up from $244,842,068 the previous year. Earnings were $22,463,657 compared to $19,278,648 in 1955.

Insurance Firm to Build Lockheed Missile Facilities

Prudential Insurance Co. has entered into an agreement with Lockheed Aircraft Corp. under which it will provide facilities costing about $14 million and lease them to Lockheed's Missile Systems Division on 25-year terms.

The deal is believed the first in which an aircraft company has used facilities provided by insurance companies as a means of preserving working capital.

In the Lockheed program, Prudential is acquiring title to 83 acres of the 275 owned by Lockheed at Sunny-

vale, Calif. and also is taking a 99-year lease on a portion of the research laboratory ground at Stanford Industrial Park, Palo Alto.

Navy Orders *Talos* Missile

Navy has awarded Bendix Aviation Corp. a $27 million contract for quantity production of the ramjet-powered *Talos* surface-to-air missile. First *Talos* deliveries are expected in less than a year and are earmarked for two new missile cruisers—the *Little Rock* and *Galveston*—now undergoing conversion.

Northrop Sets Up Redstone Office

Northrop Aircraft has established an office at Huntsville, Ala. under A. A. Demetriou, former contract administrator of its Anaheim Division.

New installation will represent Northrop's subsidiary Radioplane Co. at nearby Redstone Arsenal.

Thiokol Acquires New Firm

Thiokol Chemical Corp. has acquired full control of National Electronics Laboratories of Washington, D. C. through an exchange of stock. It will operate the company as an independent, wholly-owned subsidiary under its existing name.

Republic Payroll Tops $1 Billion

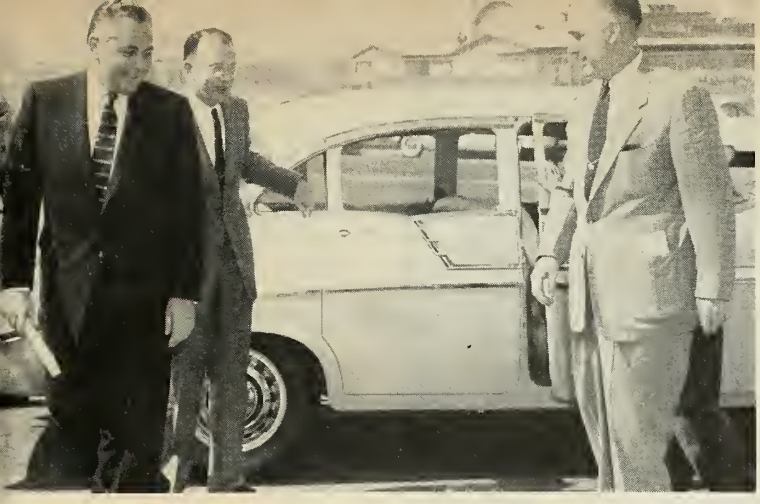
Republic Aviation Corp. builder of the *Terrapin* upper air research rocket, recently joined the ranks of aircraft manufacturing firms paying out $1 billion or more in salaries when its 1956 payroll reached $1,002,074,000.

Republic paid a year-end bonus of nearly $2 million to put it in the billion-dollar wage bracket for the first time.

$19.5 Million Contract for Associated Products

Martin-Denver has awarded Associated Products Corp., subsidiary of American Machine and Foundry Co., a $19.5 million missile instrumentation contract, presumably for the *Titan* ICBM.

Simultaneously, AMF announced plans for a 28,000-sq. ft. plant expansion in El Monte, Calif. to be used for production and assembly of missile ground instrumentation and check-out equipment and an 18,000 sq. ft. structure at Englewood, Calif., for field engineering.



Dr. Louis G. Dunn, Vice President and Director, Guided Missile Research Division, The Ramo-Wooldridge Corporation, left; Dr. Dean E. Wooldridge, President and Treasurer, Ramo-Wooldridge Corporation and the Honorable Lyle S. Garlock, Asst. Secretary of the USAF for Financial Management arrive at the Western Development Division Headquarters to attend a briefing.

Col. D. F. Miller, left, and Brig. General Don R. Ostrander, register at the Western Development Division for a meeting with Maj. Gen. D. N. Yates, Chairman Guided Missile and Space Vehicle Committee.

r. Ralph W. E. Reid, Asst. Director, Bureau of the Budget, far left; Alvin O. Waggoner, xecutive Secretary Ballistic Missile Committee, Office of the Secretary of Defense; Wreatham . Gothright, Asst. Director, Bureau of the Budget, sign in at the Headquarters of the Western Development Division while Capt. Dan Babcock looks on.

laj. General B. A. Schriever and the Honorble Richard E. Horner, Asst. Secretary of ıe USAF for Research and Development disıss phases of Ballistic Missile research uring a visit Sec. Horner made to WDD.

Dr. Clark B. Millikan, Acting Chairman Scientific Advisory Committee, left: Brig. Gen. D. R. Ostrander, Asst. Deputy Commander for Weapons Systems, ARDC, and Committee member George B. Kistiakowsky enter the WDD Headquarters building for a Committee meeting.

ARDC Information Director Col. Albert A. Arnhym, right, gets congratulations after receiving Legion of Merit from Lt. Gen. Thomas S. Power, ARDC Commander.

J. R. Dempsey, formerly program director of the ICBM Atlas project, has been named manager of Convair's new Astronautics Division. Other officers appointed are **K. J. Bossart,** tech. dir.; **Mortimer Rosenbaum,** chief engr.; **H. R. Friedrich,** asst. chief engr. for development; and **Krafft A. Ehricke,** asst. to the tech. dir.

Dale A. Lichty, senior vp. has been elected president of Hydro-Aire, Inc., succeeding **Homer H. Rhoads,** resigned.

Joseph Philipson has been appointed director of Atlantic Research Corp.'s newly formed Western Div. with headquarters at Pasadena, Calif. **Turner W. Ivey** has joined the Chemistry Div. in Alexandria, Va., where he will supervise junior engineers in the production of solid propellant rockets, and in further development of propellant production methods and processes.

LICHTY

DEMPSEY

Dr. L. L. Wheeler, formerly chief engr., has been appointed industrial relations vp of Sperry Gyroscope Co.

Dr. Robert P. Petersen, former dir. of nuclear research for Republic Steel Corp., was elected president of Applied Research, Inc.

Asst. Secy. of Defense **Frank D. Newbury** has been appointed to the newly created position of Asst. Secy. for Research and Engineering, with **William M. Holaday** as his Deputy.

R. L. Cunningham, asst. mgr. of the engineering personnel offices of both the Missile Development division and Autonetics, has been named mgr. of Missile Development division's engineering personnel.

Philip I. Chase, head of the materiel div., has been elected vp-manufacturing, and **Joseph Corie,** asst. to the executive vp, has been elected secy.-treas. of Radioplane Co.

James R. Lewis has been appointed dir. of public relations for The Ramo-Wooldridge Corp. Formerly senior staff asst. in the Guided Missile Research Div., he will continue special assignments on management problems and program information.

Three promotions have been announced by the U.S. Naval Air Rocket Test Station: **Irving Forsten** becomes chief engineer, **Frederick R. Hickerson** replaces Forsten as senior project engineer, and **John J. Canavan** goes from head of the Test Branch to head of Rocket Test Div.

Orrin C. Bowers has been appointed chief engineer of BJ Electronics, Borg-Warner Corp.

Alfred Finzel, former Chief of Structures for the Army Ballistic Missile Agency at Redstone Arsenal, has been appointed Project Engineer in Ramjet Design for the Wright Aeronautical Div. of Curtiss-Wright Corp.

James M. Jackson and **Dr. David S. Stacey,** formerly in charge of the Research Service Laboratories at the Univ. of Colorado, have been named director and technical dir. respectively of the newly formed Ball Brothers Research Corp. at Boulder, Colo. The corporation will conduct research in electronics, aerophysics, optics, servomechanisms, and other instrumentation.

Louis Bucalo has been promoted to asst. chief engineer at Specialties, Inc. and **F. P. Caruthers** has been appointed project engineer at the company's Syosset plant, L. I., N. Y.

Dr. Robert W. Buchele, formerly a faculty member of the UCLA School of Business Administration, has been named staff administrator for Northrop Aircraft's new executive development program.

O. A. Wright, staff engineer for Lockheed's Missile Systems Div., has been appointed engineering mgr. of Actuation Research Corp., Glendale, Calif.

Capt. Marshall B. Gurney (USN, ret.) has been named manager of the Govt. Relations Dept. at Raytheon Mfg. Co.'s Santa Barbara, Calif. laboratory.

C. M. Martenson has been elected vp and gen. mgr. of Hydraulic Research and Mfg. Co. Other company officials announced are: **S. A. Baker,** treas., and **J. R. Haber,** asst. secy. and treas.

FINZEL

missile literature

GYROS. Aeronautical Division, Minneapolis-Honeywell Regulator Co. has published a 28-page booklet containing specifications and variations of its major hermetic integrating, rate and cageable vertical aeronautical gyros.

Circle No. 109 on Subscriber Service Card

INFRARED DEVICES. Electronics Corporation of America has prepared an 8-page booklet describing infrared-sensitive lead sulfide photoconductors it produces for detection and guidance systems.

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INSTRUMENTS. Precision guidance and control instruments produced by Humphrey, Inc. are illustrated in 24-page catalog.

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LIQUID OXYGEN SWITCHES. Engineering Bulletin issued by Revere Corp. of America describes its series of liquid oxygen float switches designed to indicate or control liquid oxygen levels. Units weigh 4 oz., operate at temperatures from —320° to 200°F.

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MISSILE CONTAINERS. Specially designed containers for missiles, missile components and electronic equipment are described in 8-page brochure by Craig Systems, Inc.

Circle No. 100 on Subscriber Service Card.

HITEMP ALLOYS. Twenty-page booklet issued by The Carpenter Steel Co. gives engineering data and fabrication characteristics of ten high-strength alloys it produces for elevated temperature service in aircraft and missiles.

Circle No. 101 on Subscriber Service Card.

SILICONE FLUIDS. Dow Corning Corp. offers a 4-page reference brochure outlining physical and electrical properties of all leading silicone fluids now commercially available.

Circle No. 102 on Subscriber Service Card.

SEALED RELAYS. Four-page bulletin published by A'G'A Division, Elastic Stop Nut Corp. of America. describes hermetically-sealed, Agastat time delay relays.

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