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missiles and rockets

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In This Issue:

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editorial

How USAF Can Aid and Benefit Too

THROUGHOUT THE ALMOST FIVE DECADES of military aeronautical development, civil aviation has been a great and positive beneficiary.

Will the civil sciences (including civil aviation) benefit in like measure from the military development of missiles and rockets?

This is a very logical question. There are many skeptics unable to foresee much real gain for the civil world in the necessarily hush-hush weapons projects now under tight military control. Up to now, at least, the military services have hardly been in a position to use an open road approach for cooperating with the civil sciences.

But the answer to the question of benefit is resoundingly in the affirmative. And there is at least one positive indication that the military services are fully cognizant of the need for cooperation.

Meteorologists, astrophysicists, geologists and others have been aware of the tremendous potentialities that guided missiles embrace as research tools for their respective fields. Up to now much of valuable scientific information obtained from upper air rocket research has been closely held by the military.

But now comes the USAF's Air Research and Development Command with a heartening attitude. Lieutenant General Thomas S. Power, ARDC's Commander, told the Aviators Post of the American Legion in New York last month that there must be better cooperation between civilian and military in joint scientific ventures and that such cooperation will benefit both. He gave every indication of recognizing and understanding the grave problem of scientist and engineer shortage. He stressed, too, the importance of giving scientists freedom in their work.

This forward-looking attitude is being translated into action. The test phases of the advanced USAF missile projects, such as the ICBM programs, are understood to be considered for joint scientific-military advantage. Since USAF needs to test its big missiles under almost true space flight conditions, it realizes that such tests will yield incalculably valuable information to many sciences.

The cooperation between the military and scientists in the space flight program is well known. The extension of this cooperation into the field of missiles and rockets holds great significance, for ICBM's in true space flight conditions should harvest a vast amount of scientific data.

We salute ARDC and General Power for this new look of cooperation and suggest that this joint effort can lead to even greater scientific progress. Many top missile scientists have discussed the feasibility of using ICBM hardware for scientific research flights to the moon and for circumlunar flights. In its search for the "ultimate" weapon in ballistic missiles, the USAF may find unlimited avenues to success by greater use of scientists from many fields in its weapons program.

WAYNE W. PARRISH.

missiles and rockets **vol. 1 no. 3**

features

news & trends

rocket engineering

industry spotlight

next issue

January m/r will feature Navy Missile Power and Navy Astronautics. Also: Buyer's Guide to the Electronics Industry.

cover picture:

M/R's cover shows test bed firing of a 50,000 lb. North American/Rocketdyne oxygen-alcohol engine for Cook Research Laboratories' Mach 2 test sled. Perfect diamond shock patterns depicted here will become an increasingly common sight to American missileers as vehicles like NAA's intercontinental Navaho reach full operational development. See Henry T. Simmon's feature article, page 77.

columns

departments

photo credits:

Harry Compton, E. Hull, pp. 24, 25, 26; GE, p. 32; Avco, p. 33; U.S. Air Force, pp. 55, 57, 58, 59, 60, 61, 62; Douglas, p. 65; NAA, pp. 77, 78; m/r, pp. 82, 83, 84; Aerojet, pp. 90, 91, 131; Westinghouse, pp. 99, 101; South African Interplanetary Society, p. 102; Exide, pp. 106, 112.

when and where

NOVEMBER

Nov. 28-30—First International Congress on Ozone, sponsored by Armour Research Foundation, Sheraton Hotel, Chicago.

DECEMBER

Dec. 3—Flight Safety Foundation's 1956 seminar in cooperation with MATS, West Palm Beach, Fla.

Dec. 5-7—Instrumentation Conference sponsored by IRE Professional Group on Instrumentation, Atlantic Section, Atlanta Biltmore Hotel, Atlanta, Ga.

Dec. 6-7—Third Annual Meeting of American Astronautical Society, Edison Hotel, New York City.

Dec. 10-12—Eastern Joint Computer Conference sponsored by IRE, AIEE, ACM, Hotel New Yorker, New York City.

Dec. 17—Wright Memorial Dinner, Sheraton-Park Hotel, Washington D. C.

JANUARY

Jan. 14-15—Third National Symposium on Reliability and Quality Control in Electronics, sponsored by IRE, AIEE, RETMA and ASQC, Hotel Statler, Washington, D. C.

Jan. 28-31—Eighth Annual Plant Maintenance Show, Public Auditorium, Cleveland.

Jan. 28-Feb. 1—Institute of the Aeronautical Sciences 25th annual meeting, Sheraton Astor Hotel, New York City.

Jan. 30—Electronics in Aviation Day, sponsored by PGANE, IAS and RTCA, New York, N. Y.

FEBRUARY

Feb. 14-15—Air Force Assn. Annual Jet Age Conference, Sheraton Park Hotel, Washington, D. C.

Feb. 26-28—Western Joint Computer Conference, sponsored by IRE, AIEE and ACM, Hotel Statler, Los Angeles.

MARCH

March 7-9—National Conference on Aviation Education, sponsored by National Aviation Education Council, Mayflower Hotel, Washington D. C.

March 25-27—American Society of Tool Engineers, Silver Anniversary annual meeting, Shamrock Hilton Hotel, Houston, Texas.

book reviews

AIRCRAFT MATERIALS AND PROCESSES. *By George F. Titterton, 5th edition. Published by Pitman Publishing Corp., 2 West 45th St., New York. 398 pp., illustrated.*

An up-to-date treatment of latest processes, materials and specifications used in the aircraft industry, authored by the Asst. Chief Engineer of Grumman Aircraft Engineering Corp. Includes emphasis on new materials such as titanium, plastics, superstrength steels. J. S. M.

OPERATIONS RESEARCH, ARMAMENT, LAUNCHING, *By Grayson Merrill, Harold Goldberg, Robert H. Helmholtz, Third of a series of six edited by Capt. Grayson Merrill, U.S. Navy. Published by D. Van Nostrand Co., Inc., 120 Alexander St., Princeton, N. J. 508 pp. $10.00*

This third volume of this ambitious series sets out to tell guided missile designers, engineers, instructors, graduate students and everyone connected with modern aerial warfare something about the strategy and tactics of missile warfare; why they're needed; what kind of warheads for what kind of targets; the operational conditions under which they will be stored, transported and used.

The book was apparently written on the very valid assumption that even the most technically concerned will be better able to make the best judgment if he knows something of the why and how of a project's ultimate use.

It is not, however, a book for the layman or political science student. It treats its subjects—operations research, armament and launching—with scientific accuracy and thoroughness. But for all its thoroughness, it is still broad in scope as a listing of some of the chapter headings will indicate. The first, National Procedure, covers the basic responsibilities in the missile field of the armed services and of the contractor, including sections on Government laboratories, educational institutions, etc. Chapter three is called Determination of an Operational Requirement, covering weapons effectiveness, target damage definitions, weapons shortcomings, etc. Additionally there are chapters on tactical doctrine, mathematics of operations research, armament research and development, target vulnerability, warheads; fuzing requirements, safety requirements and arming components, evaluation and testing; elements of launching and design principles.

Operations Research shows how armed services requirements derive from legal roles and missions and outlines the teamwork in the missile industry needed to meet these requirements. The Armament section describes how to design a missile warhead and fuze to destroy its target. The Launching section treats the booster assemblies, catapults, and airborne and surface launchers that are used. The vocational potentialities of the book are rather obvious.

For those who intend to develop, manufacture or use guided missiles this third volume should prove a valuable library addition. S. H.

RADIO TELEMETRY. *By Dr. Lawrence L. Rauch and Myron H. Nichols, 461 pp, 2nd Edition, $12.00. John Wiley & Sons, Inc., New York.*

At last a book on this subject is available. For the first time material previously scattered in reports and papers is brought together. Although a 2nd edition, the first was a limited printing for the Air Force. Methods, foundations and techniques are given together with appendices. For anyone doing telemetry research and development the book is a "must". Rauch's position among the "firsts" in this field as a telemetering scientist is well known. His and Nichols' experience is well attested in the completeness of the material both in technical and practical matters covered.

PROPERTIES OF COMBUSTION GASES. *Prepared by Aircraft Gas Turbine Development Dept., General Electric Co. Published by McGraw-Hill Book Co., Inc. Two volumes. $75.*

A set of comprehensive combustion gas thermodynamic tables, compiled for the first time, with the aid of an International Business Machines Co. electronic computer, that is expected to prove of considerable value to those engaged in combustion research, in development of gas turbines and turbojet engines and in aircraft and missile propulsion studies.

FLUID DYNAMICS OF JETS. *By Shih-I Pai. Published by D. Van Nostrand Co., Inc., Princeton, N. J., 228 pp. Price, $5.50.*

A comprehensive treatment of the subject by an associate research professor of the University of Maryland's Institute of Fluid Dynamics and Applied Mathematics, this book was designed to meet the needs of engineers, research workers and students.

letters

British Not So Far Ahead

To the editor:

. . . In your November issue, page 50, under the heading "British Move Ahead," you make the following statement about the rocket grenade experiment for upper-atmosphere temperatures and winds:

"This is not a new technique, having been previously used by a U.S. Naval Research Laboratory . ."

Actually, the experiments have been carried out previously at the White Sands Proving Ground by the Signal Corps, U.S. Army.

It might be of interest to your readers that the all-weather rocket-grenade experiment will be carried out during the IGY at Fort Churchill, Manitoba, Canada, as a joint Signal Corps-University of Michigan venture. A pre-IGY firing, Aerobee SM 1.01 was successfully carried out on November 12, 1956 . . .

Dr. Joseph Otterman
High Altitude Engineering Lab.
Dept. of Aeronautical Engineering
University of Michigan
Ann Arbor, Michigan

Satellite vs. Earth Rotation

To the editor:

. . . MISSILES & ROCKETS, Vol. 1, No. 1, p. 78, says: "*Vanguard* will be launched at an angle of 35 to 45 degrees to the equator in a southeasterly direction. During each orbit of the satellite the earth will have moved about 1600 miles to the east if the orbit requires an hour and a half." Page 18 of the National Academy of Science's booklet INTERNATIONAL GEOPHYSICAL YEAR states that the satellite is to be sent into a southeasterly orbit at 18,000 mph and at an altitude of 300 miles above the Florida coast; it will make one revolution every 1½ hours, each time appearing about 25° further to the west of the launching site, due to the eastward motion of the earth beneath it. These calculations appear to be in error through failure to consider that the satellite, into whatever orbit it may be accelerated, will still retain the eastward motion it possessed while resting on the surface of the earth, so that the entire orbit will revolve almost in synchronism with the rotation of the earth.

It is fallacious to state that the "earth will rotate beneath the satellite" while the satellite is making an orbit, as if the satellite had been captured after approaching from outer space. As acceleration is imparted to the satellite at the launching site it will have only one relative motion; it will return (at the surface) to the original position after completing an orbit, regardless of any motion of this point in space, since the satellite also has this inherent motion.

It is apparent that any simple acceleration in any direction can only determine the angle of the satellite orbit with the equator, but will not prevent the satellite from returning to the same point, or the rotation of the orbital plane with the rotation of the earth. The orbit will be distorted by the Coriolis effect but this effect is equal and opposite in the two hemispheres, cancels and may be disregarded in relation to this problem.

The eastward motion of the surface of the earth crossing the earth-sun line at Cape Carnaveral (N. Lat. 28°30′) will be about 923 mph. The satellite will be in orbit at an altitude of approximately 300 miles, however, at which heighth the circumference of the earth would be an additional 1,917 miles, requiring an easterly motion of 993 miles per hour to maintain the position of the orbit with respect to the rotating earth surface at the launching site. Since no special east-west accelerations are to be provided, the satellite will fall behind, but only 120 miles further west of the launching site with each revolution of 1½ hours, approximately 2° of longitude, not the anticipated 25°.

This means that the satellite would return approximately overhead again only after some 180 revolutions, or 270 hours (11¼ days), rather than the expected 14-15 revolutions (21-22 hours). It will appear only some 120 miles to the west of Cape Carnaveral after completing the first revolution, 240 miles after the second, etc., giving the observers of the western U.S., Asia and South America excellent opportunities for observation, but possibly not surviving long enough to be seen over the eastern U.S.

As startling as these considerations are concerning the success of proposed observations, it appears that they are soundly based and an immediate review of plans are in order . . .

Yours truly,
Charles C. Littell, Jr.
Engineering Associates
Dayton 9, Ohio

The U.S. Office of Naval Research which has cognizance over VANGUARD launching, states that the earth's velocity has been taken into account in the original launching and orbiting calculations. It is a vector in the total. NRL says further that once the satellite is in an orbit, it is a separate entity, and the earth can rotate under it just as it does under its larger satellite, the moon.

ed.

Radiation Pressure

To the editor:

. . . In reading the articles on space flight and the earth satellite program, I wonder if any scientist has considered the effect of the sun's light on the satellite or the space vehicle. When I took physics in high school, we had an instrument in the classroom which reacted very readily to light projected against it. I have forgotten its name, but you will recognize it from my description.

Two pieces of aluminum foil were mounted at 90° to each other upon a bearing to form a crossed vane assembly which because of the bearing were free to revolve. Alternate sides of the vanes were painted black.

As the assembly revolved in the beam of light, the shiny side of one vane was always exposed to the light and was repelled by the light rays causing the vane assembly to revolve very rapidly. This entire assembly was enclosed in a glass bell from which the air had been removed.

If such an action takes place under comparatively weak light in a partial vacuum, what will the result be when extremely strong sunlight strikes the surface of a light shiny object such as your satellite in perfect vacuum of outer space?

You will recall another effect indicating the strong pressure of sunlight in the action of the luminous particles and gas making up the tail of a comet as it approaches the sun and swinging around it heads out into space again. The tail of the comet is always *away* from the sun as if a strong wind from the sun were blowing it, even when the speed of these particles in the tail must exceed that of the comet itself to place the tail always *ahead* of the comet as it rushes away from the sun in its return to outer space.

I'm not a scientist and I lack the "know-how" to calculate the pressure of sunlight on a surface of any given size, but as a very interested layman in the conquering of space I can't help wondering from my high school science whether this idea has been considered.

Perhaps if the pressure is sufficient why not utilize it, like a ship when sailing at sea in a strong wind, to propel a space vehicle once it had neither atmosphere nor gravity to retard it.

Norman F. Blubaugh
7148 W. 93rd Place
Los Angeles 45, California

Reprints Wanted

To the editor:

. . . I very much enjoyed reading the first issue of your magazine. It is timely and fulfills a real need in the field.

Particularly, I enjoyed the article entitled "Teamwork: Key to Success in Guided Missiles," by Dr. Wernher von Braun.

If reprints of this article are available I would greatly appreciate it if you would send me six copies . . .

Joseph M. Cahn
Guided Missile Research Division
The Ramo-Wooldridge Corporation
8820 Bellanca Avenue
Los Angeles 45, California

To the editor:

. . . The performance chart concerning liquid propellants and oxidizers included in your November, 1956 issue of Missiles & Rockets, after page 134, can be very useful to me. I would appreciate a reprint of the chart if one is available . . .

L. H. Sachs, Attorney
Legal Department
General Electric Company
Building 100
Evendale, Ohio

To the editor:

. . . The article, "Teamwork: Key to Success in Guided Missiles" by Dr. von Braun in the October 1956 issue of M&R, expresses most succinctly the attitudes here at Douglas regarding the development of guided missiles. We would like to give each of our engineers a copy of this article and therefore wish to know whether reprints of it are available.

E. P. Wheaton
Chief Missile Engineer
Douglas Aircraft Company, Inc.
Santa Monica Division

Missile Production Is Challenge

To the editor:

. . . Congratulations on the test flight and number 2 of Missiles & Rockets. They are excellent prototypes for what is destined to be the leading publication in man's last frontier.

We who are actively engaged in this field have awaited just such a magazine; the context and format of M&R are perfect.

The writer hopes that future issues will carry some articles on the production aspects of the business, as well as the interesting engineering side. The actual production analysis, tooling and material handling problems which production engineers must surmount to produce these new vehicles are challenging. The new avenues explored and techniques developed for the fabrication and assembly in metals which were laboratory specimens a short time ago are every bit as fascinating as the aerodynamics and propulsion problems which daily confront the designer. Tooling up for miniaturized cybernetics can be as interesting and challenging as the original design for the systems.

This production engineering is what gave America her technological advantage over the rest of the world. It is hoped that, within the limits of Security, (there goes that word again) some of these facets can be explored in your pages . . .

Chris Lembesis, P.E.
Unit Leader, Material Handling and Plant Layout
Missile Development Division
North American Aviation, Inc.
Downey, Calif.

Wilson Shocks Nation's Rocket Experts

Defense Secretary Directive Confounds Missile Men at American Rocket Society Annual Meeting

By Erik Bergaust and Seabrook Hull

NEW YORK—The timing of Defense Secretary Wilson's "roles and missions" directive cutting the heart out of the Army's guided missile effort was uncanny enough almost to have been intentional. The edict fell and exploded like one of their own devices, wreaking shock and confusion among some 1600 top U.S. rocketeers and missileers gathering in New York City for the Eleventh Annual Meeting of the American Rocket Society.

Though Wilson's latest missile order (see page 70) was meticulously avoided as a subject for discussion on the Society's formal agenda, it topped all others as a topic of talk and perplexed-to-heated comment in hotel hallways, rooms and hospitality suites.

The general consensus among the men who design, engineer and produce America's super-weapons ranged from a puzzled "Hmmm . . ." to "It just doesn't make sense . . . a life or death decision for the country . . . the easy way out in settling an interservice squabble . . ."

In other ways, the ARS annual meeting was the most successful yet. To the industry, it was certainly newsworthy and profitable. Papers presented ranged from such titles as: *Theory and Experiment on the Burning Mechanism of Composite Solid Propellants, Molybdenum for High Strength at High Temperatures,* and *British Sounding Rockets to: Lifetime of Artificial Satellites of the Earth, Some Social Implications of Space Travel,* and *Projecting the Law of the Sea into the Law of Space.*

More than ever before, there was a sense of "having arrived." Missiles and rockets were fast becoming the most important U.S. defense industry. Space flight already was in the serious planning stage. The general public's knowing smile of tolerant superiority had changed to a look of serious respect for a vital, deadly business.

As outgoing ARS President Noah Davis handed over the keys of office to incoming President Commander Robert C. Truax, the society found itself in the best condition in its history. It was financially solvent with "comfortable" reserves. Membership was increasing at a rate of 200 a month with an "over 6,500" year-end membership virtually assured.

Plans were approved for doing even more to enable the ARS journal, *Jet Propulsion,* to serve its membership better. New committees were set up in the areas of solid propellant rockets, liquid propellant rockets, ramjet propellant and combustion, instrumentation and guidance and space flight. Commander Truax predicted that these committees would "sink their roots deep among the

1957 ARS President Truax
. . . *Calm mind for crucial job*

Rocket Society's A. C. Slade
ARS finances in good shape

IRBM man Lovell Lawrence
"I could teach in Carolina . . ."

membership and play a major part in fostering the technical life of the society." Two new board members, Convair's Krafft Ehricke and Lt. Col. John P. Stapp, were elected to replace retiring members John B. Cowen and George P. Sutton.

Wilson Brings Consternation

The shock and surprise at Wilson's order limiting Army missile operations to firings of 200 miles or under stemmed not from theories and convictions over the military roles and missions of the three services. It came from deep concern, even alarm, at the possible ultimate effects of this decision on America's race with Russia to maintain technological superiority in the air.

The most oft-heard question was "What does this mean to Redstone Arsenal's Intermediate Range Ballistic Missile project?" The most advanced of all the ballistic missile programs, it looked at first glance as though when money appropriated for research in 1957 had run out, that would be it. Why should the Army fight for research funds to build a missile it could never use? And what would happen to the top research and development team, a ballistics missile team, built up under rocket pioneer Wernher von Braun?

In line with the Army's newly assigned sole cognizance over short range surface-to-air missiles would they be ordered to adapt ballistics know-how to anti-aircraft missiles? Bell Telephone and Douglas Aircraft wondered too—would their anti-aircraft *(Nike)* missile experts suddenly be asked to go ballistic? And Chrysler Corporation wanted to know: "Do we stop making *Redstone* missiles or will our contract be shifted over to the Air Force?

Wilson's directive may have cleared some confusion in the Pentagon, but what everyone is wondering now is if it didn't create a great deal more on the outside where many think it counts more—in the industry.

And there was bitterness too. "What ballistic missile does the Air Force have?" was one question. "Of course, the Air Force has *some* missiles, but what are they? Of their air breathing missiles the *Matador* is inadequate and obsolescent. The *Snark* is a subsonic missile which is already obsolescent, although it is not even ready."

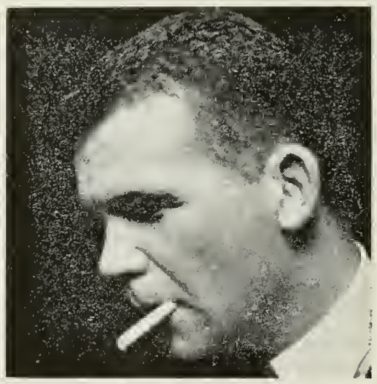
". . . the *Nike* can shoot down a *Navaho* . . . four USAF fighters and a bomber, the B-58 Hustler, are faster than the *Snark* . . . After fooling around for 12 years with air breathers; only after much resistance, AF finally conceded there might be something to ballistics missiles after all . . . Army already has much experience . . . in the joint Jet Propulsion Laboratory-Army project a *Jupiter* device was fired more than 3,000 miles . . . 95% of U.S. ballistics know-how is in the Army."

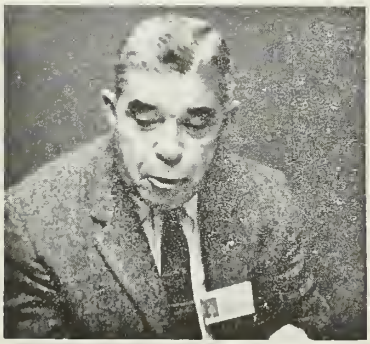
These were but a few of the comments that flew fast and heavy against the decision during the week-long ARS session. Some points might have been stretched a bit in the enthusiasm and deep-seated feelings of the speakers. However, they express the views and feelings of men who form the very heart of our missile effort. They are the brains, the inspired and dedicated men, the pioneers with the imagination and technological abilities to probe the unknown. They are the brains without which this country cannot win the battle of technology it now wages with Communist Russia. And the fact that these brains are now troubled

ARS Personalities


Wernher von Braun
. . . People stood up and applauded


Edwards AFB's Gompertz
. . . Keep testing until they work


GE's Fred Brown
. . . Rocket engine sales up


Aerojet's George Pelletier
. . . No change in ICBM contracts


Convair's Krafft Ehricke
. . . New ARS director


Boeing's Norman Baker
. . . Will the AF keep Bomarc?

COOPER DEVELOPMENT'S WASP ROCKET displayed at Coliseum power show.

may be the most serious result of the new roles and missions directive.

In this connection MISSILES & ROCKETS obtained the following statement from Major General J. B. Maderis, Commanding General, Army Ballistic Missile Agency, Huntsville, Ala.:

"The Department of Army has authorized me to announce that any existing developmental missile program will not be affected by any forthcoming decision in service operational responsibilities. The Secretary of Defense has repeatedly stated that a decision with reference to roles and missions would not involve the termination of any particular weapon system."

There was a notable lack of comment in support of the Defense Secretary's decision. Though there were AF representatives attending the meeting, most were notable for their silence. Those who did comment backing up Wilson's views, did so without enthusiasm, apparently without conviction. And many of those who claimed agreement obviously were suprised, if not shocked, at the sweeping nature of the directive. They too wondered what it would mean in the future.

Little Hope in Loopholes

Little hope was taken from the apparent "loopholes" in the order—that this limitation on Army operations did not prevent it from "making feasibility studies." Again questions. "What did this mean? Maybe the Army could make three or four missiles and test them, but why do it, if they could never use them? Better to spend research money on projects included in roles and missions."

But talking and walking about, you got the feeling from top researchers, production men, salesmen and military leaders alike that this wasn't the end of the affair. There were guesses that Wilson would think again when he realized the full impact of what he risked. And there were convictions that Congress in the next few months would have something to say on the matter as well. As one disgruntled ARS member put it: "Wilson may have settled an argument but he started a fight."

ARS Meeting Details

Now, covering the week's order of scheduled business in a little more detail, members got a preview of some new high-altitude sounding rockets.

W. C. House, C. H. Dodge, R. D. Waldo, A. Schaff, J. L. Fuller, and O. J. Demuth—from Aerojet-General Corp., Azusa, Calif., detailed four future research rocket systems.

Douglas Aircraft Co., Santa Monica, Calif., is believed to have a *Rockair* system under development and almost ready for launching, the Aerojet group reported. This system uses an airplane as a launching platform for any suitable sounding rocket. The plane zooms into a vertical attitude, fires the rocket upward.

System No. 2 is designed to extend the 250-mile summit altitude potential of the present *Aerobee* research rockets to above 300 miles. The new system would employ an advanced vehicle similar to the *Aerobee* but with four thrust chambers which would fire two-at-a-time.

A third vehicle known as the *Spaerobee* simply adds a second stage to the *Aerobee*, pushing the rocket to a summit altitude of 350 miles with a 40-pound payload.

System No. 4 is a more general concept, concerned essentially with a staged vehicle. "Using presently available solid propellant rockets," stated the Aerojet planners, "staged vehicles can be assembled yielding almost any desired performance."

Homer E. Newell, Jr., Naval Research Laboratory, reported that a number of new sounding rockets are under development. And, said Dr. Newell, less expensive solid propellant vehicles comparable in altitude and payload capabilities to the liquid propellant *Aerobee-Hi* may be available in the near future.

John W. Townsend, Jr., Naval Research Laboratory, and Robert M. Slavin, Air Force Cambridge Research Center, described two new versions of the *Aerobee-Hi* expressly designed for upper air research in the forthcoming IGY Program.

Leslie M. Jones and Nelson Spencer of the University of Michigan, William Stroud of Fort Monmouth Evans Signal Laboratory, and

Confidential friends at ARS annual meeting.

ARDC's Col. Wm. O. Davis presented one of 48 technical papers.

Warren Berning of Aberdeen Ballistic Research Laboratory reviewed the development of the new solid propellant sounding rocket, the *Nike-Cajun,* reported that work with solid propellant sounding rockets is just beginning. Interesting developments in this field are underway, they said, and will be completed soon.

Rocket transport seen feasible

Use of a rocket vehicle as a transport capable of spanning the 3,000 miles between New York and Los Angeles in a little less than an hour has been visualized by many rocket experts for some time. G. Harry Stine of White Sands Proving Ground said that such a vehicle could be built within the next five years and proposed a possible design for a prototypal craft.

It would look similar to the Bell X-2 or the Douglas Skyrocket. Of its 65,500-pound total take-off weight, 43,500 pounds would be propellants, 20,550 pounds structural weight, and 1450 pounds would be payload.

Powered by liquid oxygen and gasoline, the rocket would cover its 1,500-mile range at speeds up to Mach 7, at altitudes up to 155 miles. This proposed vehicle, said Mr. Stine, would be an excellent research tool, an important first step in transcontinental rocket transport.

In coping with high temperature flight, one of the most promising developments, according to Robert R. Freeman of Climax Molybdenum Co., is the creation of four new arc-cast molybdenum alloys. These alloys, they claimed, have higher useful strength at temperatures over 1,600° F than any other material now known, and for temperatures over 2,400° F, ceramic and vapor-deposited molybdenum-disilicide coatings show promise of long time protection where mechanical impact, high stresses or severe thermal shock is not involved. Only recently made commercially available, the four alloys can be easily produced and fabricated.

George L. Macpherson of General Electric reported success in the solution of those problems relating to development of the *Vanguard's* first-stage power plant. First delivery of the engine, known as the X405, was made on schedule last month.

Rocket Exhibition

A special exhibition on missiles and rockets under the auspices of the American Rocket Society was featured at the 22nd National Exposition of Power and Mechanical Engineering at the Coliseum.

Nineteen exhibitors, including the prime contractor and subcontractors for all three stages of the Navy's Project Vanguard, had displays (Martin Company, General Electric Company, Aerojet-General Corporation, and Grand Central Rocket Company). Other exhibitors included the company holding systems responsibility for the Air Force IRBM and ICBM missiles (Ramo Wooldridge Corporation); the company building the rocket engine for the ICBM (Rocketdyne, Division of North American Aviation); and the country's oldest rocket engine manufacturer (Reaction Motors, Inc.).

Redstone Mortgage Crisis Eased by Local Group

Determined community action by citizens of Huntsville, Ala., has broken the tight mortgage money shortage that threatened to halt urgently needed new housing for many of Redstone Arsenal's 9,000 civilian workers.

In September, the Federal Housing Administration designated Huntsville as an emergency area and authorized "Title 809" loans of 30 years, very low down payments and 4½ per cent interest. This action had been requested by Alabama's Senator John Sparkman and Huntsville and Redstone officials. Hundreds of Redstone employes applied for loans under the new dispensation but only a sparse number was able to obtain financing through normal commercial channels.

Five Huntsville citizens and four financial companies banded together in this crisis to form a new firm to buy, sell and service FHA and Vet-

Unique Grand Central stand at Coliseum power show stresses VANGUARD challenge.

erans Administration-guaranteed mortgages. Quick Washington approval of the new firm was given by FHA at instigation of Sen. Sparkman, and loan applications are now being processed in Huntsville. Profits of the new company will be very narrow, as the 4½ per cent loans will be discounted at from 1½ to 2 per cent through the Federal National Mortgage Association, a government-sponsored agency which serves as a secondary mortgage market.

Redstone Personnel Passes 12,000 Mark

The expanding scope of missile and rocket activities at Redstone Arsenal, Huntsville, Alabama, is indicated by announcement that the military and civilian personnel at its three units has now passed the 12,000 mark and is still expanding. This includes the Arsenal itself, the Army Ballistic Missile Agency and the Ordnance Guided Missile School. This is an increase from 8,700 at the same time last year. It is very near the total employment at the same site during World War II when the Arsenal was concerned with manufacture of explosive ammunition.

UFO Board Set

The National Investigations Committee on Aerial Phenomena has named a nine-man board of governors to direct its effort to provide "more honest information" about flying saucers and space flight.

The committee is a non-profit organization set up recently to provide the public with a "broader understanding of such aerial phenomena as unidentified flying objects and the technical problems of space flight."

Elected to the board were:

Dr. Charles A. Maney, professor of physics, Defiance (Ohio) College; Rear Admiral D. C. Fahrney, retired; A. M. Sonnabend, president, Hotel Corporation of America, Boston; the Rev. Albert H. Baller, Robbins Memorial Congregational Church, Greenfield, Mass.; Brig. Gen. Thomas B. Catron, retired; Frank Edwards, radio-TV commentator, Indianapolis; Talbot T. Speer, Speer Foundation, Baltimore; the Rev. Leon C. Levan, New Jerusalem Christian Church, Pittsburgh, and Robert Emerson, Nuclear physicist, Kaiser Aluminum Company, Baton Rogue, La.

Admiral Russell Quotes m/r To Predict A-Rockets Soon

As the main speaker of the Honors Night dinner of the American Rocket Society's 11th Annual Meeting in New York, Navy Bureau of Aeronautics Chief Rear Admiral James S. Russell, USN, forecast the advent of successful atomic power for space flight in the not-too-far-distant future. In his prepared text* he said: "I have read in MISSILES & ROCKETS magazine that the Atomic Energy Commission is working on rocket propulsion. With you (ARS) and the Atomic Energy Commission working in the same science, it takes practically no extrapolation to envision safe and non-poisonous atomic fuels and extra-mundane use of atomic power for casual space travel . . . I expect these things sooner than we would normally expect them to happen."

He also predicted the wedding of rocket and turbojet engines for manned interceptors. "The manifest answer is to blend the capabilities of the turbojet and the rocket engine in a combination power plant . . . Thus with rocket power we are giving the airplane greater reach and maneuverability, as with rocket power we give its armament greater reach and flexibility of employment."

Showing how missiles are being adopted into the Navy, he said that there are now 10 *Regulus* ships operational, including submarines, and that five years from now there will be at least eight *Talos* cruisers, 22 *Terrier* ships and 17 *Tartar* ships. And he looked forward to delivery for operational use of the joint Army-Navy 1500 mile IRBM *Jupiter,* thus perhaps taking a little of the sting out of Defense Secretary Wilson's recent controversial "roles and missions" directive.

**In the actual delivery of his speech at the ARS dinner, Admiral Russell deleted the words "MISSILES & ROCKETS". ARS Secretary A. C. Slade said after the dinner that she and ARS Board Chairman Andrew G. Haley had asked the Admiral beforehand about the wisdom of mentioning m/r at the ARS Honors Night dinner. However, in the release of the speech from the Department of Defense, Washington, D. C., to the world's press, the wording was that quoted above.*

New Avco Facility

Dr. Arthur Kantrowitz (left), director of the Avco Research Laboratory, and Dr. Lloyd P. Smith, president of the Research and Advanced Development Division, survey landscaped model of the permanent facility to be built by Avco Manufacturing Corporation. The research, administration, development and fabrication complex is on a 100-acre wooded site in Wilmington, Mass.

Three *Nike* Support Units are Activated At Redstone

Three *Nike* guided missile direct support detachments have been activated at the Army Ordnance Guided Missile School, Huntsville, Ala. They are the first such units to be activated here and will broaden the range of instruction available to students in the rapidly growing service training school. They also will expand the number of trained personnel qualified to give instruction to other Army missile units as they are activated.

Their 13-weeks training cycle will include technique of missile fire, acquisition radar and computer, track radar, internal guidance, mechanical repair and launcher control.

Scientist Sees Boom In Transistor Output

Rapid growth of the transistor industry and prospects for the future of solid state physics were highlighted in information disclosed at the second annual meeting of the IRE Professional Group on Electron Devices recently in Washington, D.C.

Dr. William Shockley, director of Shockley Semiconductor Laboratories told a PGED assembly that about 13 million transistors would be produced in 1956. He estimated 40 million in 1957.

Shockley is generally credited with development of practical transistors while he was with the Bell Telephone Laboratories. He said that although practical transistor operation to 100 mc is feasible now, developments in the next few years would enable operation in the kilomegacycle range.

Advanced ideas on possibilities of semiconductors was fore-told by Dr. J. T. Wallmark, Radio Corp. of America Laboratories who disclosed data on a new light-sensitive device that could be used to guide missiles by sunlight with unheard-of accuracy.

RCA has developed a novel photocell based on voltage produced by a semiconductor junction when light is focused on it through a lens. Wallmark has found that moving the position of the light gives a varying voltage polarity along the junction from side-to-side.

Putting this "lateral voltage" to work, it was found an angular motion of the light smaller than 0.1 second of an arc can be measured. This angular sensitivity is so great, Wallmark said, that such a cell could detect the center point of the sun with "great accuracy" and form the heart of an automatic navigation system using the sun as guide.

AAS Controversy

In protest against American Astronautical Society management several well-known society directors recently resigned en masse. Following the earlier resignation of Dr. Robert W. Berry and Dr. C. C. Adams of National Research and Development Corporation, the following directors now have also quit: Dr. Wernher von Braun of Army Ballistic Missile Agency; Dr. S. Fred Singer of University of Maryland; James B. Cullum of Eastman Dillon; Krafft A. Ehricke of Convair Astronautics; Frederick I. Ordway, Heyward E. Canney, Jr. and Ronald C. Wakeford of General Astronautics Corporation. This leaves the future of the AAS very much in doubt.

B-52 As *Regulus* Missile Launcher

The Boeing B-52 may be modified to carry large missiles that will enable them to release their payload many miles from their target. Tests run with the Chance-Vought *Regulus* launched from the B-52 have shown that this combination is feasible. An AF concern with the B-52 is that not only is it five times the radar target the B-47 is, but its altitude over target, 50,000 feet, is such that it can be jumped from above by the Russian MiG-17. Also, with advances made in ground-to-air missiles, altitude alone, whether it's 50,000 or 100,000 feet, offers little protection.

The *Regulus* may be particularly adaptable to this operation. Its folding wings would probably enable it to be entirely contained within the B-52's massive bomb bay. The *Regulus* II will be supersonic and will have its own "lock-on-target" self-contained guidance system.

Expert Charts Future of Big Brother Satellite

General Electric rocket expert R. P. Haviland recently predicted that "television transmission will be the satellite's first major communication service." Briefing GE engineers on the practical future of satellites, he said the advent of man-made space stations will make it possible to simulcast programs all over the world without the use of coaxial cables or transmission systems.

Haviland, who was project engineer on the *Bumper* two-stage rocket that set a world altitude record of 244 miles in 1949, said satellites can serve as relay stations in a world-wide television system in the same way that an airplane recently relayed live TV programs from Cuba.

This is a dream long held by television network operators. Long before the coaxial cable and microwave relay stations came into their own. Not-so-dumb artists and engineers proposed elaborate networks of specially-equipped cargo planes orbiting on station continuously during each broadcast day. This was one of the first plans offered for nationwide TV coverage. But, other systems less dependent on weather and, over the long haul, less expensive came along and they were never developed.

However, the distances covered by satellites could be much greater. TV transmission is line-of-sight, and is not limited by signal strength. Being very short wave, neither would it be bothered by the ionsphere.

Haviland, now a flight test planning engineer with GE's Missile and Ordnance Systems Department, Philadelphia, said a world-wide TV system could be established with four satellite stations traveling 4,000 miles high.

They would be equally spaced about the earth and be visible at any instant from any point in the earth's equatorial region. A TV signal could then be transmitted from any ground location in this region to the nearest satellite and relayed from satellite to satellite. At the proper location, the signal would be retransmitted to a receiving station on earth.

Equipment that the satellites would have to carry for this system would be good quality receivers and transmitters. The major ground equipment needed would be large directional antenna.

Haviland continued that Project Vanguard is now under way. Yet only 10 years ago an earth satellite was strictly science-fiction material. "If large satellite relay stations could be established in an orbit 22,300 miles above the earth, then the world-wide TV system could be simplified."

He explained that at this height only three stations would be needed to cover the earth. He also forecast that satellites will be used for mapping primarily to determine the shape of the earth. This would significantly aid both astronomers and navigators.

Haviland also said that the day would come when satellites would be used in weather forecasting. He pointed out that they could view cloud coverage over extremely large areas in a short time.

Obviously, too, they would be useful strategically in watching and reporting enemy build-ups, industrial expansion, etc.

However, in the final analysis, the uses to which post-Vanguard "big brother" satellites will be put will depend largely on their initial cost of installation and their subsequent cost of maintenance in comparison with alternative means of accomplishing the same thing. Strategically, there may be no substitute for the satellite in accomplishing certain military objectives. And since the military services traditionally are not concerned with the profit motive, big satellites will find many military uses.

However, their role in such things as TV relaying will have to successfully pass close cost examination before anyone signs the first contract for hardware.

Rocket expert R. P. Haviland thinks a "Big Brother" satellite will facilitate world-wide television coverage.

Murphree: Better AAM Weapons Needed

First public disclosure that missiles would be used to defend U.S. bombers against attacking enemy aircraft was made recently by missile czar Eger Murphree when he cited the need for "more effective" air-to-air missiles for that specific purpose.

The need for air-to-air missiles will continue, Murphree explained, since the need for long range interceptor planes "will exist for a long time." While the surface-to-air missile "will largely displace short range interceptor planes," he noted, it "will not take over all the functions of the interceptor aircraft."

The Special Defense Assistant for Guided Missiles outlined general missile requirements before the 11th Associates' Day of Stanford Research Institute in San Francisco. In specific areas, Murphree told the group:

1. The *Nike* I and *Terrier* will be "gradually" outmoded as aircraft designs advance because of need for greater range and altitude capability. But their replacements—the *Nike* B and *Talos*—"are real improvements" and "will meet our needs for a while" in surface-to-air developments.

2. High speed enemy ramjet and long range ballistic missiles will present a dual defense problem. The new surface-to-air missiles will "not be effective" against them nor can radar pick them up at "sufficiently long distances" for defense missiles to be effective.

3. The recently announced Navy *Sidewinder*, which he confirmed the Air Force also would use, was labeled "quite a simple missile" but it "has certain limitations in use." Also in the air-to-air category, "substantial improvements" are being made to the Navy *Sparrow* and the Air Force *Falcon* and future developments "will represent an extension along present lines."

4. Long range surface-to-surface missiles "are not likely to have the requisite accuracy" essential for hitting "hard targets where bombs must be placed essentially on the target." But they will be effective against industry areas "where a very high degree of accuracy is not required."

5. Murphree disclosed for the first time that improvements are being made to the *Matador*, presumably in the guidance area. While similar to the *Regulus*, the *Matador* improvements are "along somewhat different lines than the improvements being made in the *Regulus* missile."

Increased Accuracy by Refinement

In a summation of research needs, the Defense official found a "heavy incentive for increasing accuracy." "New ideas," he said "are needed to fully obtain what is desired," although "much can be done" to increase accuracy "by refinement of present developments."

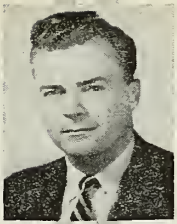
Quarles, Carlson in Redstone R&D Posts

Two significant appointments to research and development posts at Redstone Arsenal and the Army Ballistic Missile Agency, Huntsville, Ala., were announced in November.

Dr. Gilford G. Quarles, formerly director of the Ordnance Research Laboratory at Pennsylvania State University, becomes scientific and technical consultant on the staff of Maj. Gen. J. B. Medaris, commanding the ABMA, which developed the *Redstone* missile and now is pressing development of the "*Jupiter*" intermediate range ballistic missile. At Penn State Dr. Quarles directed Navy weapons research, specializing in underwater ordnance. In World War II, he was responsible for research, development and engineering of a homing torpedo.

Dr. William S. Carlson, of Frankford Arsenal, Philadelphia, is named chief of Redstone Arsenal's newly created Air Defense Laboratories, a part of the R&D Division of the Arsenal. At Frankford, he was in charge of research and development of the Fire Control Instrument Group.

The new Air defense Laboratories at Redstone perform supporting guided missile research and development in the fields of detection, acquisition, fire control, guidance and control systems and in countermeasures against all forms of enemy effort to prevent proper functioning of missile systems. It also is concerned with planning long range programs of research and development for established and future missile systems.



Rocket Trends

By Erik Bergaust

WE WERE RATHER PLEASED when LIFE magazine called us up some days ago, asking if we could provide the original art work that accompanied our little story on how the Russians—by implication—are boasting about their forthcoming IGY satellites. Those who recall this story from our November issue will remember that some Russian engineer had copied Dr. Fred Singer's MOUSE orbiter. Aside from this, we might add that this magazine, i. e., MISSILES & ROCKETS, is hard at work trying to round up as much authentic information as possible about Russian rockets and Russian astronautics trends for a forthcoming issue. We have quite given up the idea of going to Russia for first-hand information. Not having heard from the Soviet embassy here in Washington for some months, and since it is now more than one year since we applied for a visa, we take it for granted that we shall never be honored by a visit to Russian engineering and research centers. Indeed, that story in our November issue is not going to help us get any visa. But we still shall come out with a "Russian issue."

★

WHAT MAY TURN OUT TO BE THE WORST ERROR IN JUDGMENT in American technology was announced by Secretary of Defense Wilson recently, when he heralded that USAF has been picked to conduct the country's intermediate-range missile activities, leaving the experienced Army ballistic missile experts cold (see page 70). One particular aspect of Wilson's directive—which does not seem to have been taken into consideration—is the obvious fact that American missile engineering as a whole may be set back several years.

★

ADVERTISING AND EDITORIAL content don't mix we have been told since way back. Nevertheless, we cannot help having a noticeably proud feeling about the 20-page insert following this column. We are humble in our appreciation for the advertiser requesting this particular position in the magazine. Furthermore, the ad—as such—leads us to believe that liquid oxygen isn't dead. M/R will follow this up in the next issue.

★

THE AIR FORCE did not have any *Navaho* pictures to release at press time. However, Henry Simmons' fine story (page 77) on North American and their forthcoming intercontinental missile has been dressed up with an Apache/Navaho totem pole to indicate what kind of sophisticated blow must be contemplated from this side of the ocean in case someone decides to hit the war path. But everybody seems to know what the *Navaho* looks like. How about it Air Force? We feel certain the Russians know what it looks like, and that they know what this missile is capable of—with a nuclear warhead. And that's pretty much the point, anyway . . .

★

WE HAVE FOLLOWED WITH GREAT INTEREST the British Interplanetary Society in its efforts and struggles. We have somewhat tried to grasp their troubles each time we have visited the Secretary's crowded and antique 12 Bessborough Gardens office in London; we think the BIS is a progressive organization. However, it was with mixed feelings that we read a BIS press release a few days ago, with information on "*the full story of the way British engineers helped lay the path for America's artificial satellite*." The release refers to an article in SPACEFLIGHT dealing in part with the "resemblance" of the *Vanguard* design and a British satellite proposal made 5 years ago. A U.S. Navy friend says this doesn't mean the British taught us how to design the *Vanguard* vehicle. We should think not.

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missiles and rockets
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Ballistic Missiles and Management

By Major General B. A. Schriever
Commander, Western Development Division, USAF

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.

To give due and just credit to the contribution which science and industry is providing the Air Force in this dynamic program requires some explanation of the method used by the Air Force in selecting its scientific and industrial associates for the ballistic missile task, how it organized for the job, and the degree of success achieved in the program to date.

The factors effecting the acceleration of the Air Force long-range ballistic missile program were primarily scientific and technical.

The thermonuclear breakthrough in 1952-1953 was a major break. 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.

These factors brought the ICBM weapon system to the forefront as an attractive manageable proposition. The ICBM, an impractical device in the early atomic weapon age, now assumed new military worth and importance. Based on these facts and on lengthy meticulous study and analysis, sweeping changes in the Air Forch approach to the ICBM development was to take place.

These studies were conducted by the Air Force's Strategic Missile Evaluation Committee, headed by Prof. John von Neumann, Atomic Energy Commissioner and an eminent scientist, and composed of eleven of the Nation's top scientists, many of whom had worked on the A-Bomb development.

To implement the letter and spirit of the committee recommendations, the Secretary of the Air Force directed the acceleration of the ICBM program development. The program was assigned the highest priority in the Air Force with precedence over all other programs, and the Air Research and Development Command was directed to establish an organization in the field which would exercise overall responsibility and authority for the program.

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.

Three Management Elements

This overall management organization consists of three major elements operating as an integrated team. The supervising element is the Western Development Division of the Air Force's Air Research and Development Command. The technical staff of WDD is comprised of a corps of very highly qualified handpicked officers of which more than one-third have been awarded Ph.D's and Master Degrees. Many of them are experienced missile experts who have proven their capability and technical competency on other Air Force missile projects.

The second major element is the Ballistic Missile Office of the Air Force's Air Materiel Command, which, with Brig. General Ben I. Funk in charge, exercises contracting and procurement responsibility for the entire program.

General Funk directs the activities of the AMC Ballistic Missile Office, while also serving as a Deputy Director of Procurement and Production of the Air Materiel Command. In this capacity he also serves as an Assistant to AMC Commander General Rawlings, and as such has direct access to all of the Air Materiel Command Staff in support of the program. He also has directive authority over those Air Materiel Areas concerned with the ballistic missile program.

In addition, General Funk has special plant representatives who answer to him in all of the contractor plants in the program and who are able to supervise and expedite all actions involved in the implementation of program contractual requirements.

The third important element is the Guided Missile Research Division of the Ramo-Wooldridge Corporation, selected to provide weapon system engineering and technical direction to the nationwide industrial team participating in the program. Ramo-Wooldridge also provides technical supervision of the entire Air Force ballistic missile program by an industrial firm, was adopted by the Air Force in order to gain the services of an organization which possessed outstanding scientific and technical talent as well as proven systems engineering know-how.

By mutual contractual agreement between Ramo-Wooldridge and the Air Force, Ramo-Wooldridge emphasis is confined solely to technical direction and weapon systems engineering responsibilities and precludes Ramo-Wooldridge participation in any hardware phase of the weapons under development. Thus, the WDD/BMO/R-W team operates as an integrated organization to expedite the completion of the vital ballistic missile program.

A novel feature of the WDD/-BMO/R-W management approach was the formation in 1953 of the Intercontinental Ballistic Missile Scientific Advisory Committee to the Secretary of the Air Force. Composed of outstanding men in science and engineering and under the Chairmanship of Prof. John von Neumann, this committee has proven to be of inestimable value in its counseling capacity to the WDD/BMO/R-W organization, in guiding working relations with the Atomic Energy Commission, and in guiding the technical study and analysis of major problems connected with all phases of the program.

The Scientific Advisory Committee now functions as the primary scientific advisory group on ballistic missiles to the Secretary of Defense, and in this capacity provides technical advice and counsel to all three services.

Industrial partners completing the industry-science-military team's efforts are geographically located from coast to coast in virtually every state in the Union.

More than 30,000 persons are actively employed by these 17 major contractors. Numerous subcontractors and small businesses employing thousands more in support of this vital national effort.

A program of such scope necessarily needs many supporting facilities—facilities of size and complexity heretofore unknown. For example, large rocket engines to power the missiles had to be designed, developed, and tested—requiring new and unique testing facilities. Many of these new test facilities are in themselves outstanding achievements.

Detailed preliminary technical studies and systems analyses pointed strongly to the wisdom of instituting some form of industrial competition to insure availability and reliability of intricate components and subsystems. Early in the program WDD adopted a two pronged philosophy of competition—competition among contractors and alternative (not parallel) technical approaches.

The alternative technical approach is patterned after nuclear weapon development which has proven to be so successful. The principle of selective competition was adopted in the choice of the prime contractors. It was felt that such a philosophy would accomplish an end result sooner, better, and in the end cheaper, as well as provide the optimum technical backup.

The Air Force Ballistic Missile Program is a single program for which three missile configurations will emerge, two for the intercontinental mission and one for the intermediate range mission. These are not separate independent missile system approaches as often implied. While missile configuration and staging approaches differ physically and technically, there is a very high degree of interrelations and interchangeability among the subsystems (propulsion guidance and nose cone) being developed. Also the test program for each missile configuration compliments the other and even here alternate test approaches are being taken.

The concurrent development and production of the Air Force's Ballistic Missile Program under the management supervision of the WDD/-BMO/R-W team is an integrated approach without precedent. The program is on schedule. Milestones are being met and we are 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. ★

MATADOR TM-61

SM 65 ATLAS

No picture available. Missile is approx. 6 feet in diameter, more than 80 feet long, nose is blunt-shaped.

WS 107 TITAN

Unlike SM 65 ATLAS. Both ICBMs believed to be two-stage liq. rocket missiles. Nose cone represents third stage.

GAM 63 RASCAL

US Air Force Missile Arsenal

Manufacturer	Designation	Powerplant	Remarks
	Surface-to-Surface		
Convair	ATLAS SM-65	North American liquid rocket	ICBM, thermonuclear warhead
Douglas	THOR WS-315A	North American liquid rocket	IRBM under development
Martin	MATADOR TM-61A/B	Allison J33-A-17 + solid boosters (later versions to have more powerful J33)	Guided bomber; also TM-61B (longer), TM-61C and TM-61D. In service
Martin	TITAN WS-107	Aerojet liquid rocket	ICBM under development
North American	NAVAHO SM-64	2 Wright ramjets + North American liquid rocket as booster	Under development in several versions
Northrop	SNARK SM-62	P & W J57 + 2 boosters of 33,000 lbs. each	In production
	Surface-to-Air		
Bendix/ McDonnell	TALOS L	McDonnell ramjet + booster	In production; also TALOS SAM-N-6 and TALOS-W for Navy and Army
Boeing	BOMARC IM-99	2 Marquardt ramjet + Aerojet rocket	Missile-carrier missile (FALCONS)
	Air-to-Surface		
Bell	RASCAL GAM-63	Liquid rocket	Launched from B-52 or B-58
	Air-to-Air		
Douglas	DING-DONG	North American liquid rocket	Under development, atomic warhead
Hughes/ Philco	FALCON GAR-98	Thiokol solid rocket	In production. Also FALCON 2 and FALCON 3
Fairchild	GOOSE	Fairchild J83 or GE J85	ECM vehicle, no warhead
(Philco	SIDEWINDER AAM-N-7	Solid rocket	Operational, infra-red homing; NAVY MISSILE, might be used in AF fighters, such as F-104)

SM 62 SNARK

DING-DONG

High-punch air-to-air missile with atomic warhea[d]. No picture available.

TALOS

TM 61B MATADO[R]

WS 315A THOR

No picture available. IRB[M] missile somewhat simil[ar] to Army's liquid-prop. JUP[I]TER.

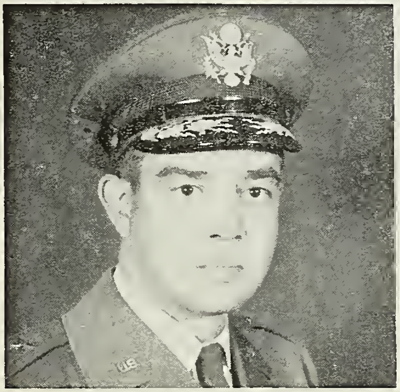
GAR 98 FALCON

SM 64 NAVAHO

Picture to be released soon. Liq. rocket booster and two ramjets. Canard stabilizers up front. Supersonic, 5,000 mile range.

IM 9[9]

Key to Survival: Missile Research and Development



By Brigadier General
Don R. Ostrander
Assistant Deputy Commander for Weapon Systems, Headquarters, Air Research and Development Command

IN THIS modern age of supersonic planes, missiles and rockets, we no longer can depend upon sheer quantities of men and weapons to bring us victory in any future war. We cannot match the Soviets either in manpower or numbers of weapons, nor do we wish to do so.

Quality and superiority of our weapon systems, then, are the keynotes of our air research and development program. The fact was emphasized last year by the Secretary of the Air Force when he appeared before the Senate Armed Services Committee. At that time, he said, in part:

"... The Air Force has no intention of getting into a numbers race with our potential enemy. We are determined, instead, to maintain the qualitative superiority of the Air Force. Research and Development is the most important activity within the Air Force and industry to insure maintaining that position."

Research and development constantly gives birth to weapons of increasingly destructive power. But the whole evolution of explosives and the vehicles which have carried or launched them shows that, in time, each weapon system was superseded by a new and superior one.

An analysis of weapons from the mace to the longbow, from the musket to the H-bomb, reveals, in truth, that "past is prologue." The analysis provides another truth. As always, military men strive to propel destructive power to greater distances at ever-increasing speeds, in their never-ending search to find the "ultimate" weapon. But never yet has that goal been attained.

Before we take a philosophic approach to the future of guided missiles, let's review how we in the Air Research and Development Command plan, manage, and provide the technical leadership for the Air Force guided missile development program.

In carrying out our mission, we receive the necessary resources and directives through a channel which starts with the Congress which appropriates the money to support our operations. The channel then flows through the President who signs appropriation bills. When this is accomplished, the Department of Defense assumes the leadership for the administration of the overall operations.

At the Department of Defense, a special assistant for Guided Missiles coordinates all such programs for the three services of our Armed Forces. Funneling down to Air Force level, the control channel extends through the Secretary of the Air Force to the Chief of Staff who has an Assistant Chief of Staff for Guided Missiles and a Dep. Ch. for Dev. who, in turn, acts as his primary advisor on all Air Force guided missile matters.

We now have reached ARDC—the operational level for the program. ARDC is responsible for planning and managing all Air Force guided missile development projects. Here at headquarters in Baltimore, Maryland, an assistant for Guided Missiles, reporting directly to the Commander, coordinates all activities of guided missile projects.

Special Organization for ICBM Development

Because of the accent today on the ICBM (Intercontinental Ballistic Missile), a special organizational structure has been superimposed on the basic structure to manage the Air Force program in the area of ballistic missile development. The special organization is the Western Development Division with headquarters in Los Angeles, California. Its commander has been delegated considerable authority to speed up this very vital and high-priority development program.

Several committees—made up of

both military and civilian experts—are in existence to speed up decisions on the review of various facets and phases of the program.

In carrying out the Command's responsibilities for the research and development programs for guided missiles, each of our major research, development, and test centers plays an important part.

Three other organizations, which report directly to the ARDC Commander, are integral components of the command and make major contributions to any end product in the guided missiles programs. They are:

The Armed Services Technical Information Agency (ASTIA), located in downtown Dayton, Ohio, which provides centralized technical information services to all Department of Defense agencies and their contractors. ASTIA is responsible for collecting and cataloging research and development information and disseminates it on a "need-to-know" basis.

The Air Force Office of Scientific Research (AFOSR), located in Washington, D.C., which conducts an exploratory research program in the physical and bio-sciences through contractural arrangements with profit and non-profit institutions and universities. The purpose of the AFOSR program is to provide new scientific knowledge, and to recognize and report scientific achievements, the application of which may result in new concepts of air warfare or new air weapons.

This Office of Aircraft Nuclear Propulsion, located in Washington, D.C., which is responsible for monitoring the development of nuclear propulsion for aircraft.

All three organizations, directly or indirectly, contribute to the sum-total input which furthers our guided missiles project progress.

All units mentioned work together as a team within the ARDC structure. But in addition to our operational command teammates, such as AMC, we have others—equally active, equally important. We work closely with industry and the universities and research groups of the Nation because it is—in this scientific, technical and production potential—that our future airpower will be built.

Perhaps because of over imagination in writers and the dramatization of the capabilities of the ICBM, press and public attention centers on this vehicle. But ARDC's responsibility is not confined to this weapon alone. The Command is concerned with the development of a whole spectrum of weapons which are essential in carrying out the roles and missions of the Air Force. Among these are:

The guided aircraft rockets which can be launched offensively from our interceptors against invading enemy targets or defensively from our own invading bombers against enemy interceptors.

The interceptor missiles which can reach out at long range, as compared with anti-aircraft and artillery missiles, to intercept and destroy incoming enemy bombers these are area defense weapons as contrasted with local defense weapons.

The air-to-surface guided missile for use either in the tactical role at shorter ranges in support of the ground forces or in a strategic role at long ranges to apply airpower to the military and economic structure of an enemy.

Several categories of missiles are being developed in this area. One is an airplane type of winged missile which follows a path parallel to the earth's surface and flies within the earth's atmosphere to its target.

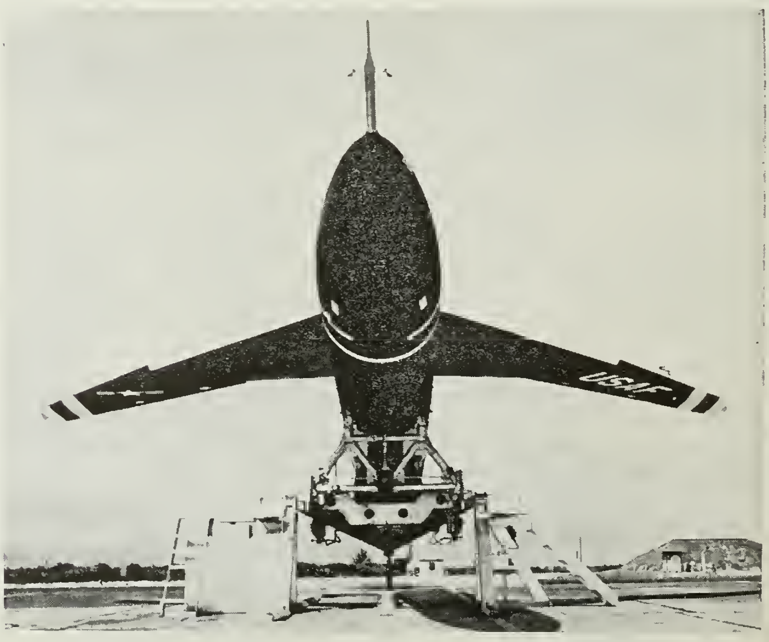
The other category is the ballistic missile which is guided into space and follows a ballistic flight path to its target. Both of these types are capable of delivering atoms and thermo-nuclear warheads.

All of this effort, then, is directed toward giving us a versatile and more effective family of guided missile weapon systems, either in combination with manned weapon systems or complementary to them.

A little more than a decade after the first powered flight by the Wright Brothers, a small group of aviation-minded men, with vision and faith in the future, began promoting the development of our first guided missile. They called it a "Flying Torpedo." Heading the dedicated group were Orville Wright, "Boss" Kettering, Elmer Sperry and General "Hap" Arnold—all men who occupy an enviable niche in Aviation's Hall of Fame.

Dogged effort on the part of the group resulted in a successful launching of the vehicle in September 1919. Since the launching of the Flying Torpedo, we've made tremendous strides in all phases of the art of aerodynamic, electronics, and propulsion. Compared with this early

Northrop's SM 62 SNARK intercontinental missile is outdated. But the Air Force has learned much and has gathered valuable information from SNARK experimentation on how to design tomorrow's more sophisticated ICBM weapons.



effort, however, our guided missiles of today are completely automatic weapons of superb sophistication and complexity, and tremendously of superb and increased capability. Their future potential is limited only by men's imagination. And we, students of modern weaponry, certainly could never be accused of being unable to see beyond present horizons.

We readily see, then, that our interest in guided missiles dates back to World War I. True, our efforts prior to and even during World War II, in the rocket and missile fields, though continuous, necessarily were limited.

On a crash basis, we did develop the famed bazooka, which helped materially in defeating the rampaging Rommel in Africa. We also crash-programmed the 4.5-inch barrage rocket used so effectively in the Pacific. During the war, the Tiny Tim and the 5-inch HVAR, the rocket-propelled mineclearing snake, and aircraft JATO—all were entered into our armament inventory.

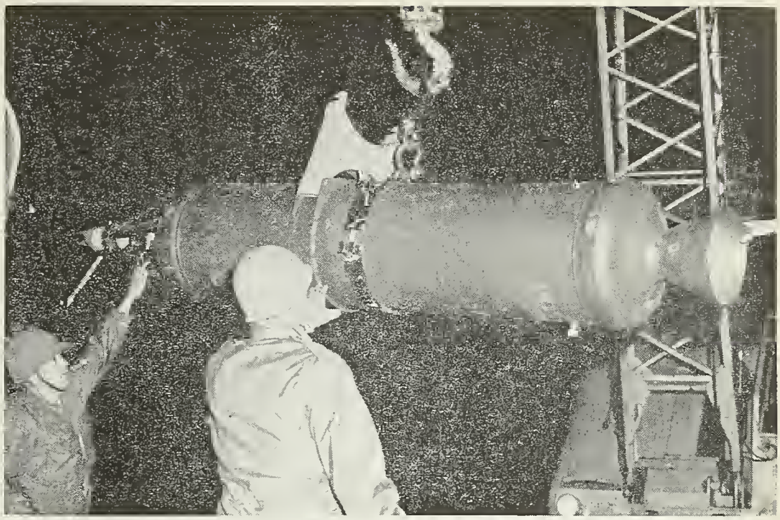
In 1942, liquid-fueled V-2 rockets were successfully flight-tested by the Germans. Between 1944 and 1945, they produced about 6,000 V-2's. Of this total, approximately 3,600 were launched against allied targets.

Compared with the spectacular German effort, however, our pace was pedestrian. The Germans first developed the "Fritz X," later the semi-guided V-1 missile, and lastly the V-2 ballistic missile. Our own development in these areas was virtually non-existent.

For some time after World War II, progress centered on the development of liquid-fueled rockets. Currently, the Air Force, as well as the Army and Navy, are researching and developing missiles using liquid rocket propulsion.

Since this article is a philosophical approach to the research and development of rockets and missiles, we shall discuss neither their technical aspects nor the advantages or drawbacks of their propellants—major features in the progress of the *state-of-the-art*.

Our current research, naturally, leads into the very vital ballistics missiles development program. Efforts fix on the "*Atlas*," "*Titan*," and the "*Thor*." The first two are designed as Intercontinental Ballistic Missiles (ICBM); the third is an Intermediate Range Ballistic Missile (IRBM).



Air Force missile researchers are engaged in varied propulsion experiments. High-energy solid propellant boosters that are easy to handle have high priority.

Philosophically speaking—are we on the threshold of forging an "ultimate" weapon?

Committed as we are solely to defense, any potent weapon possessed by us would not ride to target on a surprise mission. But it is possible that an enemy might risk launching his own if he were convinced it would wipe out our retaliatory capabilities.

Therein lies the main reason for our feverish haste to develop a superior family of weapons. A statement made recently by U.S. Civil Defense Administrator, Val Peterson, pinpoints one overriding reason why. why.

"The age of big cities is past," Administrator Peterson said—"An H-bomb of only 10 megatons (there is talk already of 40 megatons) would destroy a modern city over an area of 50 square miles and its environs . . . If 67 U.S. cities were to be subjected to H-bomb attack (equivalent to the one which caused an island in the Pacific to disappear), 22 million people would be seriously injured; nine million would be killed."

In the light of these facts, an epochal event in weaponry might come to pass in the relatively near future—a nuclear ICBM standoff. What then?

Would a standoff prove a definite deterrent to war? Would a potential aggressor push a button sending his ICBM's screeching through the stratosphere at hypersonic speeds if he knew he was automatically pushing another button setting off the enemy's retaliatory ICBM's?

If an enemy would push his button, he would do so knowing there would be little hope he could wipe out our numerous launching sites. He would just as surely know we are prepared to retaliate.

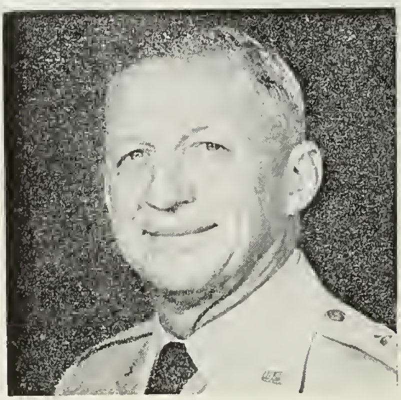
From a military standpoint, therefore, only one conclusion can be drawn from the facts presented here. Sparking World War III with the use of long-range thermo-nuclear weapons certainly would set off a chain reaction. Such rockets and missiles would then indeed be "ultimate" weapons. Ultimate that is, because the next and final one would be, as Einstein so often said, the "stone-age club."

AGAIN, philosophically speaking, can we invalidate this conclusion? We can, definitely. As military men, we do.

If "past is prologue" proves true in the case of the ICBM, we shall forever continue to seek to develop the "ultimate" weapon.

The logical step in achieving this worthwhile goal will depend entirely upon future research and development. We will always maintain a progressive attitude and look to a new frontier. This forthcoming International Geophysical Year may bring a realization of satellite launching. This within itself may open a new era of manned satellites or possibly glide rockets. With such developments, we could have stand-by forces in space guarding peace. ★

Comprehensive Testing Speeds Missile Development



By Major General Leighton I. Davis
Commander, Holloman Air Development Center, Air Research and Development Command, USAF

IT WAS my privilege several years ago to discuss with the late Dr. Robert A. Millikan the advance of modern technology. I raised the question of the relationship between theory and experiment and whether theory or experimental "gadgetry," such as electron microscopes and cyclotrons, contribute more to the growth of modern scientific knowledge. The context of his answer was that one could not advance without the other, that each was essential to progress in the sciences and that rapid progress was achieved only when theory and experiment were in proper balance—complementing and supplementing each other.

It can be said that testing bears the same relationship to engineering as experiment does to theory.

In missile engineering the relationship is even more firm, because designers and engineers invariably are required to go beyond available experimental data—to extrapolate into regimes of performance where there are no test data points to guide them.

The need for test information is taken for granted in missile work, but too often it is looked upon as verification or proof of design rather than as a partner in progress. The proper integration of testing into missile development results in rapid progress because experimental data is available when needed. If testing is treated as a "necessary evil," to follow rather than to accompany design and engineering, progress is slow and overall costs are high.

Before developing this thesis—the thesis that testing is an integral part of development and has a regenerative, beneficial effect on the progress of the project— we must look at the total pattern of development of a military weapon.

The study phase includes the definition of a military need and validation of that need by documentation. A necessary part of this phase is a formal statement of the problem and of the need for a solution; in other words, a "requirement."

The developmental phase includes design, engineering, fabrication, and many tests. Engineering testing, in contrast to proof or acceptance testing, runs throughout this phase. Designs are tested by work on computers and simulators. Engineering assumptions and compromises are tested by models and mockups. Critical components are fabricated and tested to determine performance limitations as well as weight, space, and power requirements. Vendor supplied items are checked against specifications in tests that simulate the new environment. Major components and subassemblies are tested to determine their compatibility in the system.

Flight test operations are a final part of the developmental phase. They are a continuation of the pattern of data gathering to verify or modify engineering assumptions and compromises. It is common to launch hundreds of missiles before levels of performance and reliability are achieved that justify production for inventory.

The production phase is accompanied by still more testing to check the product of production tooling and to check the latest engineering changes.

On casual consideration it might seem that a comprehensive testing program delays the date for operational use of a weapon. The time required to develop a new weapon for the military inventory is a matter of great concern to defense management. Steps have been taken to shorten the "study" phase by speeding up the validation of the requirement, by speeding up contractor selection and contract negotiation.

The preferred way to shorten the second or developmental phase is to treat the many testing operations in this phase as opportunities to gather data faster—to feed data back into engineering so that the product will advance up the ladder of performance and reliability in a spirited progressive manner.

A poor way to attempt to shorten the development cycle is to skimp on testing—gambling on immediate large scale production. This invariably results in expensive and time consuming retooling and crash modification programs. The writer has no quarrel with production at a low rate early in the development phase, because this phase will proceed faster if more items are available for test, and because production methods and tooling must be checked before production for inventory is initiated.

To support the main thesis that testing has a beneficially regenerative influence on the progress of missile development, one must examine the timing, the data flow, and inter-relationships of design, fabrication and testing. Well planned tests—tests that quickly disclose deficiencies, tests that make data immediately available to the engineer so that he can correct a parameter or redesign a component —these steps are essential to rapid progress.

On the other hand, tests that do not include sufficient data gathering to determine the cause of malfunction, or tests that result in loss of a missile and necessitate a waiting period for the next missile—are depressing and degenerative in the sense of lowering the rate of progress towards performance and reliability. An example of the way a sound program of testing supports and reinforces the upward trend of progress lies in component success or failure.

USAF SM 62 SNARK takes off from Patrick AFB. Numerous test models of this missile have been launched.

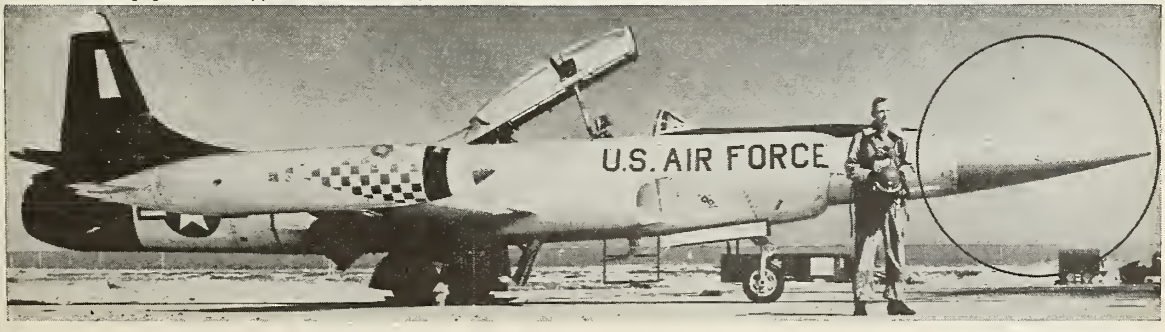
It is not uncommon—in fact much too frequent—that an untested item, a connector or a relay, fails during launch of a complete missile. As a result the whole project is set back—with no data on that test and a long wait for another missile—uncertainty results and requirements are generated for more tests to determine what failed. The net effect is a general depression of the rate of progress. On the other hand, comprehensive component testing aids in successful flight testing to the point of reducing the number of missiles required to determine performance and reliability.

Facilities for test exert a strong influence on the rate of progress. Adequate instrumentation, sufficient telemetry equipment and channels so that ground checks can be run in parallel with flight operations, "systems designed" data gathering and data reduction equipment all speed up the development cycle by feeding test data quickly back into the engineering process.

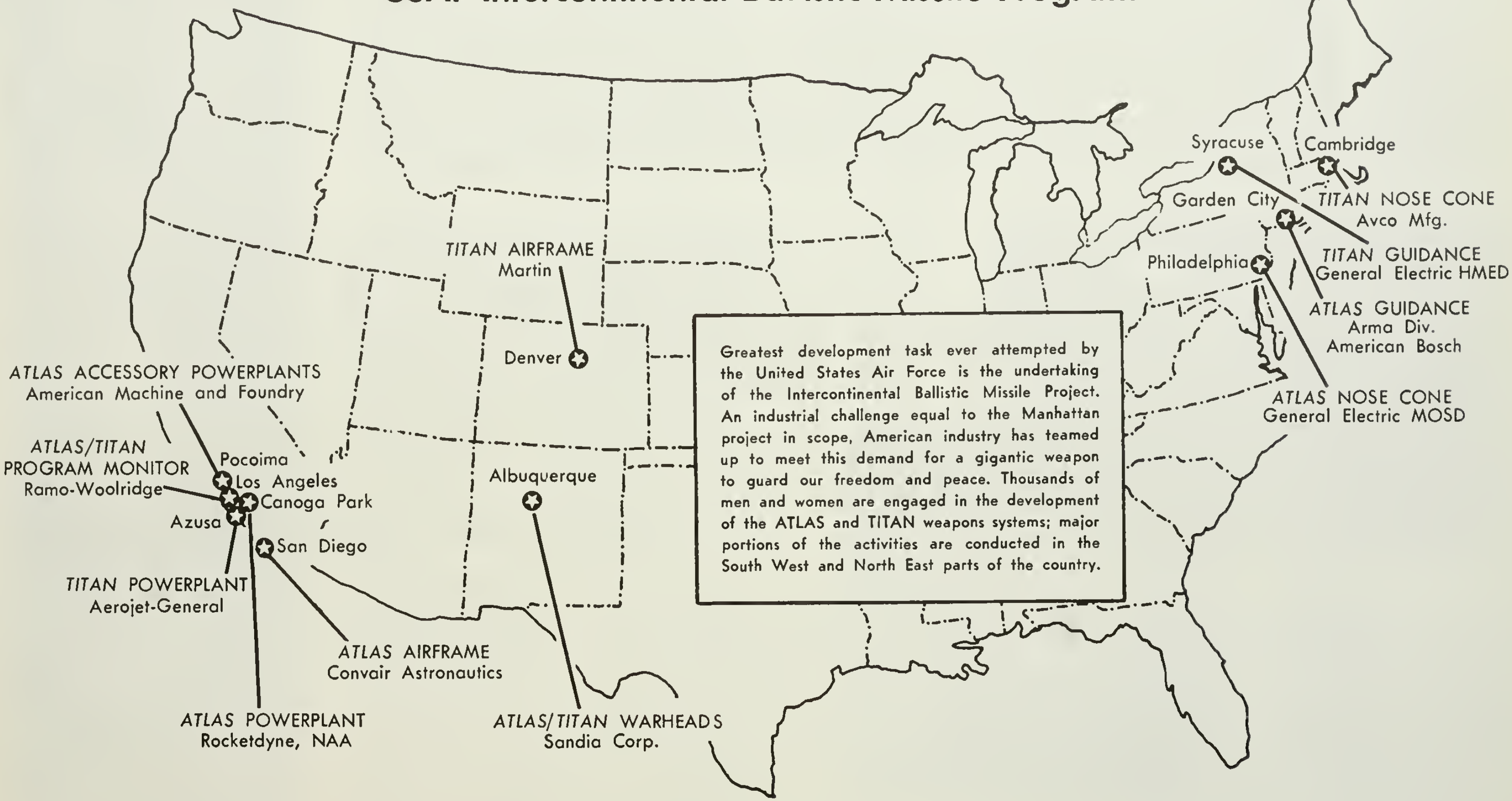
The best proof of this thesis, that well planned and intensive testing speeds up development, lies in experience. An analysis of missile projects in the flight test phase will show a wide variation in the pattern of progress. Projects that are dragging —firing missile after missile with little increase in performance or reliability—often are plagued with component failures. These troubles could have been decreased by adequate component testing earlier in the development phase. On the other hand, some projects progress rapidly —missiles are ready on schedule, comprehensive pre-flight checks reveal few troubles—and performance and reliability are demonstrated by fewer firings than originally scheduled. Behind this success you will find extensive and careful testing, testing that goes hand in hand with design and engineering, just as experiment must accompany theory in the progress of our technology.

The big pay off is reduction in time and reduction in cost. The latter part of development, the flight testing phase, is very expensive in terms of time and money. Production tooling as well as scarce designers and engineers are standing by waiting for results. The running cost of the project may be millions of dollars per month and the missiles themselves on a per pound cost are more dear than gold and diamonds. Rapid progress towards goals of performance and reliability decreases the running time of the project and saves missiles in the most critical and expensive phase of the total weapon development. ★

Lockheed F-94 carrying full-size missile in its nose (circled) is used by Air Force as flying test bed for checking out missile guidance and telemetering gear. This approach saves money. Other Air Force missiles are designed to return to base and land after test flight.



USAF Intercontinental Ballistic Missile Program



Greatest development task ever attempted by the United States Air Force is the undertaking of the Intercontinental Ballistic Missile Project. An industrial challenge equal to the Manhattan project in scope, American industry has teamed up to meet this demand for a gigantic weapon to guard our freedom and peace. Thousands of men and women are engaged in the development of the ATLAS and TITAN weapons systems; major portions of the activities are conducted in the South West and North East parts of the country.

A New Approach to Space Flight

Should the space flight challenge be attacked on the basis of our missile and rocket experience? Or should we attempt a different approach?

By Colonel William O. Davis
Office of Scientific Research, Air Research and Development Command

THE most popular approach to the conquest of space up to the present time has been the ballistic type vehicle, high accelerations, vertical takeoffs and chemical fuels. In other words, we are asking ourselves, "In what way may we extrapolate the techniques of the guided missile to manned spaceflight, how can we use the rocket to put a man in space?"

This perhaps is not the best approach today. Instead of continuing to extrapolate our past techniques into the future, let us stop and take stock—see what capabilities do exist for manned spaceflight and whether or not we can meet them with the techniques available to us. Let us forget for the moment we ever heard of the rocket and the guided missile. Let us assume that we will start from scratch with the science that is available to us and a knowledge of our objectives and design a spaceflight system from here.

In trying to decide what the requirement must be for a usable space-flight vehicle, one can take many approaches. The list below is only one possible such list.

1.) High Probability of Personnel Recovery.

2.) High Probability of Equipment Recovery.

3.) High Probability of Mission Success.

4.) Human compatibility with the system.

(a) Low but no zero acceleration.
(b) Tolerable temperature limits.
(c) Short flight times.
(d) Reasonable re-entry profile.

5.) Performs Function Compatible With Cost. Let us discuss each of these requirements briefly.

High probability of personnel recovery implies first of all adequate protection against the various environmental hazards of space; secondly, however, it implies that a power failure at any phase of the mission must not result in a loss of control and ability of the vehicle to fly. This, of course, is a very rigorous requirement and suggests either multiple motors—the failure of any one of which will not cause loss of control, a propulsion system which is inherently incapable of failure, or a flight condition where power-off control is feasible until emergency escape can be made.

The second requirement, high probability of equipment recovery, implies all the foregoing and in addition requires that the spaceship be capable of being landed with high reliability in the event of complete power failure. It also means that if staging is used each of the separate stages must be recoverable and re-usable. Finally, it points to the desirability of a single stage vehicle which eliminates the necessity for staging.

High probability of mission success implies in addition to all the foregoing that the entire system be made as completely reliable as possible and that the necessary maneuvers to complete the mission be possible and easily performed, without serious risk to personnel and equipment.

We come now to the question of human compatibility with the spaceflight system.

(a) Low but not zero acceleration: It is clear that a necessity for high accelerations will greatly limit the flexibility of space travel and in particular will require that only the most physically fit may possibly employ this form of transportation.

Secondly, high accelerations will produce a much greater stress on all parts of the vehicle thus increasing the probability of failure of the components and of the system as a whole. Thus, a desirable objective is to develop a ship which has the lowest possible acceleration compatible with fuel economy and mission to be performed.

Human Survival

At the same time even though experience may demonstrate that man can survive and even adapt himself completely to life under conditions of zero gravity, such conditions certainly will add to the difficulty of operation in space and should be avoided if at all possible. Zero gravity may be avoided either by the artificial rotation of the vehicle to substitute centrifugal force for gravity, or perhaps by the employment of a method of propulsion yielding low acceleration.

(b) Tolerable temperature limits: Any propulsion system will produce some heat. A space vehicle within sight of the sun also will be receiving heat from the solar radiation. A major problem on a vehicle well may become that of maintaining a livable temperature while absorbing heat from the propulsion system or auxiliary power system and adding it to the heat already being received from the sun.

For example, the mean temperature of a space vehicle at the same distance from the sun as the earth will, of course, be essentially the same as that of the earth—approximately 68°F. Clearly an average temperature much higher than this is undesirable, so that transfer of heat to the vehicle by the propulsion system or auxiliary power system should be minimized. Where possible the heat from the propulsion system should be used for auxiliary power, so that by doing work the total energy release to the vehicle in the form of heat may be kept as low as possible.

Finally, the man himself must be a part of this thermodynamic system and his products and his heat must fit into the system in such a way as to insure maximum survival probability and maximum efficiency. One more factor is important in connection with this requirement. The thermodynamic cycle of man and machine must be studied carefully because in this application it is clear that we wish to consume energy and conserve mass.

(c) Short flight times: Under most early approaches to flight between two planets the minimum energy orbit has been suggested. This, in general, requires a long time and may well involve serious personnel and logistic problems.

On the other hand a system of spaceflight in which the vehicle could be accelerated even though at a reduced rate for an indefinite period of time would permit much more rapid travel between two planets and, therefore, noticeably reduce personnel and logistic problems. This objective, consistent with other technical problems involved, is highly desirable.

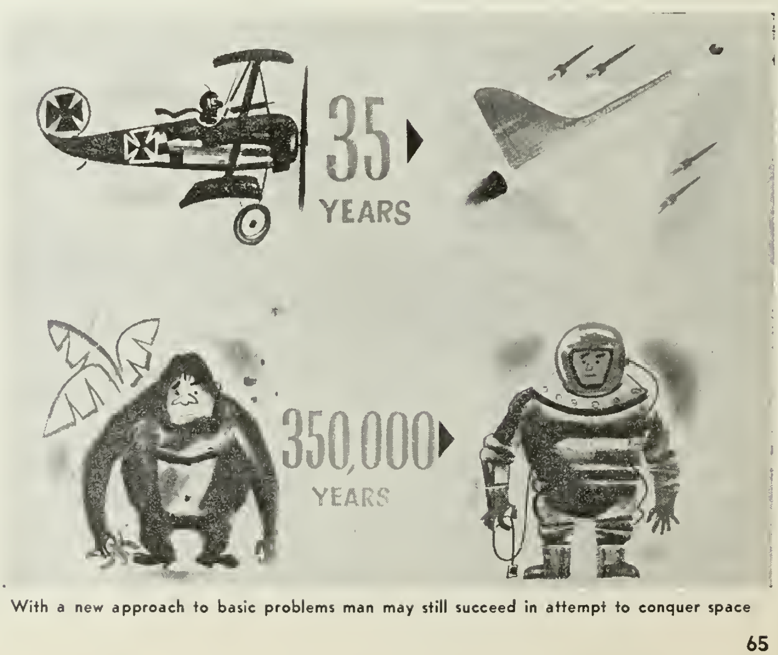
(d) Reasonable re-entry profile: It stands to reason that the return into the atmosphere of earth and landing on the earth should follow a profile which does not impose excessive thermal loads or accelerations upon the human passengers of the vehicle.

The requirement that the space vehicle must perform a function compatible with its cost implies, I believe, a very thorough study of the military and civilian utilization of space travel. At the present time, relatively little consideration has been given to this subject.

In the early days of military aviation, shortly after the Wright Brothers had made the first manned flight, the military view was limited to that of employing the aircraft for observation purposes. The development of the modern philosophy of air power took many years. Since spacecraft will inevitably be much more expensive than the early aircraft, it appears essential that this phase be undertaken prior to the development of vehicles for manned spaceflight.

Now is the time to undertake extensive studies of the strategic and tactical employment of spaceflight for military purposes. At the same time, as has been the case throughout history, there will inevitably be important civilian and commercial applications of flight in this new environment, and it goes without question that thought should be given to this subject.

In considering these applications attention should be given not



With a new approach to basic problems man may still succeed in attempt to conquer space to the difficulties of achieving spaceflight with today's techniques, but to the assumption that an idealized form of spaceflight can be developed in which many of the objections which face us today will no longer be present. In other words, one should assume that spacecraft may be flown with no more difficulty than that encountered today in the operation of aircraft for commercial purposes.

Landing On Other Planets

In order to perform a useful function for either military or commercial purposes, it would appear that a capability to land on other planets is highly desirable. This problem is undoubtedly a difficult one and is a sensitive function of the amount of atmosphere possessed by other planets, the type of propulsion system and the method of control. Achievement of this capability might well require the presence of more than one propulsion system or at least a propulsion system which might be used in two or more modes.

Since it cannot be expected that prepared landing surfaces will be available on the surface of other planets, it is clear that this vehicle must be able to land under conditions of rugged terrain. Particularly from the point of view of military operations, but later for commercial operations, a certain amount of maneuverability is desirable.

Consider, for example, a space station or other observation platform in an orbit about the earth. Such a station might in one application be used for the purpose of military reconnaissance or observation of the enemy by photographic, telescopic and radar means. Such a vehicle would be extremely vulnerable if it were committed to a completely predictable orbit. It would be necessary only to compute the exact position which the satellite would occupy at a given time in order to direct a counter missile against this target. Thus, in this particular application the ability to maneuver, to change velocity, to change position, to vary the orbit becomes important.

If indeed space is to be the next major military environment, it is clear that ultimately we may expect the possibility of combat operations in space. Under these conditions it is certain that maneuverability will be required.

Both the planetary landing capability and the ability to maneuver imply that this vehicle must be able to carry a large fuel reserve for sustained operations in space and a safe return of personnel and equipment to base. Fuel reserves should be at least comparable to those used in present day military aircraft and considering the nature of the environment a factor as high as 2 would not be excessive.

Finally, there is the matter of economy to discuss. If, as in the case of the atomic bomb, an enormous strategic advantage should be gained from the development of a space vehicle then certainly this would be worth a major national effort regardless of cost.

However, if we are to consider spaceflight as a routine future military possibility, and in particular, if we are to consider it as a commercial possibility, then the matter of economy becomes of much greater concern. It is, of course, unlikely that any such system will be developed cheaply, but if at the completion of a development program, future units can be built at relatively low cost, then this type of transportation may in time become quite feasible on a reasonably routine basis.

Let us, therefore, stipulate that for routine space operations it is desirable that unit cost of production vehicles be relatively low including the cost of fuel and other auxiliary equipment. Secondly, it will be extremely uneconomical to attempt to maintain military operations on a continuing basis with vehicles which can be used only once. It is necessary that the ultimate vehicle for spaceflight involve neither expendable vehicles nor expendable stages or other components.

Economical Aspects

All major portions of the equipment should be both reclaimable and reusable in order for this venture to be economically feasible.

Regarding the all-important question of fuel and propulsion as it affects economy of operation, it appears obvious that the most desirable system will be one incorporating a low mass ratio.

Certainly mass ratios of one hundred to a thousand or higher are completely impractical in terms of the economical transportation of payloads between the planets on a routine basis. Thus, the ultimate propulsion system should be one which provides for as low a mass ratio as possible. This means systems involving high exhaust velocities or linear systems of propulsion which do not incorporate the conversion of energy to thrust by means of heat. Nuclear propulsion, if proved feasible, would meet this requirement. Many other possibilities have been suggested—for example, ion propulsion.

If space travel is to become a routine operation between planets it is clear that the fuel for the vehicles should be relatively plentiful in the solar system and in fact the optimum situation would be one in which the fuel was available on any planet and could be refined with equipment transportable within the space vehicle itself. Hydrogen or any form thereof would meet this criterion and there are other possibilities.

Certainly this set of requirements sounds very stringent if not impossible to achieve, at least until some far future time. But if history follows its usual course, we may logically expect a capability of this type to develop rather unexpectedly. As in the case of the atom bomb. Since we cannot afford to follow all possible routes to the future the most likely avenues of research must be pursued at this time.

It seems clear that propulsion is the key to the whole problem. A propulsion system which would provide continuous though low thrust for an indefinite period of time would provide the answer to many of the problems that have been raised. If this type of propulsion system were available today, it certainly would be possible to think in terms of a workable space vehicle.

In my opinion, the way to manned spaceflight would then be open almost immediately, provided we had the auxiliary problems solved in the meantime. Although it might well take fifty years to solve the engineering problems of putting a man in space with current missile concepts, it is likely that the utilization of new concepts will achieve the same results sooner. It is easier to climb over a stone wall than to beat our way through with a jack hammer. ★

Defense Secretary Wilson

Wilson's Missile Order—Detailed Text

Because of its potential vital bearing on the rate of development of U.S. missile progress and on the outcome of the West's battle with Russia for air supremacy, m/r herewith reprints the missile sections of The Secretary of Defense's November 26 Memorandum for Members of the Armed Forces Policy Council.

MEMORANDUM FOR: Members of the Armed Forces Policy Council.

SUBJECT: Clarification of Roles and Missions to Improve the Effectiveness of Operation of the Department of Defense.

Important changes in organization and in roles and missions are not easily decided upon or effected. It is not as though we were starting fresh with a clean sheet of paper, so to speak, or could set up a theoretically perfect organization and division of responsibilities between the Military Departments. Assignment of responsibilities must continue to recognize the precedents of the past and the availability of men and facilities for carrying out assigned missions. Problems of this nature would be easier to solve if there were always complete unanimity of opinion among all responsible executives of the Defense Department, both military and civilian. The very nature of the problems, however, and the varying background and experience of the individuals serving in responsible positions make some differences of opinion normal and to be expected.

In spite of the differences of opinion which may exist, there are times when conditions require that changes should be made in administrative responsibilities and at such times decisions are mandatory. That is the situation now.

The National Security Act of 1947 states:

"Declaration of Policy

"Sec. 2. In enacting this legislation, it is the intent of Congress to provide a comprehensive program for the future security of the United States; to provide for the establishment of integrated policies and procedures for the departments, agencies, and functions of the Government relating to the national security; to provide three military departments, separately administered, for the operation and administration of the Army, the Navy (including naval aviation and the United States Marine Corps), and the Air Force, with their assigned combat and service components; to provide for their authoritative coordination and unified direction under civilian-control of the Secretary of Defense but not to merge them; to provide for the effective strategic direction of the armed forces and for their operation under unified control and for their integration into an efficient team of land, naval and air forces but not to establish a single Chief of Staff over the armed forces nor an armed forces general staff (but this is not to be interpreted as applying to the Joint Chiefs of Staff or Joint Staff)."

Nine years of experience operating under the National Security Act of 1947, as amended, have proved the soundness of this comprehensive program for national security.

The statement of roles and missions recommended by the Joint Chiefs of Staff at Key West and Newport and approved by Secretary of Defense James Forrestal and as modified in 1953, have also proved to be sound and effectively to implement the intent of Congress as expressed in the National Security Act.

No basic changes in the present roles and missions of the armed services are necessary but the development of new weapons and of new strategic concepts, together with the nine years' operating experience by the Department of Defense have pointed up the need for some clarification and clearer interpretation of the roles and missions of the armed services. We have recognized the need for a review of these matters and from time to time certain steps have been taken and we are now taking others to improve the effectiveness of our overall military establishment, to avoid unnecessary duplication of activities and functions, and to utilize most effectively the funds made available by the people through Congress.

I would like to point out that clarification and interpretation of roles and missions does not in itself predetermine the weapons to be used by each of the armed services and their numbers, nor the numbers of men to be trained in various fields. It should be clearly understood that the approval of roles and missions of the armed services for guidance in peacetime does not predetermine the weapons or forces which a commander in the field would be permitted to use in the event of war. Also, the development of a weapon by a particular military department does not in itself predetermine its use. Such determinations rest with the Secretary of Defense after considering the recommendations of the Joint Chiefs of Staff and the Secretaries of the Military Departments.

The recent clarification of command responsibilities for field commanders should be most helpful in determining weapons and forces to be employed in various missions and should assist the Joint Chiefs of Staff in making recommendations in this regard to the Secretary of Defense, in order to determine approved requirements for each of the armed services.

We have recently reviewed five important problem areas which need to be cleared up. The recommendations of the Joint Chiefs of Staff in regard to these matters have been carefully considered and their differences of opinion carefully weighed. In addition, I have given consideration to the opinions in these areas of responsible officials, both military and civilian, in the Office of the Secretary of Defense. These matters are being resolved as follows:

(Parts 1 and 2 on manned aircraft omitted)

3. *Air Defense.*

Consideration has been given to distinguishing between Air Force and army responsibility for surface-to-air guided missile systems for defense of the Continental United States on the basis of area defense and point defense, as well as the criterion of an arbitrary range limitation.

Area and point defense systems cannot be defined with precision. Area defense involves the concept of locating defense units to intercept enemy attacks remote from and without reference to individual vital installations, industrial complexes or population centers. For such a defense system to be effective, extensive information gathering networks such as the Semi-automatic ground environment (SAGE) system are required to trace continuously the enemy attack and transmit and present the data in usable form for guiding the defense weapons to counter the attack. As applied to surface-to-air missiles, this means that area defense missiles, because of their more widespread sitings, will normally receive their guidance information from the network system rather than from acquisition and tracking radars located in the vicinity of the missile launching site.

Point defense has as its purpose the defense of specified geographical areas, cities and vital installations. One distinguishing feature of point defense missiles is that their guidance information is received from radars located near the launching sites.

The present state of the art justifies development of point defense surface-to-air missile systems for use against air targets at expected altitudes out to a horizontal range of the order of 100 nautical miles.

It must be clearly understood that the Commander-in-Chief, Continental Air Defense Command, who has been given the responsibility for the Air Defense of the Continental United States, Alaska, and the United States area of responsibility in the North East, also has the authority and duty for stating his operational need for new or improved weapon systems and for recommending to the Joint Chiefs of Staff all new installations of any type. Therefore, no Service shall unilaterally plan for additional missile installations of either category (point or area defense) in support of CINCONAD's responsibilities until and unless they have been recommended by CINCONAD to the Joint Chiefs of Staff, and approved by that body.

In conformance with the above:

a. The Army is assigned responsibility for the development, procurement and manning of land-base surface-to-air missile systems for point defense. Currently, missile systems in the point defense category are the NIKE I, NIKE B, and land-based TALOS.

b. The Air Force is assigned responsibility for the development, procurement and manning of land-based surface-to-air missile systems for area defense. Currently, the missile system in the area defense category is the BOMARC.

c. The Navy, in close coordination with the Army and Air Force, is assigned responsibility for the development, procurement and employment of ship-based air defense weapons systems for the accomplishment of its assigned functions.

d. The Marine Corps is authorized to adapt to its organic use, such surface-to-air weapons systems developed by the other Services as may be required for the accomplishment of its assigned functions.

e. In overseas areas, the U.S. theater commander should normally assign responsibility for air defense to an air component commander, with appropriate participation by other components. Under this arrangement, Army units in combat zone should continue to be responsible for their own local defense, employing organic means. Other Army air defense units should carry out point defense missions under the air component commander. Air Force units should carry out the area defense missions. Special emphasis should be given to simplicity, flexibility and mobility of weapon systems employed in air defense in overseas areas. Navy forces should continue to be responsible for their own air defense at sea, employing organic means. As approved by the theater commander, the air component commander should establish such procedures for coordinating Army, Navy, and Air Force air defense forces as may be required to carry out his responsibilities, and, in addition, should establish such detailed procedures as are necessary for proper coordination with national air defense commanders of allied countries.

4. *Air Force Tactical Support of the Army.*

The Army will continue its development of surface-to-surface missiles for close support of Army field operations with the following limitations:

a. That such missiles be designed and programmed for use against tactical targets within zone of operations, defined as extending not more than 100 miles beyond the front lines. As such missiles would presumably be deployed within the combat zone normally extending back of the front lines about 100 miles, this places a range limitation of about 200 miles on the design criteria for such weapons.

b. That the tactical air support functions beyond those that can be provided by Army surface-to-surface missiles as above defined remain the responsibility of the Air Force.

It is evident that the tactical air forces programmed for Army support should be reconsidered and the Joint Chiefs of Staff have been requested to furnish me with their recommendations for specific adjustments as to the number and types of planned Army guided missile and unguided rocket units and with the number of Air Force tactical wings which may be eliminated as a result of these decisions.

In preparing these recommendations, the development of balanced and interrelated Army and Air Force tactical support forces for the accomplishment of overall U.S. national security objectives must be considered, rather than the development of completely independent Army and Air Force forces to accomplish tactical support tasks. In developing force recommendations in this area, as well as for other U.S. Military forces, it should be recognized that all operations in which our forces will be employed will be conducted under the command of the designated commanders who will have the necessary forces assigned to them for the conduct of their missions by higher authority.

5. *Intermediate Range Ballistic Missile (IRBM).*

In regard to the Intermediate Range Ballistic Missiles:

a. Operational employment of the land-based Intermediate Range Ballistic Missile system will be the sole responsibility of the U.S. Air Force.

b. Operational employment of the ship-based Intermediate Range Ballistic Missile system will be the sole responsibility of the U.S. Navy.

c. The U.S. Army will not plan at this time for the operational employment of the Intermediate Range Ballistic Missile or for any other missiles with ranges beyond 200 miles. This does not, however, prohibit the Army from making limited feasibility studies in this area.

(The Intercontinental Ballistic Missile has previously been assigned for operational employment to the U.S. Air Force.)

There are a number of other matters relating to research and development of particular weapons that will affect the choice of weapons to be used for various missions in the armed services. These choices can only be made after a careful technical review of the capabilities of the various weapons under development. I refer particularly to weapons systems such as the NIKE and TALOS and the multiple approach (JUPITER-THOR) to developments such as the Intermediate Range Ballistic Missile. This memorandum does not attempt to answer those questions which can only be decided after studies now in progress are completed, and should not be so interpreted.

In the meantime, these competing weapons systems will be continued with support from Fiscal Year '57 funds until the completion of the technical evaluation referred to above. Budget support in Fiscal Year '58 for the land-based TALOS, as required, will be provided by the U.S. Army. Budget support in Fiscal Year '58 for the land-based Intermediate Range Ballistic Missile Program, as required, will be provided by the U.S. Air Force.

In view of the great interest in these matters in the Congress, copies of this memorandum are being sent to the appropriate Congressional Committees. In addition, in order that there can be full understanding of these decisions within the Military Departments and by the public, copies of this memorandum are being made available to the press.

C. E. WILSON

Washington Spotlight

By Henry T. Simmons

The Air Force has started a detailed technical evaluation of *Jupiter* mid-range ballistic missile to determine how much of the former Army project should be continued to supplement its own work on the *Thor*. Recommendations are to be ready by Feb. 1. Big problem is how to handle the development of the Navy's Fleet Ballistic Missile if the *Jupiter* program is sharply cut back. Some airmen suggest the sailors could get along with an 800-mile weapon rather than the 1500-mile *Jupiter* in which they were participating with the Army.

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The USAF *Thor* intermediate range ballistic missile has already been shipped to Patrick AFB, Fla., and it is said first prototype will be fired this month. Douglas engineers have reportedly made phenomenal progress on the bird.

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Lockheed is begging the Air Force to let it release pictures and further news of its three-stage X-17 research rocket, designed to gather information on ICBM warhead reentry problems. (M&R, Nov., 1956, p. 43). Unclassified models of the *Sergeant-Recruit* rocket combination have been distributed.

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The Air Force is pushing research work on a workable missile defense system for bombers, but it hasn't found the answer yet. Biggest headache is the design of a finned missile which can be launched *across* the bomber's airstream without being thrown completely off course.

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Relaxation of the Defense Department's policy for dispersal of key military production facilities seems to be under way. Boeing, for example, recently took an option to buy a Ford plant at Richmond, Calif., for assembly of the USAF *Bomarc* interceptor missile. If it goes ahead with the purchase, it will mean that the hard-driving dispersal policy of former USAF Secretary Harold Talbott is virtually dead.

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Air Force intelligence has learned that the Russians have developed a rocket engine of 120 metric tons thrust—more than 264,000 pounds. Although extremely large solid propellant engines have been tested in the U.S., the largest liquid propellant engine shown publicly is the 140,000-pound North American booster for the *Navaho*. Much larger engines are under development for the *Atlas-Titan* ICBM program, however.

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Top Pentagon officials are not entirely satisfied with the progress of the Air Force missile program, noting that the airmen have only two fully operational missiles today, despite years of development labor, while the Army and Navy have four or five each. One official blames the slow progress on Air Force reluctance to top off questionable projects.

•

The stretch-outs ordered last month by the Air Force in the WS-110A chemical bomber and WS-125A nuclear bomber projects may not be enough to satisfy Pentagon budgeteers. Look for a further slowdown—particularly in the nuclear bomber—to make more funds available for the big ballistic missiles.

Aerophysics

By Seabrook Hull

The *Vanguard* project constitutes man's first venture in the fourth environment—space. It is a technological accomplishment of profound historical significance. However, in the quiet background, projects are already in the hardware stage that will take living men as well as black boxes beyond atmosphere's outer limits.

One is the AF's North American X-15. It requires not only the full abilities of near-escape, but those of a safe reentry as well. Unlike the ICBM which need only remain lethal for a few seconds, both the X-15 and its pilot must return to fly again.

Considered test vehicles for inhabited space bombers, manned satellites, etc.—X-15's A, B, and C will reportedly explore 3000 mph, 50 mi. up; 4500 mph, 100 mi. up; and 6000 mph and over, 150 mi. up and out.

The range of operating conditions of the X-15—from near-space flight to the sea-level environment of approach and landing—is unprecedented and necessitates virtually an entire new vehicle system. Throughout reentry and descent, its speed (controlled by glide angle) must be slow enough to maintain laminar flow in the boundary layer and fast enough to maintain control effectiveness. Too fast, and the resulting turbulent boundary layer will transfer heat to skin at a destructive rate. Too slow, and the loss of control will be catastrophic.

The speed band between too fast and too slow is extremely narrow and varies critically with altitude. The X-15's piloting system will be of the command variety, automatic and more sensitive than the human touch. Measurement of flight conditions—altitude, speed, rate of descent and climb, pitch, roll and yaw—requires new techniques. A thin probe would melt. A stainless steel ball with static ports may be used instead. Aneroid devices are useless. And in 100 per cent dissociated air, radio may be unreliable.

Vanguard and its successors will explore the massive high-energy spectrometer that is space, and give some indication of effect on pilot, plane and astrionics gear. As soon as these results start coming back, X-15's system will be finalized and should fly in two years.

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Dissociation becomes a vital science in itself. It is the basis for "free radical" fuels; it controls heating rates in hypersonic flight; and (the latest) it cuts combustion efficiency in low-pressure rocket engines. A little light reading on the subject will help anyone concerned with the coming ages of flight.

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Research shows that the laminar flow equilibrium temperature at Mach 8.0, altitude 150,000 ft. of a point on a wing 10 ft. back from the leading edge is 1000°F, assuming skin has 0.85 emissivity; and that of the leading edge itself is 4500°F, against a stagnation temperature of 6500°F.

THE NAVAHO CHALLENGE

By Henry T. Simmons

MANY companies have made their fortunes on a single fruitful idea but few have learned how to assure the continuous production of significant ideas and their profitable exploitation.

Among those few, the name of North American Aviation, Inc., must surely be included. Its formula: Tackle a project so challenging from a technological standpoint that the answers, when obtained, must necessarily open broad and profitable new avenues in the business and industrial world.

The challenging project in North American's case is the SM-64 *Navaho* intercontinental missile. It was initiated by the U.S. Air Force in 1950 and has been under high pressure development ever since.

Little has been said officially of the *Navaho*. Pentagon officials describe it in their speeches as an air-breathing surface-to-surface missile with a range of about 5,000 miles. Beyond that, they hold their silence.

But a considerable number of additional details have been unofficially but reliably attributed to the North American bird. It is said to be capable of speeds of about Mach 2.5 at altitudes up to 75,000 feet. Its weight is probably in excess of 50 tons. It employs some radical airframe innovations, included a canard stabilizer just behind the nose.

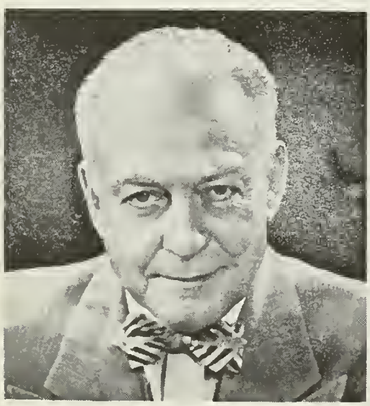
Power for the *Navaho* is supplied by two different engines. For sustained flight, it is said to use two huge Curtiss-Wright ramjet engines. And to achieve the speeds necessary to generate sufficient ram air pressure to permit the C-W engines to operate, the *Navaho* uses a large North American liquid propellant rocket engine with a designed thrust of 140,000 pounds.

An indication of the present status of the program is the fact that flight testing of the North American X-10 test vehicle is now nearing completion at the Air Force Missile Test Center, Patrick AFB, Fla. Although the firing range extends 5,000 miles from Florida to the Ascension Islands in the South Atlantic, only a fraction of that distance is now in use for the X-10 program.

The test vehicle, which is equipped with retractable landing gear, is apparently aerodynamically similar to the *Navaho* itself. Power is supplied by a pair of turbojet engines, variously reported as Westinghouse J40's and Pratt & Whitney J57's. The X-10 is used to check out advanced designs, electronics systems and flight characteristics.

With the end of the X-10 test program in sight, North American is ready to move into the final and most difficult stage of development—that of test firing the genuine article. Both range and missile instrumentation have been designed to gather performance data along the entire course of the sprawling range, and it is expected that this final stage will begin shortly.

These sketchy details illustrate something of the magnitude of North American's task in designing and developing the *Navaho*. Probably one of the most acute problems is that of aerodynamic heating. At velocities of Mach 2, for example,



J. H. Kindelberger, Board Chairman, North American Aviation, Inc.

L. L. Waite, Vice-President, North American Aviation, Inc.

Joseph G. Beerer, General Manager, Missile Development Division.

Samuel K. Hoffman, General Manager, Rocketdyne Division.

Dale D. Myers, Chief Engineer, Missile Development Division.

T. F. Dixon, Chief Engineer, Rocketdyne Division.

surface heating as great as 300 degrees F. may be expected, while Mach 3 will produce temperatures of about 660 degrees F.

To be sure, missile test vehicles have already achieved speeds of Mach 10 and above, but these were rocket-powered ballistic devices with very short flight durations. In the case of the *Navaho*, which will maintain velocities of 1650 mph to 2000 mph for a period of several hours, the problem is to lick the effects of *sustained* intense heat.

From a structural standpoint, the heat problem seems to be well in hand. In that area, the principal headaches are heat-induced expansion and shrinkage, further complicated by stress and vibration. While aluminum alloys and steels remain useful for certain applications in the *Navaho*, very extensive reliance on titanium alloys proved necessary to meet new strength-to-weight requirements. Titanium is much stronger than aluminum, possessing the strength of some carbon steels, but at the same time it is 40% lighter than steel.

Thermal Problems

One of the knottiest heat problems in the *Navaho* has to do with fuels and hydraulic fluids. How do you prevent the liquids from boiling or detonating at the enormous temperatures to which the skin will be subjected? North American engineers have sought a variety of answers, including ways to keep liquids from boiling, development of fuels requiring no refrigeration and methods of cooling fuels without greatly increasing weight. Just how they have resolved the difficulty has not been suggested.

Still other new problems were encountered in designing control surfaces capable of handling mammoth air loads. One of the *Navaho's* control planes is the size of a drafting table, yet it is sturdy enough to bear the weight of six automobiles.

North American engineers ready a model, possibly suggestive of the NAVAHO, for wind-tunnel tests. Note the extreme fineness ratio, the delta airfoil on the aft section and the small canard stabilizer close to the nose.

Vibration and flutter are particularly acute problems for all missiles, including the *Navaho*. Notes one expert:

"Vibration in the wrong place can cause disaster. All missile systems and equipment are sensitive to some form of vibration. Suppose, for instance, that automatic control equipment is improperly mounted or located. It may send the wrong set of signals to the control surfaces, which would amplify the vibrations. Control surfaces could be ripped off and the vehicle entirely destroyed."

Fabrication of one large aluminum section for the *Navaho* also involved peculiar problems. There was no tooling large enough to hold certain important structural units, nor was there a proper fusion welding machine available. Engineers of NAA's Missile Development Division coordinated the construction of one of the largest jigs in the company's history to hold the aluminum pieces tightly against one another. They also adapted a fusion arc welder bathed in a stream of inert gas which is capable of joining seams at the rate of 20 inches a minute.

New Industrial Know-How

As a result of its weapon system responsibility for the *Navaho*, North American has encountered virtually every problem facing missile engineers today. Its response to these challenging difficulties has resulted in the development of valuable new industrial processes and know-how, and has opened important new avenues of future growth.

During the brief period the *Navaho* has been under development, for example, three new divisions have been split off from the parent Missile Systems Division. All were organized last year.

Most important is Rocketdyne, which came into being as a result of NAA's development of large, high-powered liquid propellant rocket engines not only for its own requirements but for other highly important missile projects. With headquarters at Canoga Park, Calif., the division presently has 8600 employes and expects to add another 3000 in 1957. It now has orders to supply rocket engines for all but one of the large rocket-powered missiles now under development in the U.S. They include the *Navaho*, the Army Ordnance *Redstone*, the Convair *Atlas*, Martin *Titan*, and the Douglas *Thor*. The exception is the Army-Navy *Jupiter* project.

Recently described by NAA Board Chairman J. H. Kindelberger as "one of the brightest spots in the North American picture," Rocketdyne is presently the leader in U.S. rocket propulsion technology by virtue of its long head start in the field. Although other companies are now beginning to press it, Rocketdyne remains "the only company able to deliver proven engines of very high power," Kindelberger declared.

In addition to its Canoga Park facility, where Rocketdyne has more than 450,000 square feet of new engineering and administrative space in operation or under construction, the division operates two other important facilities. These are the Propulsion Field Laboratory, located in a 1600-acre section of the Santa Susana Mountains north of Los Angeles, and an engine plant at Neosho, Mo.

The Santa Susana facility is used to test very large rocket engines, turbopumps and other components; for this purpose, more than a dozen test stands capable of withstanding enormous thrusts during firing runs have been installed. The Neosho facility was originally scheduled to be operated by Aerojet-General Corp., but the USAF abruptly switched it to Rocketdyne.

Two other NAA divisions which owe their origin to early work on the *Navaho* and other missiles are Atomics International and Autonetics. The former was created to exploit peacetime uses of atomic energy for generation of electric power, following NAA's early studies of the feasibility of nuclear energy for propulsion of missiles and aircraft. Its two principal projects are a sodium reactor experiment at Santa Susana and an organic moderated reactor in Idaho, both under construction for the Atomic Energy Commission.

Autonetics was organized to exploit advances achieved in the development of automatic navigation and control devices required for missiles and piloted aircraft. One of its most promising fields is that of inertial navigation for guided missiles. Although its work is still largely in the research and development stage, Kindelberger said, "it is hoped that several of the good products emerging now from development will bring large production orders."

North American has also developed a number of important industrial processes as a direct outgrowth of the *Navaho* program. One of these is the CHEM-MILL process, patented by NAA and licensed throughout the aircraft industry by Turco Products, Inc., Los Angeles. It is an etching process which cuts away unwanted material by chemical rather than machining methods.

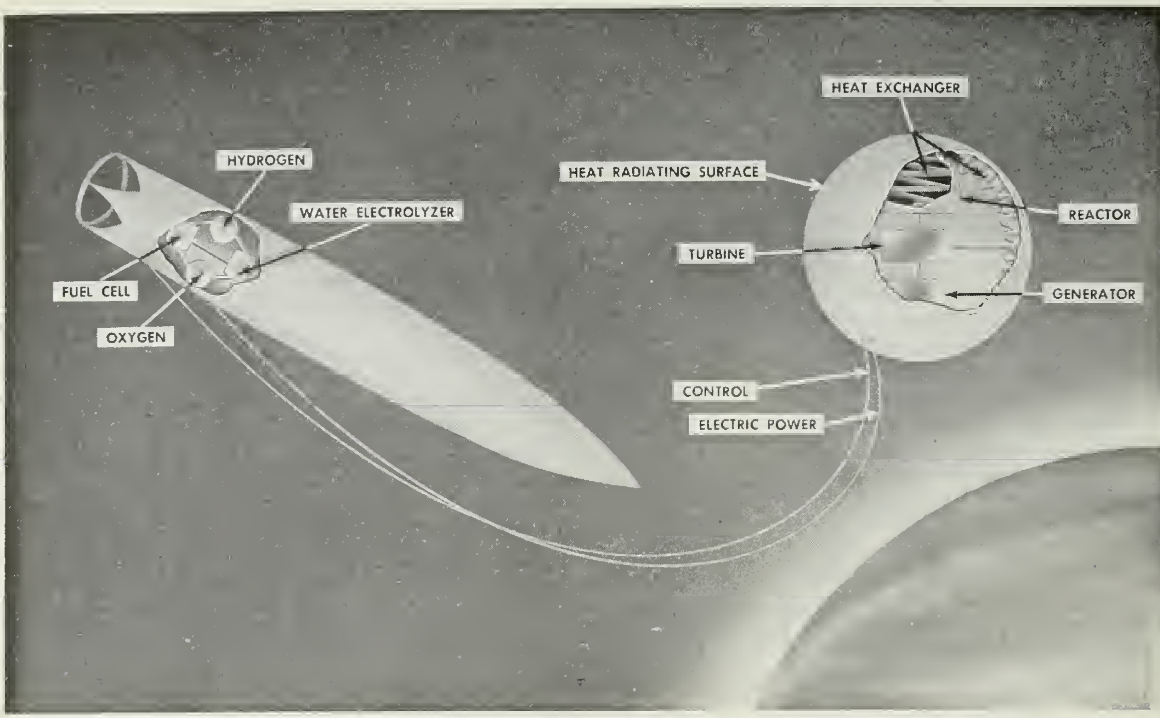
Development of this process came about when an NAA research unit found there was simply no other means of forming a particular missile section. Its value lies in the fact that it can carve many complex single-piece sections out of metal which previously had to be assembled from as many as 20 bits and pieces. Furthermore, the new sections are lighter from the assembled sections.

Navaho Test Flight

First Navaho test flight from Patrick AFB is being planned. North American engineers and Air Force officials are believed to have scheduled the flight for late this year. Although the ARDC missile range extends 5,000 miles into South Atlantic to Ascension Island first flight is not expected to cover this distance. The huge missile—first true intercontinental U.S. guided weapon—will use conventional turbojet engines in addition to ramjets. Operational model is designed as liquid rocket/ramjet vehicle. Navaho is scheduled to become U.S. Air Force's first long-range missile—until the Atlas and Titan ICBMs become operational.

Despite North American's success in converting the problems of missile engineering into new and profitable lines of activity, the real significance of its *Navaho* effort is the fact that this weapon will probably be the first full-fledged operational intercontinental missile to go into the Air Force inventory.

Although the Northrop *Snark* turbojet-powered intercontinental missile could probably go into operational use any time the Air Force desired, it is likely that the Air Force will postpone procurement of such a weapon until the *Navaho* is available. No less an official than Pentagon Missile Czar Eger V. Murphree supports this view, noting that the *Navaho* represents a bolder attack on the state of its art than its Northrop rival. ★



Artists' conception of how a satellite vehicle—manned or unmanned—may use atomic power supply. Power unit may follow the satellite at some distance for radioactive protection.

Power Sources for Space Flight

By Dr. S. Fred Singer
Professor, Physics Department
University of Maryland

NEXT to rocket propulsion, electric power is the most important ingredient of space flight whether unmanned or manned. Guiding equipment, computers, electronic circuits, transmitters and receivers, all require electric power; and human occupation increases these requirements markedly.

No wonder then that in the design of space vehicles the provision of electric power plays such an important role. There are two general methods for solving this problem: one can either take the power along or, one can pick it up along the way. Chemical batteries, radioactive and nuclear power supplies belong to the first category.

In the second category we must make use of energy sources which exist in the universe, our most convenient source being the sun. Among these four methods, namely chemical, radioactive, nuclear and solar, the choice generally can be made in terms of the overall degree of complication of the satellite, the amounts of power required, the importance of radiation hazard, and similar factors. For example, one would not put a nuclear power supply in a minimum satellite whose total requirements are in the order of a few watts of electric power. Similarly, a chemical battery by itself could not economically furnish power for a large space vehicle.

Table I
Energy Output of a Power Supply Divided by its Weight

	Watt-hour/lb	Power Range (Watts)
Dry battery	14	< 10
Activated battery types	25	< 10
Re-chargeable nickel-cadmium battery	12	< 10
Fuel cell battery .	60	> 100
Radioactive battery	10^4	< 10
Nuclear reactor power supply ..	5x10^9 (max)	> 100
Fusion power supply	5x10^{10} (max)	> 100
Solar battery	infinite	< 100

As in all space vehicle applications, the primary and most important criterion is weight. Table I expresses some typical energy-per-weight factors.

But energy output per pound is not the only criterion. Depending on the application the amount of power which can be furnished instantaneously may be important. Here, for example, the solar battery which is best by the weight criterion makes a rather poor showing. The third criterion relates to the total amount of power needed in the vehicle. Different power supplies require different amounts of overhead, e.g. the initial weight investment for a nuclear or fusion power supply is very large so that the supply becomes economical only if the power requirements are fairly high.

At this stage we can discuss the characteristics of the various power sources; their optimum application will then become fairly obvious.

The Leclanche cell or the usual dry battery is not a very efficient device but convenient. It is always ready for use, requires no preparation, evolves no gases, poses no radiation hazard and has a reasonably long shelf life. The same advantages also apply to the *mercury cell* with the additional point that its voltage does not drop until near the end of its useful life. The initial Vanguard vehicles will be powered almost exclusively with mercury cells.

Other one-shot batteries, e.g. silace-zinc cells are more efficient but are best suited for short time applications such as for guided missiles and high altitude rocket flights. They require activation which can at times be inconvenient; they evolve gases which are corrosive. Otherwise they are very similar to the dry batteries, except that their shelf-life is essentially infinite until they are activated. After the electrolyte has been added, their life becomes very short, of the order of 1 or 2 days.

The *re-chargeable batteries* of which the nickel-cadmium or silver-cadmium are the most efficient, have no special advantage for space flight vehicles unless we can supply another power source e.g. solar power or nuclear power, which will recharge the batteries. A typical application therefore would be in a satellite circling the earth which spends about half of its time in the earth's shadow. During that portion the batteries would supply the electrical power and during the daylight portion the solar battery might recharge the storage cells. The storage cells would be useful also for *stand-by duty* e.g. during maintenance or repairs of a nuclear power supply in a manned space vehicle. Storage cells furnish a convenient power package to supply occasional peak loads such as extremely high power bursts for radio communication purposes; it is more economical to store energy in batteries than in condensers.

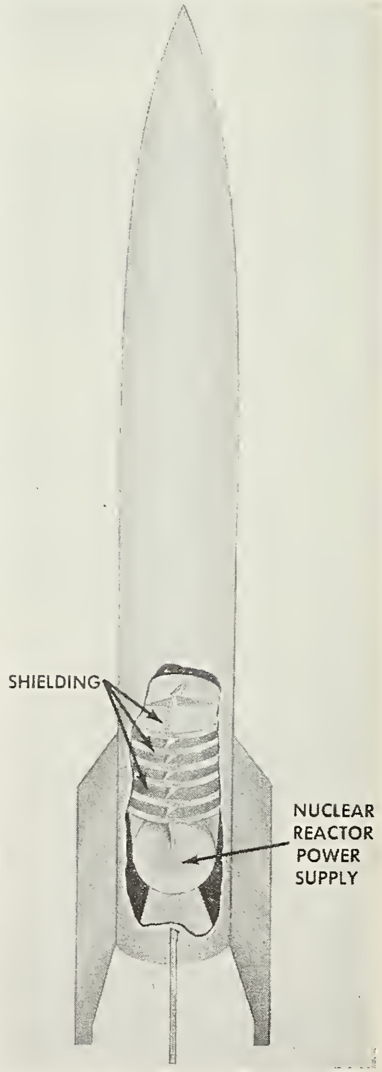
A very interesting type of chemical re-chargeable battery is the so-called *fuel cell* which is being intensively studied in Great Britain. Basically the fuel cell consists of a container for hydrogen gas, another for oxygen and the fuel cell itself which converts the chemical energy of recombination directly into electrical form. The output therefore consists of electrical energy and water. It is perfectly possible then to circulate the water to a nuclear power source which decomposes it again into oxygen and hydrogen by electrolysis and feeds it back into the oxygen and hydrogen tanks. In this way a large nuclear power installation could continuously electrolyze water and recharge fuel cell batteries which could then be used by space vehicles. Such an application would be of importance for example in interplanetary explorations where small exploration vehicles would operate from a mothership. The smaller vehicles might be manned; therefore a nuclear power supply and associated shielding would pose a heavy weight penalty. In this case the fuel cell would be a simpler and more convenient solution of the problem.

Solar Battery

The *solar battery* is by this time well established. It will certainly find its use in small instrumented satellites, possible not in the Vanguard series but certainly soon thereafter. The battery works on the photovoltaic principle with photons from the sun giving up their energy directly in a thin silicon wafer by moving an electron against the built-in potential. Taking the solar energy input at the top of the atmosphere as 1400 watts per square meter and the measured efficiencies of about 10% for the cells now available, one arrives at an electrical power output of about 100 watts per square yard of battery.

It also happens that 100 watts is adequate for the power requirement of the larger instrumented satellites, the meteorological satellites carrying television cameras, and even for satellites which explore the space between the earth up to and beyond the moon.

An interesting method for supplying power at a low level, 5 to 10 watts, is a *radioactive power source.* In distinction to a nuclear reactor this would be a passive source which does not use fission, does not generate any neutrons or additional radioactivity. It simply uses the heat energy from a quantity of material which has been made radioactive and whose activity is now decaying. There is a wide choice of radioactive materials. The important parameters are the *half-life* which must be long enough to compare to the period of applica-



Nuclear reactor power supply sources need only be shielded on the side facing instrumentation or crew compartment.

tion of the power supply; the *mean energy* of the decay, which should be as high as possible; and *availability* since in many cases the overriding consideration will be the cost. For this reason authors always have considered the waste products from nuclear fission reactors.

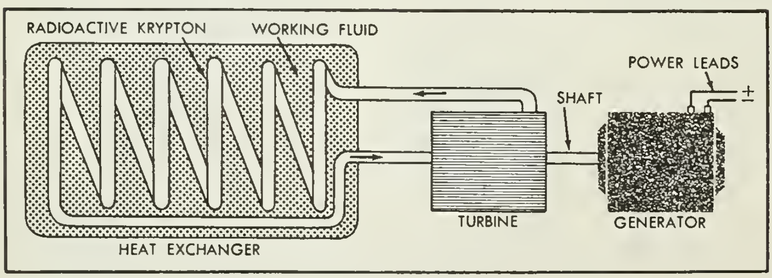
For example, L. Lawrence's Astrosatellite (see MISSILES & ROCKETS, Issue No. 1) uses a strontium 90 radioactive supply. Calculations show, however, that there are special advantages in using gaseous radioactive fission products for satellite power supplies. One of the most promising is Krypton-85. It has a number of special advantages particularly from the safety point of view. It is not stored by the human organism and can be dispersed easily by evaporation into the atmosphere.

Atomic Power

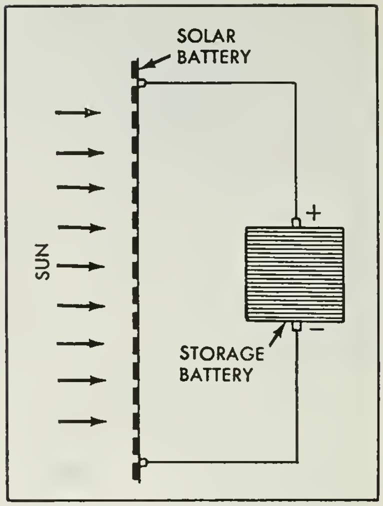
Nuclear reactor power supplies are bound to be of importance for any application requiring more than 100 to 1000 watts. The nuclear power supply is practically without competition. As discussed before it can be augmented with a chemical fuel cell. Basically the nuclear reactor acts as a heat source, approximately one billion B.T.U.'s are produced for every ounce of uranium which is fissioned. This heat must be transferred to a working fluid which then can drive a heat engine. It is well known that the efficiency of a heat engine depends on two temperatures, namely the extremes of its temperature cycle. The nuclear reactor itself can be run very hot, limited only by the strength of materials at high temperatures. However the achievement of a low exhaust temperature may be a problem since there are no means of conducting heat away from a space vehicle. Nearly all of the heat energy must therefore be radiated away into space. A design study has been made by the author which shows that an exhaust temperature in the vicinity of the freezing point of water always can be obtained provided one is willing to build a large satellite and therefore a large radiating surface. Its area in square yards is given approximately by expressing the energy to be radiated in kilowatts.

Another special problem for a nuclear reactor supply is the effect of its radiations on structure of materials, electronic instrumentation and human beings. The structural effects can be designed for and have been by this time well studied. The effects of nuclear radiations on electronic components can be quite severe, particularly on transistors which depend for their operation on the presence of minute traces of impurities. Changes in the internal structure of these transistors will upset their operation. For human beings the tolerance limits are closely specified and must not be exceeded for long periods of time. The two general choices the designer has are: (i) to make use of the inverse square law and put the nuclear power supply far away from the space vehicle instrumentation and occupants; or (ii) to make use of shielding.

Obviously choice (i) is the more efficient method and in the absence of large accelerations is to be preferred, e.g. the reactor power supply on takeoff could be integral with the space vehicle but would be shut off, all of the power being furnished by batteries. On reaching orbit or whenever the propulsion system is off and the acceleration becomes zero, the reactor would be removed to some safe distance from the space vehicle, with only a cable connecting the two. Then the reactor can be turned on by remote control and electricity piped into the space vehicle. Similiarly for landings the reactor would have to be shut off first before it is brought close to the vehicle.



Nuclear power source diagram. Radioactive Krypton is used as working fluid. Conventional turbine and electrical generator are employed.



Simple diagram of solar battery principle. This system may be applicable to small, uninstrumented satellites shortly.

For other applications shielding may be a preferable method for solving the radiation hazard problem, particularly if no human beings are involved. In that case it would pay to make the reactor as small as possible in order to cut down the weight of shielding material; the so-called "fast" reactors developed at Los Alamos would be particularly well suited. Also the vehicle would be designed so that the solid angle subtended by the reactor to the rest of the vehicle is small; in other words a long, thin construction would be preferred. This would make possible the use of a small amount of shielding material, so-called shadow shielding, covering only a fraction of the solid angle and therefore weighing only a small amount.

All of the power sources discussed here are essentially in the prototype stage or beyond, and should be available when required. The futuristic power source, of course, is controlled fusion. When this problem is solved, we will have not only an electrical supply of great efficiency, but one which could make use also of the hydrogen which exists everywhere in the universe. It will then no longer be necessary to carry uranium within the space vehicle.

The abundant amount of electric power which now can be furnished by nuclear supplies and by large solar supplies especially will be important for electrical propulsion schemes such as ionic propulsion. In more ways than one then, the electric power supply problem holds the key to interplanetary flight. ★

World Astronautics

By Heyward E. Canney, Jr.

Dr. Ralph E. Lapp's new book *Atoms and People* (largely on earthbound H-reactors) has brought forward ideas significant to nuclear spaceship propulsion. Dr. Homi Bhabha, an Indian physicist, he noted, predicts that a method will be found for the controlled liberation of fusion energy within the next 20 years. A hydrogen spaceship is far away indeed, but considerable progress seems to have been made in the basic energy problem. In fact, the contents of a recently published Russian progress report on thermonuclear controlled-power have so startled the AEC, that some pressure has been generated to reduce the high secrecy on American thermonuclear work (such as Project Sherwood) which is suspected widely to be hampering progress.

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What may be the nearest thing yet to a real space suit has been recently revealed by the B. F. Goodrich Rubber Company. The wearer breathes 100 per cent oxygen at all times, and has under it a special suit of underwear which provides him with ventilation. Bodily freedom is apparently good, and protection is provided against low atmospheric pressures, high acceleration, heat, cold, and sea water in the event of ditching. This suit has been designed for the Navy, which seems thus far to have been continually in the lead in the design of such equipment.

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Dr. Hubertus Strughold of the USAF School of Aviation Medicine introduced a new term "the ocosphere" which defines that zone in a planetary system within which life-supporting elements occur. In the solar system the zone would lie approximately between the orbits of Venus and Mars and the critical chemical element in question would be oxygen. He reiterated the long-held estimate that there are 100,000 planets in the Universe capable of sustaining life as we know it.

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The "paraballoon", an air-transportable inflatable tactical radar station, developed by Westinghouse, is 30 feet in diameter and weighs 1700 pounds. Air pressures ranging up to 10 psi are used to maintain dimensional stability. Techniques of this kind may well be adapted for future satellites or other space vehicles where large light-weight curved surfaces are desirable. These include parabolic reflectors for microwave radio relay and mirrors for large space telescopes.

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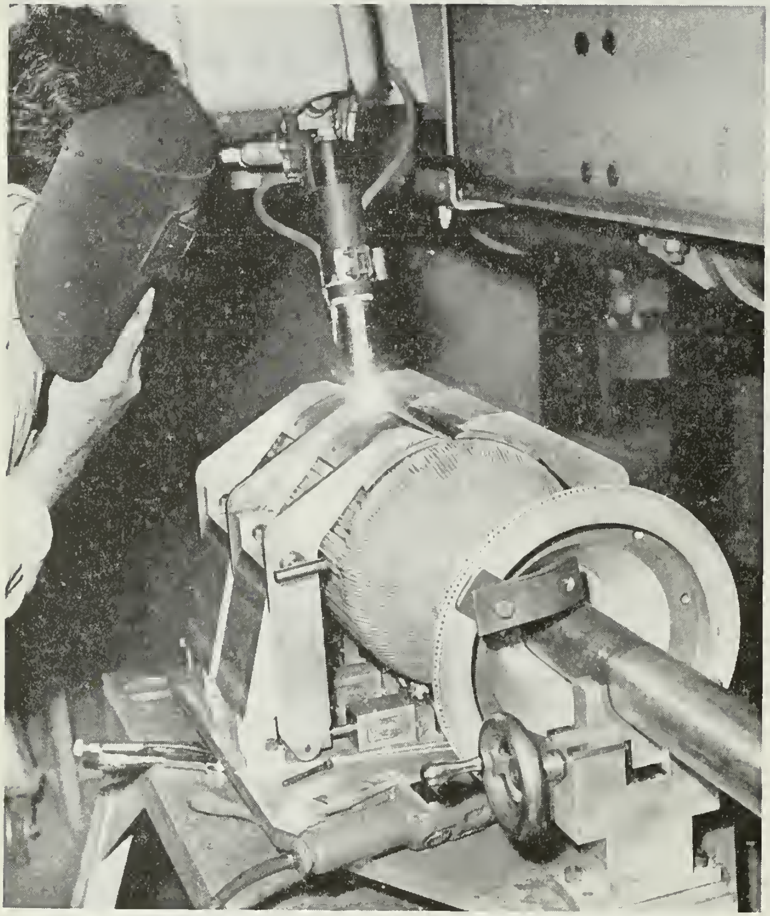
Recent public concern over possible injury from repeated exposures to X-rays has prompted research on the subject. The clinical danger, with good practice, does not seem to be serious, though the question does arise whether or not X-rays from the sun might not prove to be a problem in space.

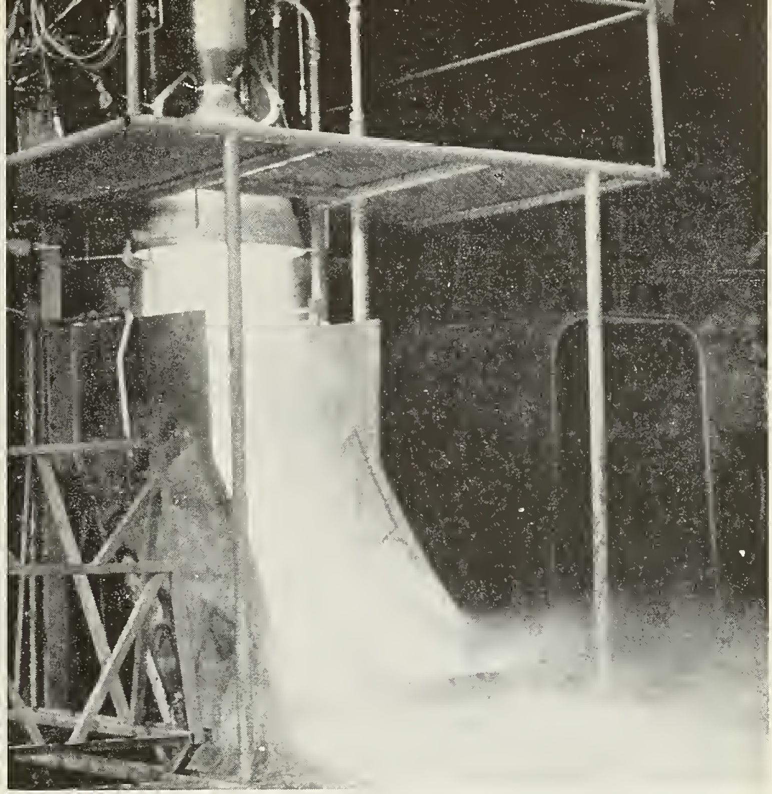


Second Vanguard

Automatic welding of Aerojet's new regeneratively-cooled "spaghetti"-type VANGUARD thrust chamber prior to its being wire wrapped. Aluminum-alloy tubes are used to form the walls of the chamber and also serve as passages for the coolant liquid (oxidizer). Unique design gives considerable saving in overall weight compared to conventional thrust chambers, with no sacrifice in system performance. One of these chambers has been test fired an aggregate of eight minutes—considerably greater than the specific operating duration the second-stage propulsion system will be called upon to deliver.

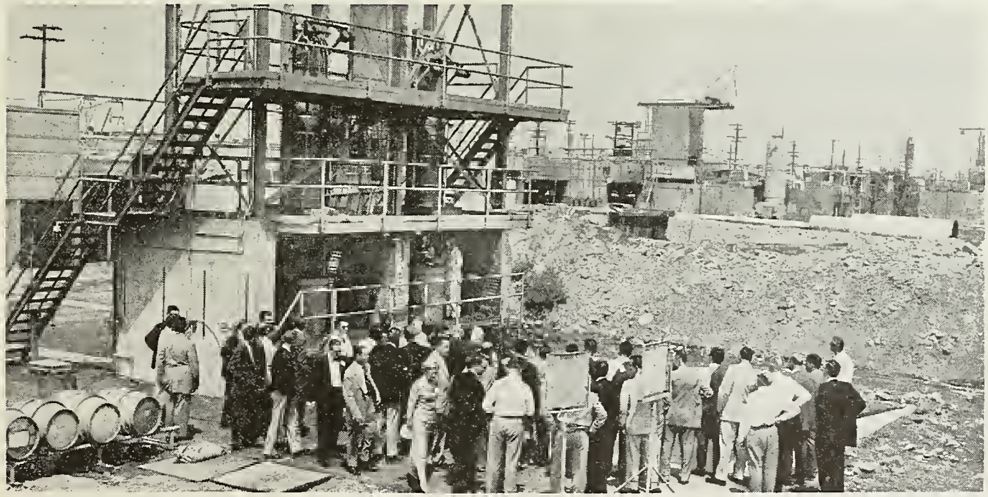
Members of Aerojet-General Corporation's top technical team on the design, development, fabrication, and testing of the second-stage propulsion system for the VANGUARD Launching Vehicle get together around a model of the VANGUARD to consider one of the many difficult engineering problems associated with this pioneering scientific effort. From left to right are C. C. Ross, Liquid Engine Division Manager; W. C. House, Chief Engineer; E. R. Elko, Chief Project Engineer, Missile Rocket Projects; and W. D. Stinnett, Vanguard Project Engineer.

Stage Engine

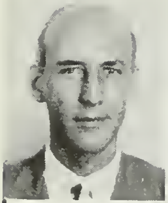


Second-stage thrust-chamber assembly undergoes static test firing at Aerojet's Azusa Plant. Propellant combination used is unsymmetrical dimethyl-hydrazine (UDMH) as fuel and white fuming nitric acid (WF-NA) as the oxidizer. This unit provides impulse for the complete second stage (which also houses the inertial guidance system, the third stage, and the satellite itself) to propel it from burn-out of first-stage boost at 36 miles to orbital altitude of 300 miles. The second-stage propulsion system includes integral propellant tankage, the helium-pressurized direct feed system, the gimballed thrust-chamber assembly, and related electromechanical valve and control components. Thrust is almost 10,000 pounds.

Representatives from the Department of Defense, the Naval Research Laboratory, The Glenn L. Martin Company (prime contractor), and Project Vanguard sub-contractors inspect test facility designed and constructed by Aerojet at its Azusa, California, plant for static test firing of second-stage engine. Successful full-scale static test firings have been conducted for durations from 5 to 100 seconds. Engine is designed for 130 second during period.



Newly-constructed test stand at Aerojet's Sacramento plant is shown in final stages of completion. This structure has been activated and is presently being used for full-scale static test firings of the complete second-stage system. Aerojet's Azusa and Sacramento test facilities are both being utilized for VANGUARD component and system evaluation and are currently in full operation.



Propulsion Notes

By Alfred J. Zaehringer

Liquid ozone (LOZ) still hasn't been fired in a rocket motor. Reason: only small amounts have been prepared and LOZ stability is still critical. Armour and Linde have spent several years of research on LOZ preparation and stability, but even purest LOZ detonates. Although not having performance characteristics of LOZ, fluorine-type oxidants have better chances of early test stand runs.

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Look to the solid-fuel ramjet to compete with solid propellants. Several companies are hard at work on this system. One company has had the system under development for over 8 years. University of Detroit's Missile & Rocket Section is working on the thermochemistry of solid-fuel ramjet propellants. Usual fuels: highly compressed aluminum or magnesium metal powders. Reports are that air-fuel specific impulses of around 200 lb-sec/lb have been achieved. Despite long-term work, SF ramjets have "flown" only in tests stands for limited time runs. Although SF ramjets with metallic fuels give highly smoky exhausts, claims are that this is no objection for surface-to-air missiles and would be a tracking aid.

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Another new entry in the solid-propellant field: Propellex Chemical Corp., prexied by Dr. R. A. Cooley who formerly headed Olin Mathieson solid-propellant operations at East Alton, Ill. New Group will locate in the St. Louis area and will develop and manufacture solid propellants (including double base), cartridge systems, and explosive devices.

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Present trends in solid propellants are toward *one* versatile propellant with both high and low-burning rate possibilities and with performance of over 225 lb-sec/lb. Two most widely used oxidants in composite propellants are smokeless ammonium perchlorate (near 225) and ammonium nitrate (near 200), although Aerojet is still using smoky potassium perchlorate (180-190) for many applications. Standard fuel-binders are the polysulfide (Thiokol) and synthetic rubbers (Grand Central, Phillips, and Standard Oil). Development work now is being carried on with epoxy, polyester, polyurethane, and vinyl-type fuel-binders.

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"Pusher" is the large booster rocket development by Phillips Petroleum using same propellant combination used in M15 RATO (see M/R Prop. Notes, Nov., 1956). The 2-ft. diameter rocket has a total length of about 15-ft. Although no data were given, the booster appears to have an impulse rating of below the British RAVEN (about 350,000 lb-sec) and well below the Soviet T-7A (ca ½-million lb-sec).

Problems and Promises of Free Radical Fuels

To bridge the vast energy gap between conventional chemical fuels and the ideal nuclear rocket, efforts are being made to develop a whole new concept of rocket propellants known as free radicals.

The goal is a relatively uncomplicated fuel with, say, 10-to-20 times the per pound energy content of the best rocket propellants now available. Another realistic target is some means for high Mach number vehicles at high altitudes—300,000 feet or more—to "get something for nothing" in the way of propulsive efficiency. Subsidiary, but still important considerations include: Reduction of the gross-launching-weight-to-payload ratio; and the conservation of national resources.

Dissociation Phenomenon

A striking example of free radicals in nature is the phenomenon of dissociation. The skin of a missile flying at Mach 8 at 150,000 feet should theoretically heat up to 6,000°F. But it doesn't. In fact, North American Aviation's Chief Thermodynamicist, Maury Sulkin, says it will zip smoothly, albeit warmly along at an equilibrium temperature of only 1,000°F.

There are two reasons. One is that as the missile body heats up, the more heat fed into the skin; the more heat radiates away. But more importantly, air at this speed hitting and passing over the vehicle dissociates—breaks down first into atomic oxygen and nitrogen; then into charged ions.

These are free radicals. The tremendous energy required to break them loose from their normal stable diatomic molecular state serves to reduce the temperature of the air passing over the skin. But once past the missile and out of its high energy gradient, these particles bounce around, collide and reform into molecules. When they do, all the energy that went into dissociation originally is given back to the air.

The free radical reaction itself is not new. Atomic hydrogen, freed by passing H_2 through an electric arc, has been a chemist's tool for years. It is the desire to utilize this reaction to develop a "conventional" family of fuels that is new.

For example, suppose that ordinary ethane, C_2H_6, has been broken down through the prior application of energy into ethyl free radicals—a rather disorganized mixture of C-C, CH, H, C, etc. Upon ressociation into ethane, it will give off heat energy at the rate of 200 kilocalories per mole. This compares to 33 kilocalories per mole when ordinary JP4 fuel is burned with nitric acid. The ethane reaction is one of the least productive of the free radical reactions. Others with much higher heats of reaction are now being researched. A ressociation reaction, for example, involving ethyl free radicals and oxygen raises the temperature of exhaust gases to over 12,000°F.

Storage Problem

Preparation of free radicals is relatively simple. Apply enough heat or electrical energy and they bust apart. Storage, however, is quite another thing. They are highly unstable—gregarious, as it were, to the Nth degree. Keeping them separated into their free radical state until they are used is one of the main problems now being studied. There are several avenues of possible solution. These include:

- Supercooling down towards absolute zero. The Army, a pioneer in the present work, has succeeded in doing this in the laboratory. Disadvantages of this method include the need for heavy cooling equipment (all right on the ground, but self-defeating in the air), costly cryostat storage facilities and the ever-present danger of an unavoidable catastrophic explosion should temperatures rise to the critical point.
- Magnetic suppression of the free radical gas. A monatomic polarized magnetic field will prevent rotational excitement of the particles and prevent ressociation. This system might be the answer on the ground, but the weight of the permanent magnets would be a handicap to flight.
- Mixing with noble gases such as helium, argon, etc., to keep the highly reactive free radicals separated. Problem is how to filter away the suppressant gas when pure free radicals are wanted for fuels.
- Storage under extreme pressures when standard gas laws no longer apply. Little is known about this phenomenon as yet. But weight of the pressure vessels would again be a likely disadvantage.
- Electro-static separation—similar to the magnetic phenomenon. However, at voltages required corona discharge would probably be a problem. Again, so would the weight of the necessary equipment.

The problem of designing and lining combustion and exhaust chambers to cope with the temperatures involved in free radical reactions. Possible solutions now being studied include the use of very dense ceramics and/or fluorinated plastics. Though the latter do not remain solid at the temperatures involved, the liquid film they form when they melt is chemically inert (whereas free radicals are extremely active chemically and has a very low heat transfer rate. In any case, these liners would certainly have to be replaced after each flight.

If the tremendous air stagnation heat flux at the nose of a hypersonic vehicle could be recovered and utilized to dissociate fuels in flight instead of melting the vehicle's nose cone, the range of any initial fuel load could be immensely increased.

Similarly, at very high altitudes (300,000 feet and up) the air is believed to be 100% dissociated by the energy of ultraviolet radiation. And, while it is very thin, properly designed intakes at high speeds could bring sufficient free radicals to materially assist the internally-carried fuel load. This sounds like getting something for nothing. It isn't. It is merely one possible way of utilizing the sun's radiated energy. ★

Bell Sets Up Guided Missiles, Rockets Divisions

Separate guided missiles and rockets divisions were established last month by Bell Aircraft Corp. in a sweeping reorganization of its Niagara Frontier operations.

Bell's former Niagara Frontier Division has been dissolved in favor of two major operating groups —an aircraft division and weapons systems division. The new missiles and rockets groups will be subdivisions of the latter organization.

Bell president Leston Faneuf said the new set-up has been under study and planning for a year. It is designed to decentralize the company's diversified products business and strengthen product lines.

Vice presidents Julius J. Domonkos and Roy J. Sandstrom will head the aircraft and weapons systems groups respectively. Each will have full responsibility for sales, design, production and procurement for its particular product lines.

In the weapons systems group, the new guided missiles division assumes full control of the GAM-63 *Rascal* air-to-surface missile and other programs.

The rockets division takes over all rocket propulsion design, testing and manufacture.

Two other components of the WS group are avionics and research. The former will handle all of Bell's electronic and servomechanical work. Latter will concentrate on applied research and study contracts, will be in charge of nuclear engineering.

Martin On Schedule In Denver Move

The Martin Co. on November 30 expected to start "on schedule" its move into a new engineering administration building near Denver—site of its *Titan* ICBM airframe production (M/R October, p. 55).

Some 300 employes will transfer to the permanent plant site during the first three weeks of this month.

Martin schedule now calls for completion of its main factory building at the new location late in January. In all, the company now leases six buildings in the Denver area—the most recent a 50,000 sq. ft. structure to be used as a warehouse until the permanent plant is ready for occupancy.

Douglas To Test *Thor* At Sacramento Plant

Component testing of *Thor* IRBM missile will be conducted by Douglas Aircraft Co. at its new test installation under construction on a 1,750-acre plot leased from Aerojet-General Corp. at Sacramento, Calif.

Field station supervisor of new plant will be J. F. Goodman and initial employment is expected to reach 200. First complete *Thor* airframe is now being built.

NAA Head Sees Bright Future For Rocketdyne Div.

J. H. Kindelberger, board chairman of North American Aviation, Inc., views the company's Rocketdyne Division as one of the brightest spots in the North American picture.

Addressing some 1,300 NAA management club members recently in Los Angeles, Kindelberger said the Division has orders to supply engines for all the larger rocket-powered missiles being developed in the U.S. He cited North American's own *Navaho*, Army's *Redstone*, Convair *Atlas*, Martin *Titan* and Douglas *Thor*.

He also noted that Rocketdyne Division employment, now approximately 8,600, is about double that of a year ago and probably will increase another 3,000.

For the present, he added, NAA is the only firm able to deliver proven rocket engines of very high power, but told supervisors the company is going to have to work hard in the future to keep ahead of its nearest competition.

Kindelberger indicated the hope that the *Navaho* missile program will move into a production phase that would demand more of the area and facilities of NAA's Los Angeles Division.

Of another North American missile activity, he classed inertial navigation (guidance) development and production as one of the most favorable aspects of its Autonetics Division activities.

Navigation in Interplanetary Space

October M/R featured an outstanding article on NAVIGATION BY SATELLITES, written by Lovell Lawrence of Chrysler Corporation. His article was based on a paper "Astro—an Artificial Celestial Navigation System," presented at a Franklin Institute symposium and published by the Institute's JOURNAL, in Monograph 2. The response to Mr. Lawrence's article has been so great that M/R decided to pursue this fascinating subject further. The navigation aspect of astronautics has not been considered to any great extent, and we are honored to publish this follow-up feature article, written for M/R by Dr. Peter Castruccio of Westinghouse Corporation. He is currently engaged in advanced planning of interplanetary astrionics communications and navigation aids of the future.

By Dr. Peter Castruccio

DURING the first phase of the development of space flight, it is likely that the navigational aids will be primarily optical, with only limited radio aids. In the second phase of ever-expanding space traffic more automatic means will come into existence and we will witness the ever-increasing use of radio-navigation. To navigate successfully, the ship's pilot must know:

1) His position with respect to some frame of reference.

2) His direction of travel with respect to the same frame of reference.

3) His speed.

4) The position of the body towards which he is traveling.

5) The direction of travel of the body.

6) The speed of travel of the body.

7) Any predictable deviations from a straight-line course of the body.

Of course, 4), 5), 6), and 7) must be related to the same frame of reference as 1), 2), and 3).

In space the position of all major celestial bodies is accurately known or accurately predictable. Thus the principal problem of the space navigator is to know his position, direction of travel and speed. This can be done by observing the stars, the Sun or the Planets within the Solar System by means of accurate optical instruments and with the aid of a clock—a method similar to that of the sea navigator when he takes a "fix."

The problems of the space traveler are, however, enormously more complex than those of the seaman. First of all, with the exception of the stars, all his points of reference move continuously. Therefore as soon as he has performed one observation and is preparing for the next his frame of reference has moved. The space navigator then faces a dilemma: if he makes quick observations, his accuracy will suffer; if he takes time and does a good job in observing, his frame of reference shifts too much. If he relies solely on optical measurements, he must consult complicated tables of predicted planet positions, or he must use an electronic computer. At best, his job will be a tedious and painstaking one.

While this laborious procedure is satisfactory for slow ships, it becomes less and less desirable for faster ships. For example, if a ship were to leave Earth under a constant "ig" acceleration, directed to Mars at its closest distance, and halfway during the trip it were to reverse its direction and slow down at the same constant acceleration, the trip would take only 39 hours. Although the motor for such a ship is far beyond our present possibilities, recent announcements, such as Dr. Saenger's photonic rocket, foreshadow what may come.

Navigational systems similar to the ones now employed for airships can be employed in space and, as far as we know today, they should work better because no distortion or deflection of the rays will occur in space. Also, the problem of "radar horizon" caused by the Earth's curvature will not arise. Space navigation is more complicated than earth navigation because while Earth-based navigational aids are fixed with respect to the Earth's frame of reference, space systems must of necessity move with respect to each other because of the constant motion of all planets and satellites.

Different Systems

Nevertheless, such systems can still be conceived in several forms:

1) Beams aimed between planets (or satellites of interest), forming polygons of variable legs, which legs always represent the shortest distance between planets.

2) Very broad beams, or even omnidirectional radiators, placed on the planet of destination.

3) Space Loran or analogous systems.

In cases 1), and 2), the ship's pilot would tune his guidance equipment onto the frequency of the source of destination and close the ON switch; the automatic equipment would do the rest. It is conceivable that tuning could be automatically performed by merely pressing a button corresponding to the destination. Advantage could be taken of the Doppler frequency shift of the received signal to determine the ship's speed. The accuracy of the beamrider system would theoretically be very high.

With the beamrider system, an antenna of 30-foot diameter operating at a 3-centimeter wave length could theoretically guide a ship from an Earth base to Mars at its closest distance with an accuracy of 10,000 miles. This compares very favorably with accuracies quoted for celestial navigation; however, it is probably unnecessarily high.

Because of the rotary motion of all heavenly bodies, the beam would have to be rotated in synchronism with its home planet or, in the case of an omnidirectional radiator, several would have to be installed on the surface of a planet to avoid casting a shadow when the beacon is turned away from the ship.

The third navigational system is basically an extension of the Loran system in three dimensions. Surface Loran uses three ground stations—it operates basically by measuring the distance from the three fixed stations from the aircraft. If we have three fixed points in a plane and if we know the distance of an unknown point to each of these three points, we can draw three circles, centered on the three fixed points, with their radii equal to the measured three distances. The point of intersection of these three circles gives the position of the unknown point. In space we have three dimensions to contend with instead of two, so we need one more fixed point, making a total of 4 stations.

In the case of Loran, all the computations are, of course, performed automatically within the aircraft. The same would apply to Space Loran. The difficulty with Space Loran, which we do not find in Earthly Loran, is that the stations must move themselves to prevent their falling on some planet or on the Sun, and to keep them in regular orbits.

Their motion must be accurately known, otherwise the entire system becomes useless. To do this one possibility is to install them on planets, satellites, or on artificial satellites (space stations) circling the planets. Another solution is to place them in known orbits around the Sun, which makes the stations essentially artificial planets.

A drawback of this second method lies in the fact that the Loran stations (or beacons) being very light compared to the Planets, may be seriously influenced by the various gravitational forces acting within the Solar system. In fact, some believe that they never could be placed in a completely stable and permanent orbit.

Any erratic motion of great magnitude would of course spoil the advantages of this system. It would thus appear that the best location for Space Loran beacons is on existing celestial bodies whose courses are accurately known and predictable. Even knowing their exact motion, however, does not completely solve the problem. They still have the great disadvantage, with respect to the Earth-based Loran system, of moving continuously. This drawback can be combatted, however, by carrying a computer in the ship which would take their motion into account and correct for it. Special signals could be emitted by the stations at periodic intervals to synchronize the computer, i. e., to correct automatically any errors the computer may have accumulated since the preceding signal

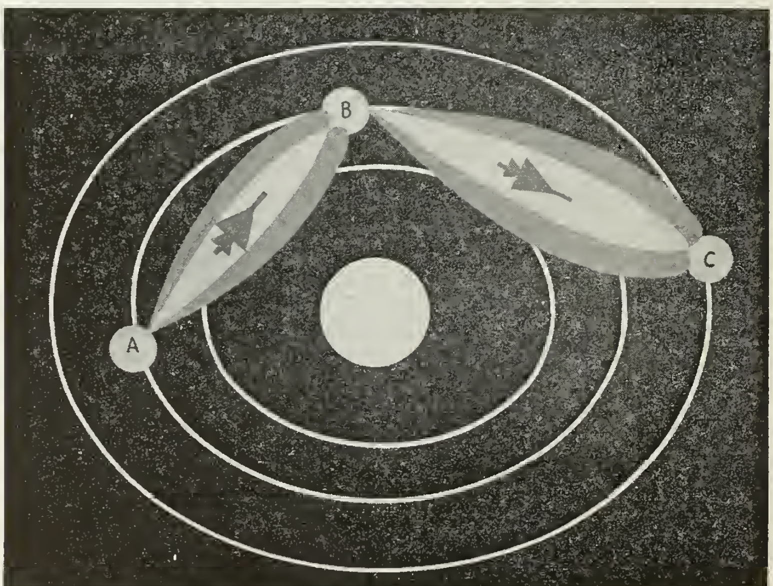
The advantage of the Space-Loran (RAVEN: Ranging and Velocity Navigation) is that it can furnish the space ship an instantaneous proportional fix, whereby the ship can know its position with respect to any point of the Solar System. In addition, RAVEN can furnish the ship its correct speed and direction of travel, by making use of the Doppler effect, i.e. by measuring the difference between the received frequency and the known frequency of the beacon.

All this information can be determined automatically by appropriate instruments within the ship and presented to the pilot by a guidance computer which would calculate, from the information received, the quantities of interest to navigation.

The difference between the first two systems and RAVEN is that while 1) and 2) furnish direct guidance to the destination, RAVEN furnishes only a fix, the pilot must then calculate and set his own course.

Technical Problems

The largest single problem of space navigation is range. Many of our Earthly communications systems are omnidirectional the transmitting antenna sends forth energy in all directions, and the receiving antenna can receive in all directions. This is the typical case for radio or TV, and also for LORAN.



Radio beams between planets will let pilots relax as automatic equipment guides them along shortest route.

It is safe to state that such a system would not be operative in space (except for relatively short distances) with the presently available techniques. The range for voice communication, for instance, with the best equipment available today and with practical size antennas aboard ship, would be about 16 million miles. This is obviously inadequate in view of the fact that the shortest distance to Mars is 36 million miles.

The range for RAVEN can be calculated (with omnidirectional-transmission and reception) at about the same figure. To achieve greater ranges, several means are available—some of these can be used today, others require further development effort but will presumably be operational by 1970. These are:

1) Beaming of the transmitted energy.

2) Beaming of the received signal.

3) Increasing transmitted powers.

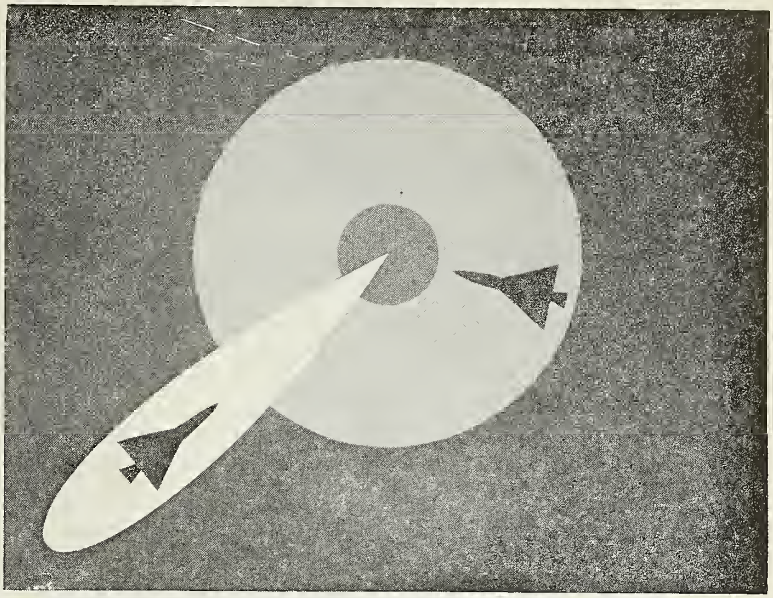
4) Improve the sensitivity of the receivers.

5) Improve the information content of the signal and the means to extract the signal from the background noise.

6) Reduce the quantity of information per unit time, i.e. "spread" the messages out in time and develop equipment capable of taking full advantage of such a technique.

While 1, 2 are immediately applicable today, 3 to 6 require further development. *Beaming*, while it increases the range because it concentrates the energy, has its drawbacks in that the beam must be aimed between the transmitter and receiver. Beaming requires a knowledge of the position of the ship from the base, and vice-versa.

While beaming is obviously necessary for the first navigational method proposed (beamrider) it would not be applicable to the second system nor to RAVEN. With existing techniques, the range achievable with a fully omnidirectional system is about 16 million miles. It is probably not too far-fetched to predict that by 1975 or so this figure can be increased by at least one order of magnitude.


Broad beams and omnidirectional radiators show how proven air navigation methods may be adapted to space travel.

Even with today's techniques, beaming will allow much greater ranges than the 16 million miles quoted above. Even a relatively broad beam, such as 30°, will increase the range from 16 to 160 million miles.

Another technique which is still imperfectly developed but which may well be useable to its full advantage by 1975 is that of *integration.* This technique reduces the quantity of information transmitted by spreading out the message in time. It can be computed that with perfect integration, the range increases as the square root of the message spread in time.

Time Spread System

It is interesting to compare the beaming system with the *time spread* system. It is obvious that the beaming system concentrates the energy in one direction, with a corresponding loss for all other directions; the range thus increases in the beam's direction, but drops in all other directions. If we are transmitting, and we do not know the position of the receiver we wish to contact, we must move our beam until contact is made. In so doing, we must: transmit in a certain direction, wait a sufficiently long time for the message to reach the receiver, wait for the receiver to pick up the message, then wait for the message to be re-transmitted and to reach us. We must repeat this procedure for each new beam position. It is obvious that in doing this we lose time.

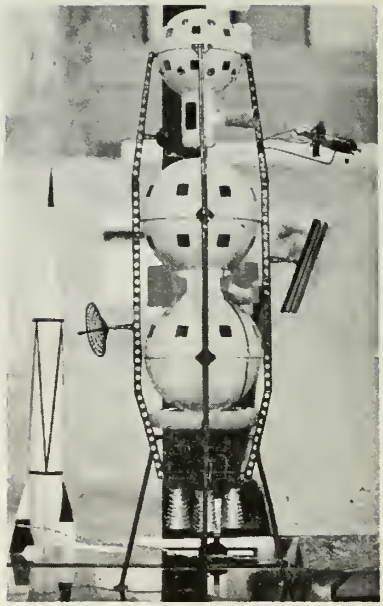
If now we compare the beam system with the time spread system in respect to the time required to contact a receiver of unknown position we find that the time spread system, operating at full efficiency, will require less time. Conversely, for the same lost time, the time spread system will reach out further in range.

We can thus conclude that beaming has an advantage over a perfect time spread system only if we know the position or the general area of the receiver to be contacted, so that our scanning time may be rather limited.

It is worth mentioning that the Solar system is very nearly flat and the orbits of the planets all lie approximately in a plane. Space navigation within the Solar system may well be confined within this plane, unless other noteworthy objects be discovered in other regions of space which, in the light of our present knowledge, appears unlikely. Thus, all navigation and communication radiation patterns need be omnidirectional only in azimuth, and confined to a relatively narrow elevation sector. This arrangement would further increase the ranges of all our communications systems. ★

South Africa Prepares for Satellite Tracking

By F. C. Durant III



South African Interplanetary Society conducts exhibits to arouse public interest in forthcoming IGY satellites.

When the U.S. launches its earth satellites from Florida during the International Geophysical Year they will head southeast approximately along a 40° path. In South Africa, eyes will be trained northwest, waiting for them. No one at the southern extremity of Africa waits with more anticipation than members of the young but growing South African Interplanetary Society.

The Union of South Africa will probably be the first land mass of any size to view the U.S. artificial satellites. Their trace will carry them too far to the north to be seen from South America on the first pass. In all probability the satellites will be launched at night to aid official U.S. tracking stations strung out into the Carribean. These early tracking data will be vital in determining the ultimate path of the satellite. Of prime importance will be the direction and velocity at burnout of the third stage of the *Vanguard* satellite launching vehicle.

Less than a half hour later the satellite will have passed over or near the tip of South Africa and will be on its way around the world to pass over the United States about on hour later. If the launching at Cocoa, Florida, were at 10 p.m., the satellite would pass near South Africa after 4 a.m. because of the six hour difference in time zones. Assuming that the time of launching will be in late evening and the early morning skies over South Africa are clear and bright there is a good chance that the satellites will be spotted on the first time around.

The South African Interplanetary Society (SAIS) was founded less than four years ago by a pair of engineers of Johannesburg, A. W. Andersen and Perry Carlson. The first president was A. E. H. Bleksley, professor of applied mathematics, University of the Witwatersrand. Professor Bleksley set forth the functions of the SAIS at the inaugural public meeting in May, 1953. He said the functions are two-fold—"To perform an educational function and to undertake research." The first function involves public lectures and publicity of a conservative nature. Membership qualification of the Society is simply to have a serious interest in astronautics. Technical or professional qualifications are required of Fellow members. Research by the SAIS has been largely academic. A Technical Advisory Committee coordinates such study and performs an advisory function on the various programs.

The SAIS maintains a library at Johannesburg and publishes a quarterly Journal containing original articles, pertinent news of the Society, its activities and items of significance to astronautics. The Journal is interesting and has carried a series of excellent articles entitled "Rocket Propulsion" and "Space Flight" by the first SAIS Technical Director, Dr. J. Venter. The Society has a close relationship with the Astronomical Society of South Africa and cooperated with them at an exhibition in Johannesburg last year. A few months ago a much larger exhibition was held at the "Spring" Festival Show of the Witwatersrand Agriculture Society. The SAIS has been a member of the International Astronautical Federation since 1953.

The SAIS membership has just passed the 100 mark. But, the Society has demonstrated that it is foverned by Directors who appreciate the fine distinction between fantasy and actual achievement. This conservative position on the often controversial subject of astronautics has won for the young Society local recognition by membership in the Johannesburg Council for Adult Education and the South African Association for Advancement of Science.

The Union of South Africa is not one of the handful of nations active in rocket and guided missile development. And yet, the average man, whether he be a professional or simply intelligent, has a strong interest in the development of astronautics. This common interest around the world has led to the formation of astronautical societies as foci of discussion and study of the subject, as well as fellowship with like-minded individuals. The South African Interplanetary Society is one of these. Their activity has been exemplary and future growth seems assured. ★

Astrionics

By Henry P. Steier

Big "missing link" in information made public on the scientific part of the *Vanguard* program is the computation facility. A news conference, presumably on the computation part of the program, was scheduled for Oct. 31 by International Business Machines Corp. but suddenly called off. Rumor has it that interservice rivalry is delaying credit-giving to Army and hence to IBM. Indications are that IBM is supplying computer equipment gratis. Even so, Army feels its big part in operating the communication link with the computer is not getting attention it deserves. So, Pentagon clamp-down persists while "security" problems are untangled.

The commonplace dry-cell battery still appears as best hope in the near future for powering small satellite communication links. Jorgen Jensen, Martin Aircraft Co. engineer, recently compared various power supplies and the dry cell came out on top. Dry cells deliver 50 watt hours per pound. Motor generator, chemically powered, delivers same power per pound of fuel but not including weight of machinery. Solar batteries deliver that power per pound but need a complex and heavy control system. Thermocouples also require controls and weight might be a few pounds per watt. Atomic power plants impose severe shielding weight problem because many astrionics components are sensitive to radiation.

Sensitivity of semi-conductors to nuclear radiation needs research. Big gap in information on the subject was indicated at recent IRE meeting on Electron Devices in Washington, D. C. Anyone with information on the subject was asked to leave name and address in a ballot-type box. Pentagon wants to arrange a symposium on the subject at an early date.

Infra-red know-how in firms doing missile guidance work might come in handy in other fields. Aerojet General, Eastman Kodak and Nevada Air Products are interested in applying missile infra-red detection and ranging techniques to civil proximity warning devices for reducing mid-air aircraft collision hazards.

Philadelphia manufacturers have made a generous offer to the IRE Professional Group on Telemetry and Remote Control. They are offering five prizes of $250 each for best technical papers to be presented at the National Symposium on Telemetering scheduled for Philadelphia, Penna. on April 15-17, 1957.

Although not among the first inboard experiments to be made with the *Vanguard* satellites, the question of whether changes in the earth's field during magnetic storms are due to ionospheric currents or to an extra-terrestrial ring current must be resolved. Information is needed for more accurate prediction of magnetic storms that wreck communication. Problem will be weight of the magnetometer. Varian Associates has flown their proton precession magnetometer in rockets. A light-weight version of it stands a good chance of being tried in a satellite.

International News

By Anthony Vandyk

One way to start an argument in Canada is to mention the *Velvet Glove*. The Canadian government's official line on the air-to-air missile project is that it enabled the nation to stockpile know-how in the guided weapons field. Critics say that the *Velvet Glove* should have been named the *White Elephant* because the missile was adopted by the Royal Canadian Air Force despite the expenditure of $24 million on it since 1950. Nonetheless, the government insists that the money was well spent. R. O. Campney, Canadian Defense Minister, has declared that the *Velvet Glove* project paved the way for the nation's industry to manufacture a more advanced type of guided weapon, the American-designed *Sparrow*.

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Visitors to Britain's rocket and missile range at Aberporth, Wales, recently got an unexpected demonstration of the jettison procedure followed when an air-to-air missile failed to fire. After it had launched its first Fairey *Fireflash*, a Hawker *Hunter* could not fire the second. Observers noted a flash as the explosive bolt was detonated and the missile then twisted away from the fighter. The *Hunter* then performed a series of rolls in quick succession to be certain that the *Fireflash* had in fact been jettisoned.

•

Plans for the reorganization of Britain's missile program now are almost complete. The FINANCIAL TIMES says that efforts will be concentrated on the development and rapid production of six projects: a medium-range bombardment missile; an intercontinental bombardment missile (using rocket motors of over 100,000 lbs. thrust); a ship-to-surface missile; a ship-to-air missile; a surface-to-air missile; and an advanced air-to-air missile.

•

France's prime supplier of rocket motors is Societe d'Etude pour la Propulsion par Reaction, usually known as SEPR. The French Aircraft Industries Association has disclosed that SEPR rockets are to be used in the Dassault *Mirage* and the Sud-Est *Durandal* lightweight fighters as well as in the Sud-Ouest *Trident*. The first French aircraft using rocket power, the Sud-Ouest *Espadon*, was equipped with a SEPR unit and jettisonable rocket fuel tanks.

•

E. G. D. Andrews, Chief Designer of Armstrong Siddeley Motors' Rocket Division, pointed out recently that none of the components of a rocket engine use up much energy except the combustion chamber. For example, he said, the turbine which drives the fuel pumps takes only about three per cent of the total energy, whereas the compressor of a gas turbine takes about 60 per cent. So, while the overall efficiency of a gas turbine is greatly affected by the efficiency of its components, the combustion chamber is virtually the key to the efficiency of the rocket engine. As long as the remaining components reach a satisfactory standard of reliability their individual performances do not greatly affect the overall performance of the engine.

INDUSTRY SPOTLIGHT

By Joseph S. Murphy

INDUSTRY CHALLENGE:

Case For Reliable Missile Batteries

Exide Industrial Division of The Electric Storage Battery Co., producer of the battery for the first wakeless torpedo, has streamlined its development and manufacturing facilities to meet stepped-up guided missile battery demands.

The company has set up within its own organization a team of specialists devoted full time to the missiles program. Task of this group is to take advantage of basic research findings, combine them with engineering and production know-how in the ordnance field, to come up with advanced missile batteries.

This year Exide created a Missile Applications Div. under RAdm. W. H. Ashford (USN-Ret.) to spearhead its missile program. It collaborates with Exide's engineering group to pick appropriate electrochemical battery systems for specific missiles.

A coordinator of missiles applications engineering has been appointed to expedite availability of new missile batteries from concept to delivery.

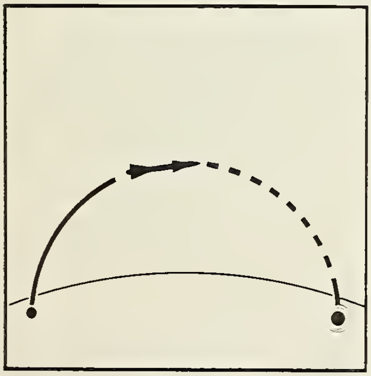
And because of the trend toward use of batteries with alkaline electrolyte in current missiles, Exide has organized an alkaline division within engineering for preliminary design, development and testing of prototypes. Fundamental information for the final design of a missile battery system comes to design engineers from this group.

Another new Exide unit is the Silver Battery Division within its manufacturing department.

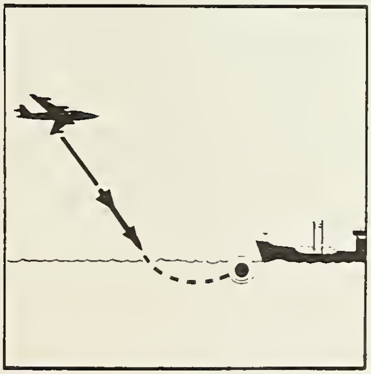
A recognition of the reliability and versatility limitations of mechanical energy sources is shifting missile engineers more and more to reliance on the battery industry to develop power units specifically designed for their intricate applications. Batteries most adequately fulfill these requisites of missile power sources:

- *Maximum reliability.*
- *Maximum energy output per unit of weight and volume.*
- *Precise voltage regulation.*
- *Efficient operation over a*

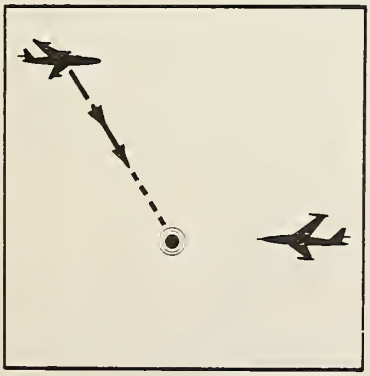
Some Typical Discharge Rates of Storage Batteries in Missile Applications



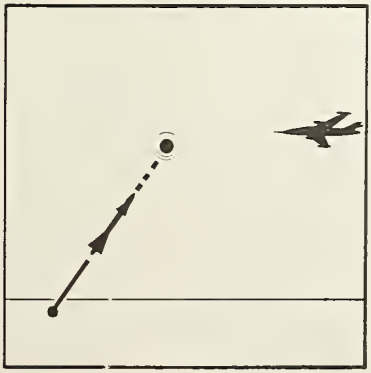
Intercontinental Missile —60 *Minutes*



Air-to-woter — *15 Minutes*



Air-to-Air — *90 Seconds*



Ground-to-Air — *3 Minutes*

Underwoter — *10 Minutes*

wide temperature range.

- *Long shelf life.*
- *Minimum activation time.*
- *Maximum mechanical stability against vibration, impact and other hazards.*
- *Minimum maintenance.*

A choice of electrodes for either primary or secondary battery systems is available. Exide designs, for example, include missile batteries with silver-oxide and nickel-oxide positive plates in combination with zinc or cadmium negatives. These supplement its lead-acid battery systems, including the newer calcium and long-life Silvium alloy batteries.

Of the electrode systems now available, silver-oxide-zinc and nickel-oxide-cadmium batteries are receiving most attention for missile application; but in certain instances other types might be desirable.

Several practical missile battery systems are available, and Exide has been active in the development of the most important types which appear to have missile applicability. Pertinent features of such systems are:

PRIMARY SYSTEM (One-Shot Application)

Silver-Zinc—High specific capacity. Extremely low impedance. Operating temperature from 32 to 160 degrees Fahrenheit. Heaters often supplied for operation at below-freezing temperatures. Excellent storage (up to two years).

Water-Activated Batteries—Have a definite place in certain missile applications, but subject to certain limitations.

Mercury Dry Cell—Better than common dry cell on storage. Low impedance and operation at low temperatures.

Common Dry Cell (Le Clanché)—Convenient, reliable and economical in price. Excellent for high-voltage sources. Maximum safe storage about one year. High impedance causes high specific weight at missile rates. Operates poorly at low temperatures.

SECONDARY SYSTEMS (Rechargeable)

Silver - Zinc — Lightest weight system. Operating temperatures from 32° to 180°F. Non-spill capacity considerably reduced at temperatures below freezing. Maintenance rather difficult. No ready way to check state of charge. Subject to premature failure from maintenance abuse. Life is short compared with some other secondary systems.

Lead-Acid—Standard for comparison of other systems. Comparatively low in cost. Has application for preliminary or check testing when space and weight are of less importance than economic factors. Capacity can be determined by voltage or specific gravity. Works at temperatures up to boiling. Can be made non-spilling. Heavy. Capacity is lowered at sub-zero temperatures.

Nickel-Cadmium—Long life. Work at temperatures up to boiling (212°F). Gives better performance than other types of couples at subzero temperatures. Exceptionally unaffected by maintenance abuse. Heavier than lead-acid missile batteries. Non-spill. Requires maintenance. No ready way to check state of charge.

Primary vs. Secondary

The missile engineer must make a basic decision on whether to employ a primary (one-shot) or a secondary (rechargeable) battery system.

Primary systems have the advantage of completely reserve-type of construction. Active parts of the cell are stored dry, with electrolyte held in a separate compartment, requiring little or no attention.

The system is completely inert until the time of discharge, when a rapid-action mechanism fills the cells from the electrolyte reservoir.

Pre-flight testing to insure battery operation, a routine procedure with secondary systems, is unnecessary with primary batteries. Their high quality makes it possible to predict their reliability. This quality can be assured by proper manufacture and control procedures.

A silver-zinc secondary battery has an obvious role in the early phases of a missile evaluation program, but in the final stages, a primary system is to be preferred. The reliability of a secondary battery can be demonstrated by preliminary discharge. It can be used for preflight testing of the missile control. It is at no disadvantage with regard to weight.

Silver-Zinc System

Generally, the silver-zinc electrode battery—either primary or secondary—is superior to others in missile applications, because of weight, volume and electrical behavior.

Like any other battery, the silver-zinc system is composed of positive and negative plates, separators and electrolyte, assembled in a suitable container which is shaped to fit the particular missile.

The active material of the positive plate is an oxide of silver. There are two states of silver-oxidation, silver oxide and silver peroxide. Certain operational restrictions make it desirable to use silver oxide—the lower state of oxidation—in secondary battery systems.

The same restrictions do not apply to primary systems, making it possible to use silver peroxide for them. Thus, the silver content of a primary battery can be about one-half that of a comparable secondary battery.

Zinc sponge in plate form is used as the negative active material in both primary and secondary silver-zinc batteries.

The active materials must be distributed and placed within the battery to give maximum plate area and minimum electrical impedance. The physical condition of the silver oxide and zinc affects battery performance. Thus, design, condition of materials and assembly are critical in the manufacture of a silver-zinc battery.

Potassium hydroxide in water, is used as the electrolyte. Higher-strength electrolyte has advantages in battery operation, but at lowest temperatures, lower-strength electrolyte is used. A concentration of 30 per cent potassium hydroxide in water has a freezing point of about —65°F.

The alkaline electrolyte of a silver-zinc cell does not change during the operational cycle. This precludes the use of a hydrometer, as in lead-acid cells, to determine state of charge.

Typical Missile Battery

A typical silver-zinc primary missile battery of proven design is shown in the accompanying photograph. It consists of much more than the cell itself. The battery cells, completely dry and electrically inactive, are surrounded by a heating blanket with thermostat.

The electrolyte for the battery is held in a bag container, separate from the battery cells but within the metal container. Space is provided for a heater and thermostat to heat the electrolyte and hold it at operating temperatures.

A closed pipe connects the

Specific Weights and Volumes of Missile Batteries [1]

	Watt Hours Per Pound	Watt Hours Per Cubic Inch	Operating Voltage
PRIMARY SYSTEMS			
Silver-Zinc[2]	30	1.50	1.35
Water-Activated[3]	28	1.60	1.10
Mercury Dry-Cell	7	0.70	1.00
Common Dry-Cell	4	0.37	0.90
SECONDARY SYSTEMS			
Silver-Zinc	30.0	1.75	1.35
Lead-Acid	12.0	1.20	1.75
Nickel-Cadmium	8.3	1.75	1.35

[1] Based on efficiently-designed, complete batteries, with auxiliaries, at missile discharge rates.
[2] Activation system included.
[3] Activation system not included.

electrolyte container with the battery cells. It has a valve or rupturable diaphragm with an opening or breaking mechanism. A pressure differential is maintained between the electrolyte bag and battery cells.

When power is required, activating devices operate to release the electrolyte into the cells. The normal activating impulse is an electrical current of about one ampere for 10 to 20 milliseconds. This power is used to fire one or more squibs, which power the activating devices.

For some applications, a mechanical activating—impulse system is used. For this requirement, internal linkages can inaugurate the flow of electrolyte, or a percussion pinion can be used.

In normal practice, the electrical load is connected to the battery, so that filling of the battery constitutes the closing of the power circuit. The load can consist of electronic gear for filament power and inverter input for plate supply current, actuating devices for flight control, detonating devices and missile motivating power.

A typical set of short-run operating conditions for which such a battery might be designed are:

Current—*Pulsing 12.5 to 45 amperes*
Voltage—*28 maximum to 26 minimum, regardless of pulsation*
Time of Discharge—*120 seconds*
Time to reach operating voltage after activating impulse—*less than one second under load*
Environmental specifications—*MIL-E-5272A*
Storage Life—*Up to two years*
Reliability—*999 per cent, plus*

Silver-zinc primary systems are adaptable to applications in all major types of missiles. They have been used successfully to provide intelligence power for intercontinental ballistic and ground-to-air missiles; intelligence and control power for air-to-air missiles; and control, intelligence and main propulsion power for air-to-water and under-water missiles. ★

Terrier to Get New Launchers

Navy has awarded a $23 million contract to Northern Ordnance, Inc. of Minneapolis to produce missile launchers for a new type frigate to carry the Convair *Terrier*.

New AF Heavy Press Engaged in Missile Work

West coast's first USAF heavy press to become operational—an 8,000-ton Loewy extruder at Harvey Aluminum Co.'s Torrance, Calif. plant—is now producing heavy structural parts of the B-52 and other advanced aircraft and missiles.

New press measures 288 ft. long and weighs 3 million pounds. A 12,000-ton extruder is being assembled at the Harvey installation.

Air Associates Subsidiary Opens New Laboratory

A new research laboratory for advanced electronic development is being established by Electronic Communications, Inc., subsidiary of Air Associates, Inc. in temporary facilities at St. Paul St. and University Pkwy., Baltimore.

A permanent research facility situated in north Baltimore is expected to be completed next spring.

General Dynamics Nets $21 Million

General Dynamics Corp., including its Convair Division which builds the *Terrier* and *Atlas* Missiles, netted $21,076,298 for the first nine months of 1956, up 53.2% over the same period last year.

G-D sales were $691,009,401, higher than the $687,274,182 for the full year 1955. Profit before taxes was $39,139,700 compared to $28,-779,390 a year ago.

Corporation's backlog on September 30 stood at about $1.8 billion, highest in its peacetime history. President and chairman John Jay Hopkins forecast that 1956 sales are expected to approximate $1 billion and that those in 1957 will exceed that figure substantially.

Tax Suits Go On Trial, Then Recess Until January

Two test suits involving General Dynamics Corp. and Aerojet-General Corp.'s defense activities came to trial in Los Angeles last month and were promptly recessed until January 16.

Both court actions are directed at Los Angeles County and local municipal governments for assessment of personal property taxes against materials used in completing defense contracts.

General Dynamics Corp. seeks return of $89,558 from the county and $28,763 from the city of Pomona for the 1953-54 tax period. Aerojet's suit asked $120,561 from the county and $32,000 from the city of Azusa.

Basic point of issue is the taxable status of work in process. Firms contend such materials actually belonged to the government and were not subject to local tax. Los Angeles county assessor claims that the materials assessed had not been paid for by the government, hence technically were the personal property of the companies.

Decision to take the claims to court was government sponsored and the two firms were chosen because together they hold virtually every type of defense contract let by the government. However, regardless of final decision of Los Angeles superior court, appeal is considered almost a certainty.

Significance of the test case is evident in the tax sums at stake—some $15,000,000 in personal property taxes in Los Angeles County alone hinge on the outcome.

Temporary recess was ordered to obtain additional information about the assessed property.

Armco To Expand Stainless Output

Armco Steel Corp. has asked Office of Defense Mobilization for a certificate of necessity covering planned $55-million expansion, including rolling and processing facilities for 17-7PH stainless steel.

Armco president R. L. Gray said 17-7PH is in demand by aircraft and missile manufacturers for wings and control surfaces to combat high temperatures generated at supersonic and hypersonic speeds.

Titanium Firm Buys New Plant

Titanium Metals Corp. of America has purchased the Ohio River Steel Div. plant of The Louis Berkman Co. and will convert it into an exclusive specialized facility for rolling and forging titanium. Plant is situated at Toronto, O., 60 miles west of Pittsburgh.

NAA Revamps Autonetics Div.

North American Aviation, Inc. has set up a new reliability and standards department and established engineering activity in five other areas as full-fledged departments of its Autonetics Division.

On the list were guidance, flight control, armament control, flight test and special products. Department managers are: E. A. Holmes III—reliability and standards; S. Y. Eyestone—guidance; D. L. Williams—flight control; J. C. Elms—armament control; D. B. Wright—flight test and G. D. Shere—processing.

C-W Building New Plant For Missile Subsidiary

A 100,000 sq. ft. facility for missile development and manufacture by Aerophysics Development Corp. is one of three new plants being activated by Curtiss-Wright Corp.

The ADC addition represents new building construction. Other plants being activated were leased from Studebaker-Packard at Utica, Mich. and South Bend, Ind. and provide more than 1-million sq. ft. each.

Raytheon Gets $35 Million Army Electronics Contract

Raytheon Manufacturing Co., Waltham, Mass. has been awarded contracts by Army totaling about $35 million for further development and production of electronic military equipment.

The new award presumably involves production of the *Hawk* surface-to-air missile, although exact terms of the contract were not disclosed. Army indicated $6 million is to be used for plant preparation and tooling.

Last month Raytheon received a $60-million Navy contract to produce *Sparrow III* air-to-air missiles (M/R November, p. 104).

Olin Mathieson 9-Month Net At $14.2 Million

Olin Mathieson Chemical Corp. reports net earnings of $14,299,715 on sales of $155,491,766 for its third-quarter ending September 30. This compares with a net of $12,514,568 on sales of $138,340,735 for the same period last year.

Nacimco—New Missile Instrument Firm

A team of four ex-Convair engineers have joined with C. L. Rubesh, owner and operator of National City Machine Co., to organize Nacimco Products, a new aircraft firm in San Diego.

Principal fields of interest will be ground and airborne technical instrumentation systems for aircraft and missiles; research on specialized engineering, and precision parts and tooling for aircraft manufacturers.

Convair engineers associated with the venture are R. C. Greenbaum, former senior electronics engineer, as chief engineer; W. D. Howell, former Convair senior buyer, as general manager; J. E. Elliot, a Convair flight test engineer, as design engineer; and, J. L. Shumway, ex-Convair flight test engineer, as research physicist.

Facilities Picked For *Atlas* Testing

Convair has designated four separate facilities to be used for testing its Air Force *Atlas* intercontinental ballistic missile when trials begin sometime within the next 18 months.

Two sites are Convair facilities in San Diego—one for testing missile components situated near Point Loma, and another in Sycamore Canyon for engine tests without firing complete missiles.

Also, at Edwards AFB, engine runs will be conducted and missile systems operated, without launching a vehicle. Convair will have a staff of 500 at this location.

Actual test firings will take place at Patrick AFB, Fla. where it will expand its staff to about 450.

In all, Convair will employ 1,000 in the test program alone and another 7,000 in production at its $40-million Astronautics plant being built in San Diego.

Motorola Gets New Transistor Contract

Army Signal Corps Supply Agency has awarded a $1 million contract to Motorola, Inc. for transistor development.

Project will be undertaken by company's Phoenix, Ariz. Semi-Conductor Products Div.

Boeing Options Plant To Build *Bomarc*

Boeing Airplane Co. has negotiated a purchase option agreement with Ford Motor Co. on the latter's Richmond, Calif. plant as an alternate site for its production of *Bomarc* surface-to-air missiles.

Earlier, Boeing had investigated two other locations—one in San Leandro, Calif. and another in Salt Lake City for *Bomarc* production. Last year the company settled on its Wichita, Kans. facility to build the missile, but a step-up in production of the B-52 there touched off the search for a new plant.

Final decision to buy the Ford facility will be made in the near future, according to Boeing president William M. Allen. If option is exercised, Boeing initially plans to use it for *Bomarc* assembly operations.

AF Missile Facility Gets New Computer

Air Force's Patrick AFB, Fla. Missile Test Center has introduced a new mechanical computer in its instrumentation system to speed the use of data from one firing in planning another.

Unit is designated FLAC (Florida Automatic Computer), has a memory of 4,096 words and can do 1,750 computations per second. Device was developed by Radio Corp of America. RCA will operate it under AF contract.

Prime Contracts to Drop For Small Business

Small business enterprises stand to get a lesser share of Defense prime contracts as more and more defense dollars are spent on aircraft and guided missiles, according to Asst. Defense Secretary Robert Tripp Ross.

Ross indicated it will be necessary for such firms to obtain much of their defense business in the future as subcontractors.

Ross told a Small Business Opportunity Meeting in Cleveland that there is not a single known small business supplier for aircraft and guided missile items costing $10,000 or more. However, the Defense Preferential Planning List shows the USAF has 73 such items for aircraft and nine for missiles.

McDonnell Sales Up, Backlog at $711 Million

McDonnell Aircraft Corp., a key figure in the *Talos* and *Green Quail* missile programs, reports a substantial boost in sales and net earnings for first quarter ended September 30.

Earnings were $1,738,978 on sales of $57,299,735 compared with $1,234,574 and $41,454,685 respectively for the like period in 1955.

A new $58-million order for F3H-2N *Demon* fighters boosted firm's backlog to a record $711,918,860 compared with $601,032,299 a year ago.

New ARDC Agency Aids Small Business

A new procurement agency—Executive for Small Business—has been set up by USAF's Air Research and Development Command to step up the utilization of small firms having R&D technical capability.

New office will be based at ARDC headquarters in Baltimore but will have representatives at the AF development field offices (New York, Washington and Los Angeles) and in the procurement section of each ARDC center. Plans call for additional representatives at other strategic points throughout the United States.

Plan is to have ESB serve as a one-stop counseling service for representatives of small business. In return, however, the AF command expects to gain greater access to source information about firms with potential R&D procurement possibilities.

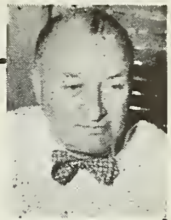
C/L Shifts NAA Pay 13 Times in Six Years

Recent 2¢-per hour pay hike at North American Aviation marked the thirteenth time since 1950 that cost-of-living allowance has affected its pay scales.

Of the 13, 10 have been pay increases ranging from one to seven cents and two have been decreases—one for 1¢ and another for 3¢.

Most frequent activity occurred between 1950 and 1952 when the Bureau of Labor Statistics' consumer price index increased 13.4%. Since then it has increased only 2.6% in four years.

Industry Highlights



By Fred S. Hunter

If you would like to work in a cave, file your application with the Rocketdyne division of North American Aviation. Rocketdyne's warehouse at Neosha, Mo., where it will produce rocket engines for the Air Force's ICBM program, is a huge underground room, 52,000 square feet in size, quarried in the side of a limestone hill. Ceiling of this unique facility is limestone 28 feet above the asphalt floor and is supported by huge stone pillars left in place by the mining operations. A railroad spur runs into the cave, which has 20 acres of space for additional warehousing. It's quite a set-up, complete with automatic sprinklers in the roof, high-type light and a silica jell humidifier to maintain constant moisture control. The air conditioning is natural; the cave has a constant temperature of approximately 65 degrees.

•

Navy's infra-red *Sidewinder* air-to-air missile is as inexpensive as it is said to be efficient. This remarkable weapon, developed under the guidance of Dr. W. B. McLean, technical director of the Naval Ordnance Test Station at China Lake, will cost only about $800 in quantity production. *Sidewinder* is 9 feet 5 inches long and weighs about 155 pounds. It is powered by a solid-propellant motor and has a speed of about Mach 2.5. Reports say it not only has shot down a larger missile, probably a *Matador,* but that it has also split a target *Sidewinder.* Dr. McLean's idea, when he began work on the *Sidewinder* project several years ago, was to develop a missile that could be handled on shipboard almost as simply as 25 inch shell. How well he succeeded is illustrated by the fact that the way to test a *Sidewinder's* combat readiness is to wave a flashlight in front of it. If it sounds a warning buzz like a rattlesnake and its nose seeker whips around following the light, the missile is ready.

•

Lockheed's Missile System division has developed a new timing generator for cameras used to record missile flights. In tests, the 2¼-ounce unit has withstood acceleration loads exceeding 100 Gs and temperatures ranging from minus 65 to near-boiling 185 degrees. The device, which is installed as a basic part of a recording camera, marks the film through use of a light-conducting "optical probe." This marking system, says its inventor, Lockheed electronics engineer James T. Path, is practically unaffected by shock, temperature change or film speed. First use of the timer will be in GSAP camera modified for data recording and in the Wollensak Fastair high-speed missile camera. Lockheed has applied for a patent on the timer and has licensed Electromation Co. in Burbank to manufacture it.

•

Hughes Aircraft Co. had so much success with its control systems reliability road show last year, it sent out a second road show this year. This time it is the GAR-1 *Falcon* and currently is on the final lap of a 12-week tour. Show consists of a large display for exhibit inside shop areas of component sub-contractors; a smaller unit for lobby display; a talk illustrated with slides; a color movie, and miscellaneous literature for hand out to employees. Purpose is to impress employees of vendors and subcontractors with the need for building quality and reliability into the *Falcon.* Workers have a better understanding after witnessing the show, Hughes says.

SUBCONTRACTORS' GUIDE TO MISSIL

STATE	FUEL	ENGINE	BODY
ALABAMA	Rohm & Haas; Thiokol	Redstone Arsenal; Thiokol	Redstone Arsenal
ARIZONA			Goodyear Aircraft
CALIFORNIA	Aerojet; Ramo-Wooldridge; Grand Central; St'd Oil of Calif. Olin-Mathieson; RMI	Aerophysics Development; Aerojet; Marquardt; Rocketdyne; Ryan; Ramo-Wooldridge; Grand Central; Cooper Development; Raytheon; Olin-Mathieson; RMI; Firestone	Aerophysics Development; Aerojet; Convair, Douglas; Hughes; Lockheed; NAA; Northrop; Radioplane; Ryan; Ramo-Wooldridge; Cooper Development; Raytheon; Norris Thermador; Hunter Douglas Alum.
COLORADO	Ramo-Wooldridge	Ramo-Wooldridge	Ramo-Wooldridge; Martin
CONNECTICUT	Olin-Mathieson	Pratt & Whitney; Lycoming-Avco; Landers, Fary & Clark	
DELAWARE	DuPont; Hercules Powder		
ILLINOIS	Olin-Mathieson	Rock Island Arsenal	
INDIANA	St'd of Indiana	Bendix; Allison-GM; Munice Gear Works	Bendix
KANSAS			Beech; Boeing
KENTUCKY	National Distillers		Reynolds Metals
MARYLAND	Olin-Mathieson; Allegany Ballistics Lab.	Fairchild	Martin; Fairchild
MASSACHUSETTS		GE	Raytheon; Avco
MICHIGAN	Dow Chem.; American Rocket;	Continental Motors; American Rocket; Universal Machine; Tecumseh Products; Utica Bend	Chrysler; Utica Bend; Brooks & Perkins
MISSOURI	Propellex Chemical	McDonnell; Rocketdyne	McDonnell; Emerson Electric
NEW JERSEY	RMI; Thiokol; M. W. Kellog	American Power Jet; RMI; Thiokol; ACF Ind.; Propeller Div., Curtiss-Wright; Wright Aero.	
NEW YORK	Olin-Mathieson; Cornell; Allied Chemical; Shell; Union Carbide; Air Reduction; Buffalo Electro-Chemicals Linde Air Prod.	Fairchild; Bell; Cornell	Sperry-Gyroscope; Fairchild; Cornell; Eastman Kodak; Republic; Bendix Scintilla; Western Electric
NORTH CAROLINA	Oerlikon	Oerlikon	Oerlikon; Douglas;
OHIO	Olin-Matheison; RMI	GE; Goodyear; Thompson Prod.; Colson Corp.; Olin-Mathieson; RMI	Firestone; Crosley Avco
OKLAHOMA	Bell Oil & Gas; Phillips	Phillips	
PENNSYLVANIA	Penn Salt; Air Products	Penn Salt; Lycoming Avco	GE; Philco; Alcoa
TENNESSEE			Crosley Avco; Sperry Farragut; Raytheon
TEXAS	Phillips	Anderson, Greenwood; Phillips; Varo	Chance Vought; Temco; Varo
VIRGINIA	Atlantic Research	American Machine & Foundry; Atlantic Research	
WASHINGTON			Boeing
WEST VIRGINIA	Westvaco		

PRODUCTION AND TYPICAL CONTRACTORS

Raw Materials Sources

MATERIALS	A	B	C
anthracite	√		
bit. coal	√		
lignite	√		
helium	√		
hydrogen	√		
natural gas	√		
nitrogen	√		
oxygen	√		
petroleum	√		
uranium		√	
aluminum	√		
antimony		√	
arsenic	√		
beryllium	√		
bismuth			√
cadmium		√	
cesium			√
chromium			√
cobalt			√
columbium			√
copper		√	
gallium	√		
germanium	√		
gold		√	
hafnium	√		
indium	√		
iron ore	√		
lead		√	
magnesium	√		
manganese	√		
mercury		√	
molybdenum	√		
nickel		√	
platinum metals			√
potassium	√		
rare earth metals	√		
rubidium			√
sodium	√		
selenium	√		
silver		√	
tantalum			√
tellurium	√		
thallium	√		
tin			√
titanium	√		
tungsten			√
zinc		√	
zirconium	√		
asbestos			√
barium	√		
boron	√		
bromine	√		
chlorine	√		
corundum	√		
diamonds (ind.)			√
fluorspar		√	
graphite	√		
iodine	√		
jewel bearings	√		
kyanite	√		
lithium	√		
mica			√
nitrates	√		
phosphates	√		
potash	√		
quartz (radio)	√		
salt	√		
steatite talc	√		
strontium	√		
sulfur	√		

A—Continental U.S.
B—U.S., Canada, Mexico.
C—Overseas dependence.

The millions now spent yearly on direct operational procurement of vehicles with names like *Talos, Nike, Jupiter, Sidewinder,* etc., will soon be billions.

If aircraft require the extensive services of a diversified industry, so do missiles to an even greater degree. All the skills and materials required for airplanes are needed for missiles, plus a great deal more.

The speeds and environments of missiles exceed those of manned flight to a point where, as in the case of the ICBM, they approximate those of meteors.

Optimum solutions to the problems facing designers, engineers and production experts in the missile field have yet to be found. They lie in the great wealth of knowledge and ingenuity that resides in the great and varied mass of American industry. Similarly, materials that never flew before, may tomorrow be the main structural and skin materials of missiles.

More than ever before, the missile subcontractor both current and potential plays a vital role not only in supplying the prime contractor with the bits and pieces and components he specifies, but also is relied upon heavily for new ideas, approaches, suggestions, inspirations.

Thus, we consider this table not only a service to the subcontractor who, we assume, is always interested in new markets, but also we feel it is a service to the missile industry as a whole, in that it will facilitate the flow, exchange and cross-fertilization of ideas that are needed if U.S. supremacy in the field is to be maintained.

The companies listed do not include all of the prime contractors (guidance suppliers are to be covered in the January issues of M/R). Rather, the companies listed are typical of those that are pioneering in this field. They are the main elements concerned with fuels, engines and missile bodies.

* * *

FOR ADDRESSES OF TYPICAL CONTRACTORS, SEE NEXT PAGE.

Information in this guide is derived by m/r's research department from industry, official and semi-official Government sources. In future issues of m/r similar data will be supplied on manufacturers of guidance systems, launching gear and other major missile components and systems.

TYPICAL MISSILE CONTRACTORS

ALABAMA

Redstane Arsenal Research Div.
U.S. Army
Wilbur Davis, Chief
Procurement & Contracting
Huntsville, Ala.

Rahm & Haas Co.
A. H. Belcher, Pur. Dept.
Redstone Arsenal Research Div.
Huntsville, Ala.

Thiakal Chemical Corp.
Redstone Arsenal Div.
Huntsville, Ala.

ARIZONA

Gaadyear Aircraft Carp.
(Goodyear Tire & Rubber Co.)
W. E. Green, Customer Rel'ns
Litchfield Park, Ariz.
(30 mi. North of Phoenix)

CALIFORNIA

Aerophysics Develapment Corp.
(Curtiss-Wright)
Arnold Grim, Contract Admin'r
924 Lobero Hotel Bldg.
Anacapa St., P. O. Box 689
Santa Barbara, Calif.

William Healey, Chief
Material & Procurement
P. O. Box 689
Santa Barbara, Calif.

Aerojet-General Corp.
(Gen'l Tire & Rubber Co.)
F. H. Gebhart, Pur. Agent
P. O. Box 296
Azusa, Calif.

Canvair-Astranautics
(General Dynamics Corp.)
C. F. Uhden, Mgr. of Material
San Diego 12, Calif.

Canvair-Pomona
(General Dynamics Corp.)
O. W. Connell, Pur. Agent
P. O. Box 1011
Pomona, Calif.

Douglas Aircraft Co.
Edw. Curtis, Dir. of Contracts
Santa Monica, Calif.

Hughes Alrcraft Ca.
Aircraft Div.
M. E. Taylor,
Director of Procurement
Culver City, Calif.

Lackheed Alrcraft Carp.
Missile Systems Div.
J. B. McChesney
Sunnyvale, Calif.
R. M. Robertson
7701 Woodley Ave.
Van Nuys, Calif.

Olin-Mathieson Chemlcal Corp.
Aviation Division
J. M. Rogers, West Coast Mgr.
1373 Westwood Blvd.
Los Angeles, Calif.

Reaction Motors, Inc.
J. M. Rogers, West Coast Mgr.
1373 Westwood Blvd.
Los Angeles, Calif.
(Joint office with
Olin-Mathieson)

Firestone Tire & Rubber Co.
Guided Missile Division
J. D. Easterly, Mgr.
811 Seville Ave.
Huntington Park,
Los Angeles County, Calif.

Marquardt Aircraft Co.
R. C. Travis, Mgr. Material
16555 Saticoy St.
Van Nuys, Calif.

North American Aviation, Inc.
M. A. Starr, Material Dir.
12214 Lakewood Blvd.
Downey, Calif.

Northrop Aircraft, Inc.
D. F. Beck
Chief Purchasing Agent
1001 E. Broadway
Hawthorne, Calif.

Radiaplane Ca.
P. I. Chase, Dir. of Material
Operations Branch
8000 Woodley Avenue
Van Nuys, Calif.

Rocketdyne Div.
North American Aviation, Inc.
E. F. Brown, Manager,
Contracts & Proposals
6633 Canoga Avenue
Canoga Park, Calif.

Ryan Aeranautical Co.
M. K. Smith
2701 Harbor Drive
San Diego 12, Calif.

The Rama-Waaldridge Corp.
Mr. Fran Brown
Purchasing Agent
6245 W. 89th Street
Los Angeles 45, Calif.

Grand Central Rocket Co.
Rick Daenitz, Pur. Agent
P. O. Box 111
Redlands, Calif.

Norris Thermadar Carp.
5217 S. Boyle Ave.
Los Angeles, Calif.

Hunter Douglas Aluminum
3017 Kansas Avenue
Riverside, Calif.

Cooper Development Corp.
Orin E. Harvey
2626 S. Peck Road
Monrovia, Calif.

Raytheon Manufacturlng Co.
Government Equipment Div.
Santa Barbara Lab.
Robert T. Kiely, Pur. Agent
Santa Barbara, Calif.

Missile Systems Div.
Pt. Mugu Plant
Fred H. Moore,
Materials Manager
Pt. Mugu, Oxnard, Calif.

Standard Oil Co. of Callf.
R. F. Bradley, Manager
Aviation Division
Standard Oil Bldg.
San Francisco 20, Calif.

COLORADO

The Glenn L. Martin Co.
Denver Division
Roth B. Hooker, Dir.
Procurement and Facilities
P. O. Box 179
Denver 1, Colorado

The Ramo-Wooldridge Corp.
(under construction)
Purchasing Agent to be named
Room 414, 1845 Sherman St.
Denver 3, Colorado

CONNECTICUT

Pratt & Whitney Alrcraft
(United Aircraft Corp.)
Bert J. McNamara, Pur. Mgr.
400 Main Street
East Hartford 8, Conn.

Lycamlng Divislon
Avco Manufacturing Corp.
George J. Rapuano, Pur. Mgr.
Stanley Brodhead, Sales Mgr.
Prime Contracts
550 S. Main Street
Stratford, Conn.

Landers, Frary & Clark
47 Center St., New Britain
Hartford, Conn.

Olln-Mathieson Chem. Corp.
Winchester-Western Div.
W. Miller Hurley
Div. V.P. and Gen. Mgr.
275 Winchester Ave.
New Haven 4, Conn.

Nuclear Fuels Division
Edward Hartshorne, Gen. Mgr.
275 Winchester Ave.
New Haven 4, Conn.

DELAWARE

Hercules Powder Ca., Inc.
917 Market St.
Wilmington 99, Del.

E. I. du Pant de Nemours & Co.
Explosives Dept.
Wilmington 98, Del.

ILLINOIS

Rock Island Arsenal
(U. S. Army)
Joseph Curley
Chief Procurement Branch
Rock Island, Ill.

Olln-Mathiesan Chemlcal Corp.
Explosives Dept.
Norl A. Hamilton
Div. V.P. and Gen. Mgr.
East Alton, Ill.

Metals Division
Jesse E. Williams
Div. V.P. and Gen. Mgr.
East Alton, Ill.

INDIANA

Bendlx Avlatlon Corp.
Produ 'ts Div., Missile Section
George Wiley, Materials Mgr.
400 S. Beiger St.
Mishawaka, Ind.

Allison Div., GM Corp.
F. J. Giorgianni
Dir., Purchasing, Matr'l C'trl
Plant 3, P. O. Box 894
Indianapolis, Ind.

Standard Oil of Indlana
137 W. 11th Street
Indianapolis, Ind.

Muncie Gear Works
Muncie, Indiana

KANSAS

Beech Aircraft Corp.
A. S. Odevseff, Mgr.
Military Engineering
East Central Avenue
Wichita 1, Kansas

Baeing Airplane Co.
Wichita Division
R. M. Barry
Wichita 1, Kansas

KENTUCKY

Nat'l Dlstill's Products Corp.
Louisville, Ky.

Reynolds Metals Co.
2500 53rd Street
Louisville, Ky.

MARYLAND

The Glenn L. Martin Ca.
E. D. Carter, Mgr.
Sub-Contracting
Middle River, Md. (location)
Baltimore 3, Md. (address)

Olin-Mathiesan Chem. Corp.
Industrial Chemicals Div.
John Logan, Divisional V.P.
10 Light Street
Baltimore, Md.

Fairchild Aircraft Div.
(Fairchild Engine, Airplane)
Louis Fahnestock, Dir.
Projects Administration
Hagerstown, Md.

Allegany Ballistics Lab.
Cumberland, Md.

MASSACHUSETTS

Raythean Manufacturing Co.
Paul B. Wilson
Dir. Planning, Procurement
Waltham 58, Mass.

Missile Systems Division
Bruce R. Brace, Pur. Agent
Bedford, Mass.

Commercial Equipment Div.
Paul B. Burns, Pur. Agent
Waltham, Mass.

Missile Systems Division
Thos. J. Flannery, Pur. Agent
Lowell, Mass.

Gov't Equip. Division
George E. Larson, Pur. Agent
Wayland, Mass.

Government Equipment Division
Elmer G. Westlund, Pur. Agent
Government Mfg. Plant
Waltham, Mass.

Avco Research & Advanced Development Dlvlsion
Albert Maki, Ass't to Pres.
208 Union Street
Lawrence, Mass.

General Electric Co.
Aircraft Access. Turbine Dept.
W. T. Coutts, Mgr. Materials
Lynn, Mass.

Small Aircraft Engine Dept.
T. Foy, Mgr. of Materials
Lynn, Mass.

MICHIGAN

Chrysler Corporatlon
Missile Operations
Magnus von Braun
Gen'l Supervisor
Contract Specifications
P. O. Box 2628
Detroit 31, Mich.

(Cantinued an Page 134)

(Missile Contractors, Cont.)

Continental Motors, Inc.
M. R. Ramsey, Pur. Agent
Market Street
Muskegon 82, Mich.

Dow Chemical Co.
R. H. Boundy, V.P.
Director of Research
Midland, Mich.

Brooks & Perkins, Inc.
J. S. Kirkpatrick
V. P., Research & Develop.
Detroit 16, Mich.

American Rocket Co.
Alfred J. Zaehringer
Wyandotte, Mich.

Universol Machine Co., Inc.
8. L. Scott, Dir. Purchasing
316 Lincoln Street
Fenton, Mich.

Tecumseh Products
955 Brown Street
Tecumseh, Mich.

Utica Bend (Curtiss-Wright)
E. K. Mashell, Dir. Purchases
Utica, Mich.

MISSOURI

McDonnell Aircraft Corp.
W. J. Gamewell, Pur. Mgr.
8ox 516, St. Louis 3, Mo.

Rocketdyne Div., NAA
Neosho, Mo.

Propellex Chemicol Corp.
St. Louis, Mo.

The Emerson Electric Mfg. Co.
J. A. Alles, Purchasing Dir.
8100 Florissant Ave.
St. Louis 21, Mo.

NEW JERSEY

American Power Jet
705 Grand Avenue
Richfield, N. J.

Reoction Motors, Inc.
Warren P. Turner, Director
Application Engineering and
Contracts Division
Denville, N. J.

Thiokol Chemicol Corp.
7B4 N. Clinton Ave.
Trenton 7, N. J.

ACF Industry, Avion Div.
William Bingham
11 Park Place
Paramus, N. J.

M. W. Kellogg Co.
Thomas B. Rees, Pur. Dir.
Foot of Danforth Avenue
Jersey City 3, N. J.

Wright Aeronautical Div.
(Curtiss-Wright Corp.)
J. M. Cowell, Dir. Purchases
Wood-Ridge, N. J.

Propeller Division
(Curtiss-Wright Corp.)
F. W. Moore, Pur. Mgr.
Caldwell, N. J.

NEW YORK

Western Electric Co.
Defense Project Division
220 Churchill, N. Y., N. Y.

Linde Air Products
(Union Carbide & Carbon Corp.)
30 E. 42nd St., N. Y. 17, N. Y.

Sperry Gyroscope Co.
(Sperry Rand Corp.)
W. G. Neumann, Pur. Dir.
Aero Division
F. Baron, Purchasing Agent
Great Neck, L. I., N. Y.

Scintilla Division
8endix Aviation Corp.
W. 8. Wilson, Pur. Agent
Sidney, N. Y.

Fairchild Guided Missiles Div.
(Fairchild Engine & Airplane)
A. W. Doherty, Contract Mgr.
T. W. Ungashick, Sub-c't rep.
Wyandanch, L. I., N. Y.

Olin-Mathieson Chemical Corp.
Liquid Fuels Div.
Dr. L. K. Herndon, V.P. and
Acting General Manager
P. O. Box 480
Niagara Falls, N. Y.

Bell Aircraft Corp.
Norman A. Lomas, Pur. Mgr.
Aircraft Division
Maurice J. Coughlin, Dir.
Procurement, Weapon Syst's Div.
P. O. Box 1
8uffalo 5, N. Y.

Cornell Aeronoutical Lab., Inc.
(Cornell University)
Joseph C. Polizzi, Pur. Agent
4455 Genesee Street
Buffalo 21, N. Y.

Eastman Kodak Company
J. E. Doyle, Dir. Purchases
343 State Street
Rochester, N. Y.

Republic Aviotion Corp.
C. E. Reid, Director
Production, Procurements
Farmingdale, L. I., N. Y.

Allied Chemicol & Dye Corp.
Nitrogen Division
40 Rector Street
N. Y. 6, N. Y.

Shell Oil Co., Aviotion Dept.
J. S. Harris, Aviation Mgr.
50 W. 50th St., N. Y. 20

Union Corbide & Corbon Corp.
30 E. 42nd Street, N. Y.

Air Reduction Co., Inc.
150 E. 42nd Street, N. Y.

Buffalo Electro Chemicals
Buffalo, N. Y.

NORTH CAROLINA

Oerlikon Tool & Arms Corp.
W. B. Buol, Purchasing Agent
P. O. Box 3049
Ashville, N. C.

Douglas Aircraft Co., Inc.
Charlotte Div.
D. J. Bosio, Dir., Materiel
1820 Statesville Road
Charlotte 6, N. C.

OHIO

Crosley Div.
Avco Manufacturing Corp.
Harold Brouse, Products Dir.
1329 Arlington St.
Cincinnati 25, Ohio

Colson Corp.
Elyria, Ohio

Firestone Tire & Rubber Co.
Defense Products Div.
C. D. Smith, Mgr.
1200 Firestone Parkway
Akron 17, Ohio

Olin-Mathieson Chem. Corp.
G. Richard Lott
349 W. First Street
Dayton, Ohio

Reoction Motors, Inc.
G. Richard Lott
349 W. First Street
Dayton, Ohio
(Joint office with
Olin-Mathieson)

General Electric Co.
Aircraft Gas Turbine Div.
Evandale Operating Depart.
F. N. Estes, Mgr.
Materials Assembly and Spares
Evandale, Ohio

W. B. Boyd, Mgr.
Materials, Components,
and Overhauls
Evandale, Ohio

Jet Engine Department
G. E. Hotaling, Mgr. Materials
Evandale, Ohio

Flight Propulsion Lab.
Wayne Wheeler, Mgr. Materiels
Evandale, Ohio

Aircraft Nuclear Prop. Dept.
Dr. A. E. Focke, Mgr. Materials
Evandale, Ohio

Goodyeor Aircroft Corp.
(Goodyear Tire & Rubber)
D. E. Zesiger, Mgr.
Sub-contract Projects
1210 Massillon Road
Akron 15, Ohio

Thompson Products, Inc.
23555 Euclid Ave.
Cleveland 17, Ohio

OKLAHOMA

Bell Oil & Gas
National Bank of Tulsa Bldg.
Tulsa, Okla.

Phillips Petroleum Co.
Rocket Fuels Div.
Bartlesville, Okla.

PENNSYLVANIA

Generol Electric Co.
Special Defense Projects Dept.
Russell W. McFall, Mgr. Eng.
3198 Chestnut Street
Philadelphia, Pa.

Philco Corp.
Gov't & Industrial Div.
William MacMurtrie
Gen. Purchasing Agent
4700 Wissahickon Ave.
Philadelphia 44, Pa.

Pennsylvonia Salt Co.
1335 Chestnut, Whitemarsh
Philadelphia, Pa.

Aluminum Co. of America
New Kensington, Pa.

Air Products, Inc.
S. S. Stewart, Pur. Dept.
P. O. 8ox 538
Allentown, Pa.

Lycoming Div.
Avco Manufacturing Corp.
C. L. Briceland, Pur. Mgr.
Raymond J. Cowden, Sales Mgr.
Williamsport Plant, Wmpt., Pa.

TENNESSEE

Crosley Division
Avco Manufacturing Corp.
Joseph D. Taylor, Works Mgr.
Nashville, Tenn.

Sperry Forragut Co.
(Sperry Rand Corp.)
C. S. Rockwell, V.P. and
Works Manager
Bristol, Tenn.

Raytheon Manufacturing Co.
Missile Systems Div.
Theodore L. Sheldon, Pur. Agt.
Bristol, Tenn.

TEXAS

Chance Vought Aircraft Inc.
W. L. Hoffman, Materiels Mgr.
P. O. Box 5907
Dallas, Texas

Temco Aircraft Corp.
Charles E. Kimbark, Jr.
Purchasing Dept.
P. O. Box 6191, Dallas, Tex.

Anderson, Greenwood & Co.
Lomis Slaughter, Jr.
V. P. and Chief Engineer
1400 North Rice St.
Bellaire, Texas

Phillips Petroleum Co.
Rocket Fuels Division
F. M. Files, Mfg. Branch Mgr.
Air Force Plant 66
McGregor, Texas

Varo Monufacturing Co., Inc.
D. H. Kennington, Dir. Pur.
2201 Walnut St.
Garland, Texas

VIRGINIA

American Mochine & Foundry
Defense Products Group
J. P. D'Arezzo, Div. V.P.
1101 N. Royal Street
Alexandria, Va.

Atlantic Research Corp.
Dr. L. L. Weil, Dir.
Chemistry Division
901 N. Columbus St.
Alexandria, Va.

WASHINGTON

Boeing Airplone Co.
Pilotless Aircraft Div.
N. W. Grigg, Materiel Mgr.
Box 3707
Seattle 24, Wash.

T. D. Teigen, Buyer of
Outside Production
Smith Tower, Seattle 24, Wash.
(Missile Production currently
at Plant II, E. Marginal Way,
Seattle 24, Wash.)

WEST VIRGINIA

Westvaco Chlor-Alkali Div.
Development Department
Food Machinery & Chemical
Corp.
South Charleston 3, W. Va.

Subcontracting Guide to the Electronics and Astrionics Industries Will Be Featured in the January Issue of M/R

Hughes Sales At $300 Million—Backlog $500 Million

Hughes Aircraft Co., prime contractor for the *Falcon* air-to-air missile, has disclosed its annual aviation sales for 1956 will be about $300 million; current backlog is approximately $500 million; and employment exceeds 25,000.

Joseph S. O'Flaherty, manager of Hughes Semiconductor Division, revealed these figures late last month as he spelled out in detail the company's activities in semiconductor production.

The Hughes official estimated the present annual industry sales volume in semiconductors runs between $55,000,000 and $60,000,000 and that Hughes accounts for about $12,000,000, or 20% of the industry total.

He also forecast that industry dollar sales volume in semiconductors will increase five-fold over the next four years, to about $300 million by 1960. At Hughes, the $12 million for 1956 compares to $5,400,000 in 1955. The company's volume has about doubled each year since 1953.

O'Flaherty said Hughes semiconductor division now employs 1,300 persons, works on a two-shift per day basis in six buildings totaling 135,000 sq. ft. of floor space. He attributed the company's entry into this field to the new high standards of performance required in electronic armament control systems and guided missiles it develops and produces for the Air Force.

Market 85% Non-Military

Of the future market potential, the Hughes official expects that the $300 million industry of 1960 will supply about 85% by dollar volume to civilian industrial markets and only 15% to the military. He estimates there are some 40 companies now engaged in producing semiconductors, but that new capital requirements and complexities of manufacture may alter the structure of competition in future years.

O'Flaherty said probably no industry is based so closely on initial discovery and research as is the semiconductor field. Advanced research in solid state physics and the chemistry necessary to produce semiconductors has already passed into a realm of physics beyond the knowledge which produced the A-bomb, the Hughes official points out. "Yet we have only scratched the surface."

"Literally thousands of scientists have a working knowledge of nuclear fission," he adds, but "only a relative handful have a comparable understanding of solid state physics."

Replaces Expensive Tubes

Of the new Hughes products, he said the company's quick-recovery silicon diode represents an engineering modification to overcome the past sluggishness of silicon compared with germanium in handling electrical current.

Hughes other new product, the small power rectifier, has working voltages up to 400 volts. It is planned for use in the place of selenium rectifiers and will do the work formerly performed by large and expensive specialized vacuum tubes, O'Flaherty said.

Both the quick-recovery diode and power rectifier are now ready for large scale production. O'Flaherty feels their development will result in the introduction of semiconductors into new and expanded industrial fields.

North American Nets $28.7 Million

North American Aviation, Inc. reports a net income of $28,760,962 for its fiscal year ended September 30, a drop of 11% from $32,349,176 for 1955. Sales, however, were at a record high—increasing almost 12% from $816,676,329 in 1955 to $913,981,913 this year.

The slump in earnings was attributed to expansion of its research and development program and an increase in R&D work for the government under cost-type contracts which do not allow substantial profit margins.

Chairman J. H. Kindelberger noted that the company's 1956 appropriations of $23,683,099 for capital construction is the highest in its history.

Among its future prospects for large-scale production, the company cited its *Navaho* intercontinental air-breathing missile, the F-100F two-seat fighter and two new planes being developed for the Navy.

IRE Groups Drop Merger

Question of a merger between the IRE Professional Groups on Telemetry and Remote Control and on Aeronautical and Navigational Electronics has been dropped.

A committee appointed to study the matter has recommended this action. Also, it concluded that the customary meeting of the two groups at the annual Dayton PGANE meeting be eliminated.

The committee said the Dayton meeting has grown too large to permit easy assimilation of additional papers.

New Accelerometer At Northrop

Engineers on Northrop Aircraft, Inc's *Snark* intercontinental missile program have developed a new manometer accelerometer said to be copied after the balance mechanism of the human ear.

Twin tubes of glass hold an electrolytic solution that covers tungsten electrodes in the glass. Connected to a Wheatstone bridge the device acts as a plumb bob to detect deviations in position or changes in speed of a missile. The capsule is temperature controlled for uniform response.

industry briefs

LOCKHEED'S Missile Systems Div. in September received more than $30 million in orders, is now negotiating R&D contracts worth about $60 million.

UTICA-BEND CORP., new Curtiss-Wright subsidiary that is to build Army's Dart missile, was awarded a $4.8 million contract to prepare for receipt and installation of machinery at its Utica, Mich. plant.

LARGE CONTRACT of undisclosed value has been awarded to Radio Corp. of America to develop and produce an air-ground data transmission system for U.S. Air Force.

THE MARTIN CO. was awarded $599,623 by USAF for modification of TM-61 Matador missiles.

LITTON INDUSTRIES, INC. reports earnings of $1,019,703 on sales of $14,920,050 for fiscal year ended July 31. Net was up almost 134% as sales jumped 67%.

AEROJET-GENERAL has redesignated its Electronics and Guidance Div., now calls it Avionics Div. Manager is J. S. Warfel.

AUTHORIZATION TO OPERATE nuclear science facility at Palo Alto, Calif. is being sought from Atomic Energy Commission by Lockheed's Missiles System Div. Purpose: R&D in reactor components.

HOFFMAN LABORATORIES, INC. plans to build a 40,000 sq. ft. electronic R & D building opposite present facilities in Los Angeles. It will house new products engineering staff and a complete engineering library.

GENERAL DYNAMICS CORP. has granted $1 million to Univ. of California for expansion of its La Jolla, Calif. campus to provide graduate program in science.

SERVOMECHANISMS, INC. has leased 13,160 sq. ft. additional space at 8825 Sepulveda Blvd., Los Angeles to house its Western Div. management, engineering, accounting, customer liaison departments.

AUTONETICS DIV., North American Aviation Inc. has moved purchasing and warehousing departments numbering 350 personnel into new 150,000 sq. ft. building at 201 W. Manville, St., Compton, Calif.

PHILCO CORP., co-producer with General Electric of Navy's Sidewinder missile, has purchased Sierra Electronic Corp. of San Carlos, Calif. SEC president Willard Feldscher becomes v.p. and general manager of the wholly-owned Philco subsidiary.

NORTHROP AERONAUTICAL INSTITUTE has broken ground for a 23,00 sq. ft. Engineering Education Building to be situated at Aviation and Arbor Vitae Blvds. adjacent to Los Angeles International Airport.

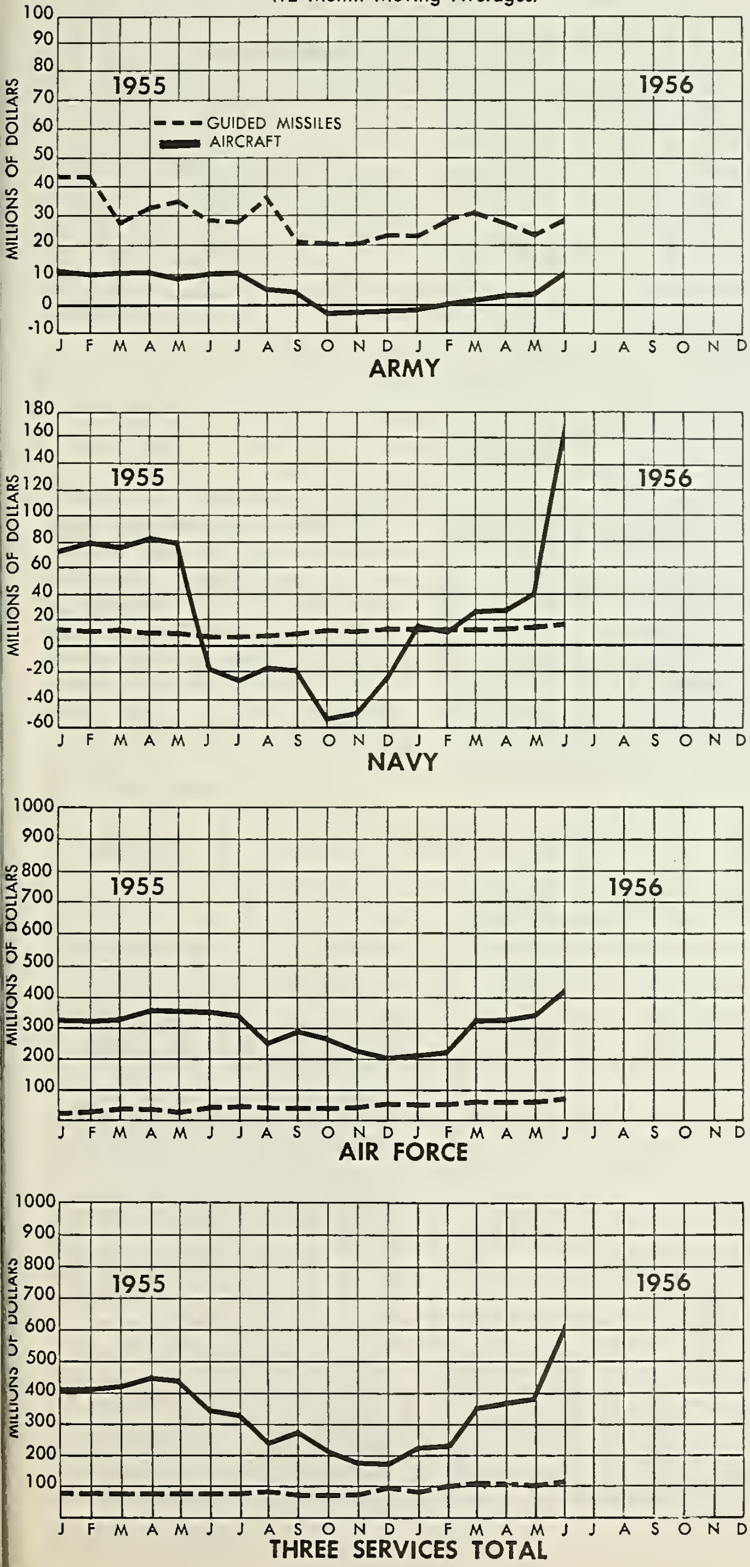
AMERICAN BOSCH ARMA CORP. reports net income of $3,385,438 on sales of $86,729,566 for nine months ended September 30 compared with earnings of $2,971,878 and sales of $55,660,928 for this period last year. Sept. 30 backlog was $175 million.

TRANSVAL ENGINEERING CORP., specialists in transistorized airborne electronic equipment, has opened its second plant and plans a 5,000 sq. ft. expansion of its main plant in Culver City, Calif.

INDUSTRY BAROMETER

GUIDED MISSILE OBLIGATIONS INCURRED

(12 Month Moving Averages)



Department of Defense is now incurring obligations for guided missiles and missile components at the average rate of $120,518,000 per month (June 1956). This is an increase of $36,012,000 from June 1955, up 43%.

In order to clear up any misunderstanding as to the exact definition of "obligations incurred," the Department of Defense uses the wording set forth in Budget-Treasury Regulation No. 1. Regulation No. 1 defines "obligations incurred" as orders placed, contracts awarded, services received and similar transactions that take place during a given period requiring future payment (expenditures) of money. Due to the complex funding system used by the three Services, it is possible to develop negative obligations which are usually called deobligations. Deobligations occur when past obligations are cancelled faster than current obligations are incurred. Sometimes huge deobligations take place that merely reflect changes in "bookkeeping" procedures. In August of 1954 the President signed Public Law 663. Section No. 1311 defined the basis on which the services should record obligations incurred. Previously, letters of intent were counted as obligations. Letters of intent are now excluded by Section 1311.

At the end of each fiscal year the Services are required to certify both the amount of funds obligated and the unobligated portion. The Navy was the only Service able to complete the tremendous task of removing letters of intent obligations from their books by June 30, 1955. Therefore, their minus obligations (deobligations) for that month reflect not only contracts cancelled, but the purging from the records of letters of intent.

For the effect this procedural revision had on Navy obligations, see the Navy chart of obligations incurred, June-December 1955.

The Army and Air Force, on the other hand, made their obligations readjustment from July through December of 1956.

This bookkeeping readjustment had no effect on DOD contractors,

DEPARTMENT OF DEFENSE OBLIGATIONS INCURRED
(12 MONTH MOVING AVERAGE)

	1955			1956		
	Missiles (000's)	Aircraft (000's)	Missiles as a % of Aircraft	Missiles (000's)	Aircraft (000's)	Missiles as a % of Aircraft
January	$ 88,227	$ 418,044	21.1%	$ 94,330	$ 234,847	40.2%
February	92,493	419,965	22.0%	104,706	240,027	43.6%
March	84,812	431,991	19.6%	110,516	368,616	30.0%
April	86,137	461,390	18.7%	108,402	378,001	28.7%
May	83,562	451,674	18.5%	106,116	396,815	26.7%
June	84,506	356,713	23.7%	120,518	610,674	19.7%
July	84,159	341,084	24.7%	$644,588	$2,228,980	28.9%*
August	94,997	255,170	37.2%			
September	80,876	288,594	28.0%			
October	81,793	216,302	37.8%			
November	81,904	187,258	43.7%			
December	100,554	183,648	54.8%			
Year 1955	$1,044,020	$4,011,833	26.0%			

* 1st 6 months 1956

since letters of intent are generally followed by written contracts.

As obligations incurred fluctuate wildly from month to month, we have employed a twelve month moving average to smooth out the peaks and the valleys while at the same time pointing up any trend characteristics. For a detailed explanation of this statistical technique, see Industry Barometer—November 1956.

Some typical unclassified obligations incurred in 1956 include contracts to Glenn Martin, $14,234,000 for *Matador* missiles (January); Aerojet-General, $9,000,000, facilities for pilot production and production testing of liquid rocket engines (January); Air Products, Inc., $3,910,000, facilities to produce LOX (liquid oxygen) (January); General Electric Co., $5,000,000, development and production of radar antennaes for use in tracking guided missiles (February); Air Products, Inc., $5,768,000, for liquid oxygen and nitrogen (April); North American Aviation, $5,325,000, for facilities for Production of the *Navaho* (April); Hercules Powder Co., $3,610,000, solid propellant rocket systems (May); Convair, $7,715,000, Facilities to support Intercontinental ballistic missile program (June); North American Aviation, $16,152,000, for *Navaho*.

The accompanying graphs and chart show both the rapid rise in Department of Defense missile obligations, $88,227,000 for January 1955; $94,330,000 in January 1956; $120,518,000 for June 1956 and at the same time provide a referential framework comparing these with aircraft and related equipment obligations. Aircraft and related equipment obligations for these same three months were $418,044,000 January 1955; $234,847,000 January 1956; $610,674,000 June 1956.

The Army's average obligations for missiles and related equipment has varied greatly from month to month. High for the period January '55 to June '56 was January 1955's obligations of $45,000,000. Present obligations level is close to $30,000,000. All present indications point to little change in obligations level for the remainder of calendar 1956. Average obligations incurred for the last half of 1956 should hover around the $28-32 million dollars per month.

Missile obligations incurred by the Navy have had only slight fluctuations. Low month for the 1½ years analyzed was July 1955 ($9,509,000). High month was $19,381,000 obligated in June 1956. During the last six months of 1956 chances are good that average missile obligations for the Navy will be accelerated to the $25 million per month level.

The Air Force is currently incurring more obligations than the Army and Navy combined. Average obligations during the last half of 1956 should rise some $25,000,000 per month over June 1956's $72,000,000.★

NEW MISSILE PRODUCTS

MISSILE CHECKOUT SYSTEM

An ultra-rapid missile tester for use in the field has been developed by the Microwave Division of Sperry Gyroscope Co. Known as RACE (Rapid Automatic Checkout Equipment), it is designed to do most of the analytical thinking for military combat technicians.

RACE brings automation into the battle field to keep modern weapons fit-to-fight. It uses computer elements to checkout all parts of a missile system, finds faulty components and delivers a punched card that identifies the fault.

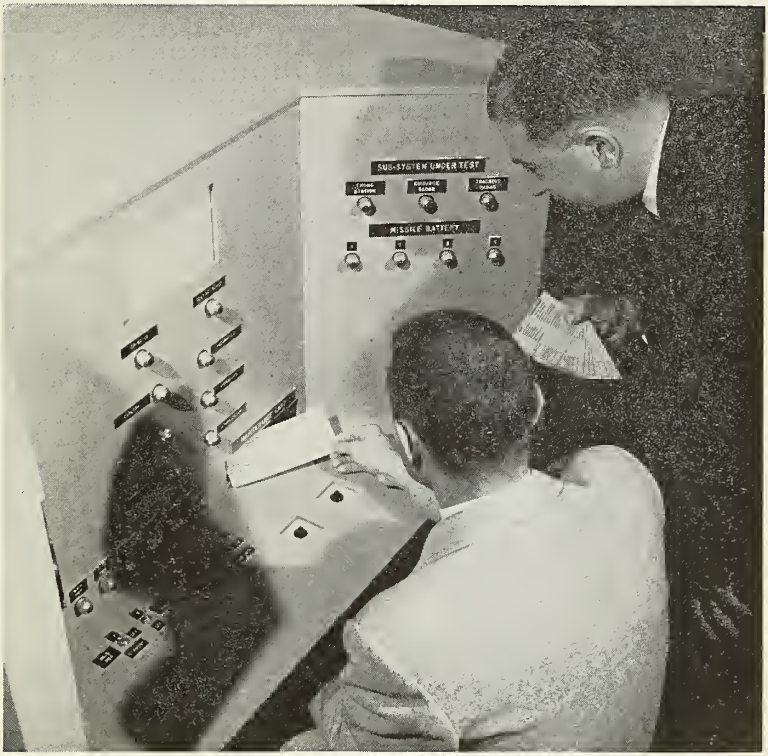
An electronic memory supervises the checkout by controlling generators that transmit test signals to each missile through cables and by microwave radio.

Progress of tests is indicated at a master console. Go-NoGo panel lights indicate progress of the tests and give a "Go" signal at the end if everything is satisfactory.

Electrical, eletronic, pneumatic and hydraulic systems used for guidance, tracking and stabilization are tested in a few minutes. When a fault is discovered, lights on a master test console pin-point the fault. At the same time a punched card is delivered.

The card shows the fault and the maintenance procedure for curing it. In this way rapid plug-in replacements can be made or the missile excluded from the battery if repair time is too long.

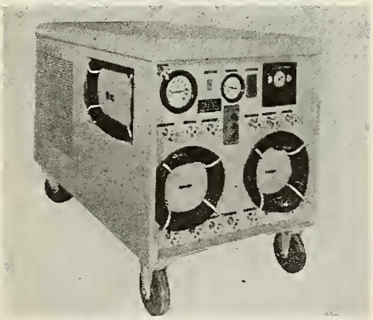
One of RACE's features is simultaneous test of slow and fast reacting circuits. With this feature RACE does not have to wait upon slow acting components that would increase test time. Write: Sperry Gyroscope Co., Microwave Div. Dept. M/R, Great Neck, N. Y.



The RACE missile tester console shown delivering a punched card for use by a technician in rapid repair of a missile component.

PNEUMATIC CART/AIR STAND

Two new pieces of aircraft and missile support equipment, a high-pressure air bottle cart and a mobile high-pressure air stand, have been unveiled by Accessory Controls & Equipment Corp.



The ACE-37 cart is rated for 3,600 psi pressures, has a capacity of 18,000 cu. in. and weighs about 2,000 lbs. It measures 42" high, 38" wide and 60" long.

The ACE-36 air stand is designed to provide a 5,000 psi source of dry air for starting jet engines and calibrating instrument systems. It supplies capacity to dry 16 cfm by means of a refrigerant-type dehumidifier and desired dryness may be selected by adjustment of a thermostat setting.

For rocket and missile applications, it is capable of boosting nitrogen to pressures of 6,000 psi.

The stand has two supply systems—one to serve for direct loading of air bottles and a second that may be regulated automatically for any pressure from about 100 to 5,000 psi. Write: Accessory Controls & Equipment Corp., Dept. M/R, 146 Willard Ave., Newington, Conn.

ANALOG-DIGITAL CONVERTER

An 8-ounce digitizer for converting analog information to binary-coded decimal digital information has been announced.

For use in telemetering to convert meter readings into digital readings for printing on charts at range stations, the device is flexible and permits handling any desired number of decimal digits through addition of modules to the basic assembly.

Measuring 2 11/16 x 2 in., each module added to obtain another decimal place adds ¾ inch to the length. Each module has a code disk and gear train.

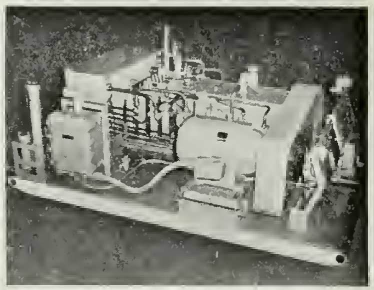
A code and dual brush system is used that eliminates ambiguity. Write: Commercial Sales Dept., Federal Telephone and Radio Co., Dept. M/R, 100 Kingsland Road, Clifton, N. J.

PLUG-IN SWITCH BOARDS

Plug-in circuit boards used in ground support and field test equipment for the Northrop Snark missile permit plugging-in such items as a 12-deck 26-position stepping switch. Switch contacts are produced by etching circuit boards.

The method allows 348 connections to be made simultaneously. Northrop has licensed United Geophysical Corp. to make the new device. Write: Electrodynamic Division, United Geophysical Corp., Dept. M/R, Pasadena, Calif.

COMPRESSION SYSTEM



New "central compression system" developed by Cardox Corp. for testing aircraft and missile pneumatic systems delivers 54 acfm of air with —70°F or lower dewpoint at any needed pressure from 3,000 to 12,000 psi.

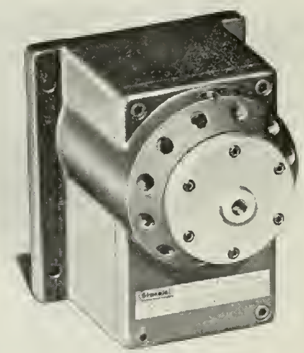
The new system, devised from components used in the coal mining industry for almost 20 years, is said to be operable within a day or two after delivery.

It consists of a semi-portable, self-contained assembly including compressor, 50-hp electric drive, controls, filtering and drying equipment and storage vessels that are mounted on structural steel skids. Write: Cardox Corp., High Pressure Air Div., Dept. M/R, 307 No. Michigan Ave., Chicago 1.

PRESSURE SCANNER

The Datex Model SP-101 pressure scanner introduced by G. M. Giannini & Co. is aimed at lower cost and improved accuracy in pressure instrumentation. It is designed to permit measurement of up to 12 pressure sources with only one transducer.

The SP-101 can be used to automatically introduce calibration or zero pressures during each scan cycle, thereby allowing calculation of exact transducer response and enabling greater accuracy.



Basic unit consists of a stator having 12 input ports and a rotor that connects any one of these to an output port. A unidirectional high-torque motor rotates the rotor to a desired position and built in provisions are available for indication of position either visually or digitally for operation of recording devices.

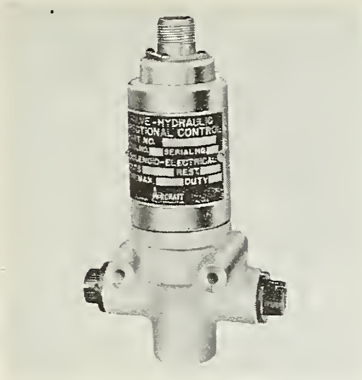
SP-101 operates over a range from 0.1 psia to 350 psig and is usable for dry air and non-corrosive gases. Dimensions are 6⅜ x 5¼ x 5½ in. Write: G. M. Giannini & Co., Inc., Dept. M/R, 918 E. Green St., Pasadena, Calif.

MISSILE HYDRAULIC VALVES

A series of hydraulic accessories developed by Aircraft Products Co. for 3,000-psi missile and aircraft systems includes two-way, three- and four-way shut-off and selector valves and low-leakage sequence valves.

Series 6100 and 6200 two-way, solenoid-operated shut-off valves weigh 1.40 and 1.47 lbs. respectively and employ a balanced, inverse poppet said to allow a wide range of flows and pressures in either direction. Available sizes are adapted to ¼, ⅜ or ½-in. line installations.

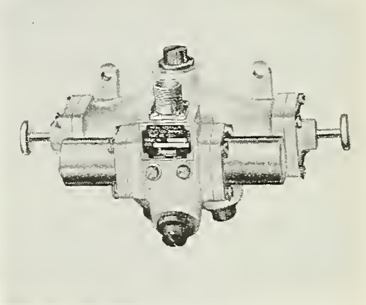
APC's Series 6000 three-way selector valve is designed to handle flows up to 6 gpm through ¼ or ⅜-in. tubing compared to 3.2 gpm for standard ⅜-in. models. Also solenoid operated, this series weighs 1.5 lbs. for ¼ to ⅜-in. applications and 1.61 lbs. for Series 6050 for ½-in. line installations.



Series 7300 four-way, pilot operated solenoid selector valves are available with a variety of design variations—with or without manual override; three-position, spring centered; two-position, spring offset; three-position detent; with thermal relief; and, with spool and sleeve combinations to meet varying porting needs.

New slide-type sequence valves have a maximum internal leakage of 15 drops per minute but are produced in special models with maximum leakage of only five drops per minute.

Valves are available for ¼ or ⅜-in. tube sizes and are provided with either full flow by-pass or thermal type auxiliary relief valves for cracking pressures ranging from 8 to 4,000 psi. Write: Aircraft Products Co., Dept. M/R, 300 Church Rd., Bridgeport, Pa.

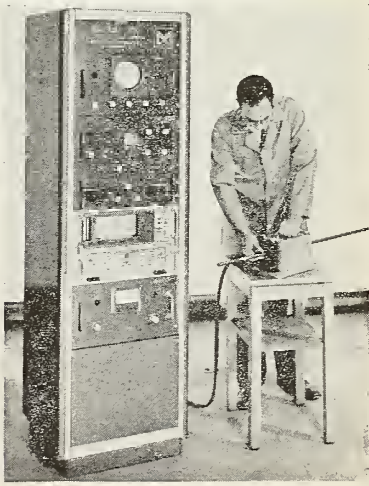


TUBING TESTER

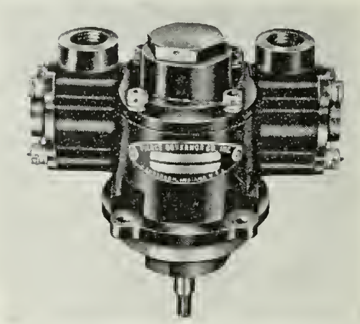
A completely automatic test device for inspecting non-magnetic rod, tubing wire or bar stock has been introduced by Magnaflux Corp.

Called Magnatest FW-400, it locates such defects as overlapping seams, diameter changes, inclusions, voids, metallurgical variation and splits. Unit is designed to handle aluminum, brass, copper, tungsten, austinetic stainless steel and titanium from 1/64 to 3 in. diameter.

FW-400 is available for hand operation in laboratories or for completely automatic, high-speed operation on production lines. Speeds in excess of 150 to 300 fpm can be accommodated. Write: Magnaflux Corp., Dept. M/R, 7300 W. Lawrence Ave., Chicago 31.



FUEL CONTROL UNITS



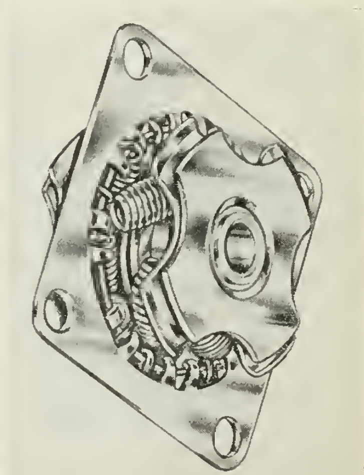
Two new fuel control units for use on turbine-type auxiliary power units and guided missiles have been unveiled by Pierce Governor Co.

New units are basically mechanical type governors with single or dual valve systems. Simple valve units control flow of one fuel, whereas the dual valve type controls and proportions flow of two fuels ranging from JP-4 jet fuel through red fuming nitric acid.

Complete Pierce unit, weighing less than 3 lbs., requires only 0.8 hp input. At speeds of 10,000 rpm, flows of 10,000 pph can be controlled with complete stabilization reached in 0.2 seconds after transit from full open to full closed positions.

Units are adaptable to control fuel flows of 500 to 15,000 pph at higher or lower operating speeds. Write: Pierce Govern Co., Inc., Aircraft Accessories Divs., Dept. M/R, Anderson, Ind.

ALL-METAL MOUNT



New Series 1255000 diagonal spring Equiflex vibration isolator and shock mount marketed by The Ucinite Co. are said to withstand repeated 15g shocks without loss of efficiency and 30g ultimate.

Design features all-metal construction, non-linear spring characteristics, high damping and all-positional or all-attitude performance. Units reportedly withstand hours of resonance with input of .036" double-amplitude per Spec. MIL-E-5272A. Write: The Ucinite Co., Div. of United-Carr Fastener Corp., Dept. M/R, Newtonville 60, Mass.

SOLENOID VALVES

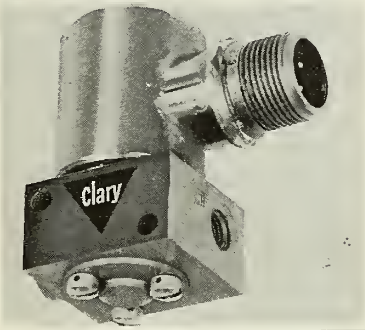
New lightweight solenoid valves designed for guided missile systems measure 2" long by 1" diameter and weigh only 10 oz.

Valves feature a two-in-one operating arrangement whereby they can be operated from either an open or closed position. Changeover from one use to another is accomplished by simple mechanical rearrangement of the solenoid.

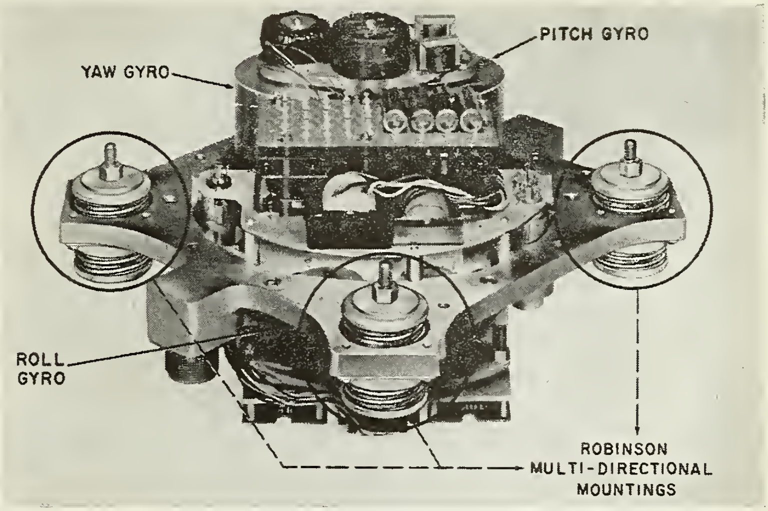
Another feature includes a zero leakage provision made possible by an internal vent to the atmosphere through a controlled outlet which prevents moisture or contaminated air from reaching moving parts.

Valve coil is hermetically sealed and solenoid may be rotated on the valve body to position electrical connector in most desirable location.

Valves are designed for use with air, helium, nitrogen, liquid oxygen or corrosive liquids. Write: Automatic Controls Div., Clary Corp., Dept. M/R, San Gabriel, Calif.



Shockmount for Vanguard



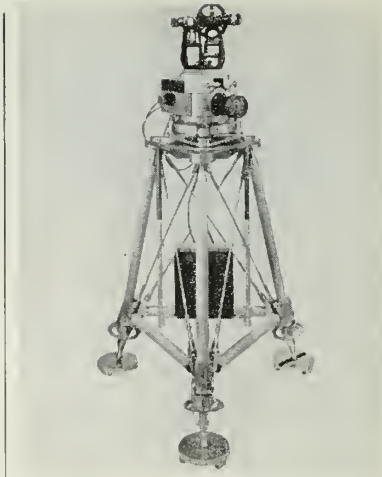
Multi-directional mounting system built by Robinson Aviation, Inc. will protect Vanguard earth satellite's Minneapolis-Honeywell inertial guidance system. Four Robinson Met-L-Flex resilient elements will be attached to the rocket bulkhead with the equipment installed inside. Mounting system is designed to instantly attenuate shock of 6 g or vibration over 65 cps.

THEODOLITE

New azimuth alignment theodolite introduced by Perkin-Elmer Corp. permits alignment of precision missile guidance gyros within an accuracy of 2 secs. of arc.

It is designed to automatically detect gyro alignment discrepancies by continuous observations of reflections from a mirror mounted on a monitored wall. The discrepancies produce error signals which are applied as corrective signals to the drive elements of the gyro.

Components are a dual optical sys-



tem, a mount, and a precision electronic reading system. An upper optical system serves essentially as a precision theodolite, whereas a lower unit consists of two modulated light sources, a telephoto objective, a beam-dividing "Vee" mirror and a photomultiplier tube.

Operation of the system hinges on use of a telephoto lens as a monitoring objective and the reflected beam of a monitored unit's mirror provides the source for indication of alignment condition. If out of alignment, light energy entering a photomultiplier originates an error signal. The phase relationship of the energy is then used to determine direction of error.

Write: Perkin-Elmer Corp., Engineering and Optical Div., Dept. M/R, Norwalk, Conn.

SERVO MOTOR

Smallest standard subminiature servo motor available claims Ford Instrument Co. for its Model SM-58 motor which weighs less than 1 oz. and measures ⅝-in. dia. by 1-in. long.

New motor is proposed for variety of applications in servo systems, computers, indicating systems and missile control systems.

Model SM-58 operates on 26 volt, 400 cycles with a control range of 0 — 26 volts. Other characteristics include 2½ watt input; 1/10 watt output; 0.063 in. oz. stall torque; 8,800 rpm no load speed, and ambient range from —75 to 200°F.

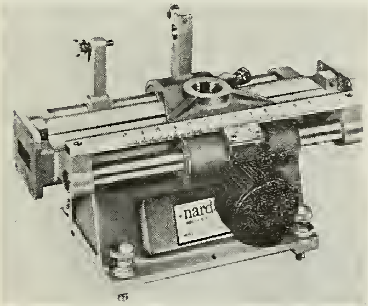
Write: Ford Instrument Co., Div. of Sperry Rand Corp., Dept. M/R, 31-10 Thomson Ave., Long Island City 1, N. Y.

SLOTTED LINES

Six portable slotted lines, Models 319 to 324 that have a carriage drive mechanism integral with the waveguide assembly have been announced. The impedance meters can be used to measure VSWRs and impedances from 2600 to 18,000 mc covering the waveguide sizes from 3 x 1½ inches to 0.702 x 0.391 inches.

The meter is supported by a removable pedestal casting. Residual VSWR is said to be under 1.01 with imperceptible slope and slot leakage.

A mounting hole is provided for use with all standard military and commercial rf probes. Write: John Mather Lupton, Inc., Narda Corp., Dept. M/R, 420 Lexington Ave., New York 17, N. Y.

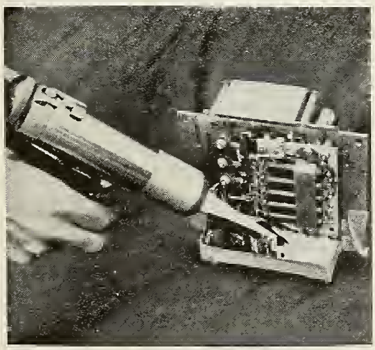


SILICONE RUBBER

A silicone rubber that cures at room temperature has been developed for use in high impedance electronic circuits in missiles.

Coating of component parts in circuits with the new rubber improves resistance to vibration, moisture resistance, surface resistivity and other electrical properties.

Components may be inspected by slitting the rubber after application, and then patching. Application is with a gun at about 100 pounds pressure. The material is being used in the Snark missile. Write: Dow Corning Corp., Dept. M/R, Midland, Michigan.



SUB-FRACTIONAL HP MOTORS

Series of sub-fractional horsepower motors introduced by George W. Borg Corp. are rated in the range from 1/2000-hp to 1/750-hp for precision instrument use.

Designs feature end bells and gear train cases of die-cast alloys that are precision machined to form a totally enclosed housing. Available types include synchronous and induction motors,

with or without gear trains. Write: George W. Borg Corp., Borg Equipment Div., Dept. M/R, Janesville, Wisc.

GAS GENERATORS

Pre-packaged gas generators, produced by McCormick Selph Associates to make explosive power widely available, can provide power for pressurization of fluids, ignition of liquid propellants, operation of turbines and actuation of pistons and expandable rings.

The units are capable of creating a known amount of gas at predictable pressures and temperatures for a given time and it is said that they are insensitive to vibration and acceleration due to the absence of moving parts.

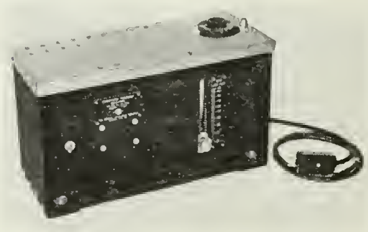
Included as part of the generators or as separate sub-assemblies are electrical squibs, and electrical connections can be made by leads or by quick-connect plug and receptacle combinations.

Horsepower ranges from 0.01 to 150 and output pressures from 15 to 25,000 psi. Write: McCormick Selph Associates, Dept. M/R, 15 Hollister Airport, Hollister, Calif.

VIBRATION TESTING MACHINE

The Model 14-28 Vibration Testing Machine, developed for vibration testing of small items, is said to be small and lightweight with widely variable amplitude and frequency.

Product of the Ahrendt Instrument Co., the machine has a cast aluminum base and weighs 30 lbs. Dimensions are 15½ in. length, 6 in. width and 9 in. height.



Write: The Ahrendt Instrument Co., Dept. M/R, 4910 Calvert Rd., College Park, Md.

DISC-TYPE THERMOSTAT

A miniature, Klixon, snap-acting thermostat especially recommended in aircraft controls and guided missiles has been developed by the Spencer Thermostat Division of Metals & Controls Corp.

The C7216 unit features the Spencer Disc thermal element, silver electrical contacts, a hermetically sealed assembly, and is protected from moisture by a copper nickel-plated casing.

Fixed temperature settings range from —20°F to 400°F.

Write: Metals & Controls Corp., Spencer Thermostat Div., Dept. M/R, Attleboro, Mass.

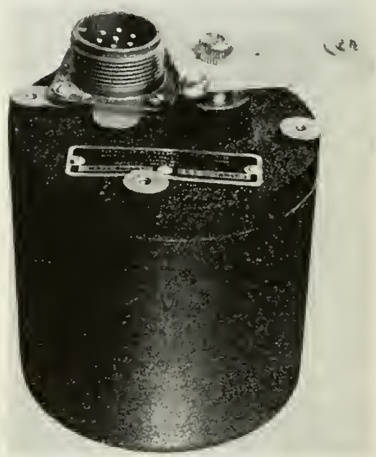
MOTOR-GEAR-TRAIN

High torque, low speed and wide temperature range combined with smaller size are the unusual features claimed for a new motor-gear-train designed by John Oster Mfg. Co. Only 2.8 in. long, the size 18 torque is 25 oz.-in. at 1.7 rpm unloaded and operates in temperatures as low as —55°C.

Type 5602-02 uses a single phase capacitor or 2-phase servo motor and is rated for continuous duty at 115V 60 cycles.

Write: John Oster Mfg. Co., Dept. M/R, Avionic Div., Racine, Wisc.

SERVO ACTUATOR



White-Rodgers Co. has announced a D-9 permanent magnet type rotary servo actuator designed for continuous operation at an output rating of 70 inch-pounds at 8.5 rpm.

The servo, which the company says meets applicable military specifications, features limit and centering switches and potentiometer for feedback of position information.

Weight of the unit is 1.9 lbs., diameter is 3 5/16 in. and overall length is 4⅞ in.

Write: White-Rodgers Co., Dept. M/R, 4407 Cook St., St. Louis 13, Mo.

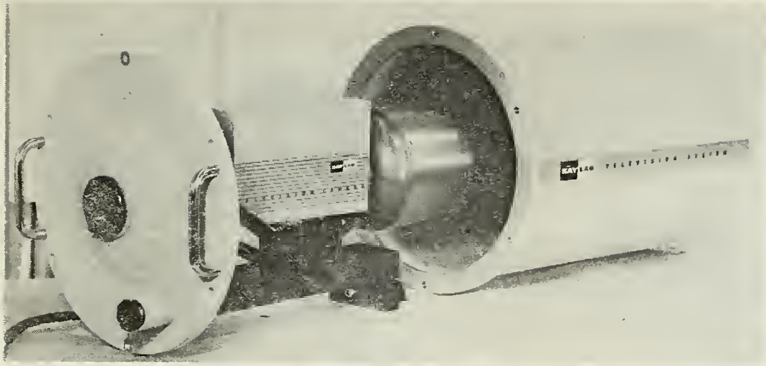
FLUSH LATCH

An improved flush latch with specially designed rubber gaskets for better latch sealing characteristics has been reported by the manufacturer, Missile-Air.

Self-sealing is accomplished by rubber gaskets which are fuel-resistant and surround "push" and handling buttons at access doors and panels. These Series 1100 units have over-center toggle action, weigh only one ounce and are available for all door and offset thicknesses.

Write: Missile-Air, Dept. M/R, 1616 West 134th St., Gardena, Calif.

RUGGEDIZED CAMERA



A new ruggedized camera developed by Kay Lab for rocket and jet engine test facilities and rocket launching sites has been designed for high-noise applications.

The camera combines with another new development, an acoustical housing, which provides about 45 db of isolation. Housing is arranged to accept the remote iris-focus, auto-zoom lens and three-lens turret accessories for the camera.

In tests with the equipment at rocket firing sites, performance was reported trouble-free at locations where sound levels well over 150 decibels had previously been measured.

The new combination camera and housing is expected to make possible the use of television in many applications where such equipment previously could not be employed due to high noise conditions. Write: Kay Lab, Dept. M/R, 5725 Kearny Villa Rd., San Diego 11, Calif.

ACCELEROMETERS

A new line of accelerometers, pressure pickups and force gages using piezoelectric materials has been announced. Change in sensitivity over a temperature range of —65 to 230 degrees F is less than 10 percent, according to the manufacturer.

High sensitivity is maintained at 10mv/g. Natural frequency is 35 kc, and a high g range of 10,000 is handled.

Information is available in Bulletin 803. Write: Endevco Corp., Dept. M/R, 161 California St., Pasadena, Calif.

missile literature

TEMPERATURE CONTROLS. Six-page brochure MC-132 gives physical dimensions, current ratings, temperature ranges and other characteristics of miniaturized temperature controls for missiles and related applications. Write: Fenwal Inc., Dept. M/R, Ashland, Mass.

INSTRUMENTS. A 31-page general catalog gives specifications, descriptions and illustrations of instruments for analysis, control and data processing. Write: Consolidated Electrodynamics Corp., Dept. M/R, 300 North Sierra Madre Villa, Pasadena, Calif.

OSCILLOSCOPES. Quick reference catalog of a complete line of oscilloscopes, large screen cathode ray tube indicators, electronic test instruments, and equipment for photo-recording. Write: Allen B. DuMont Laboratories, Inc., Technical Sales, Dept. M/R, Clifton, N. J.

PRINTED CIRCUITS. A 15-page brochure covers processing and materials data used in making printed circuits. Step-by-step information is given together with the characteristics of various base materials. Write: Formica Corp., Dept. M/R, 4617 Spring Grove Ave., Cincinnati 32.

POWER CONVERTERS. A 4-page brochure, catalog 56P, describes newly developed ac-dc converters using semiconductor devices to replace vibrator or dynamotor conversion. Test is directed to designers of missiles and airborne systems where operating environments are a problem. Write: Power Sources, Inc., Dept. M/R, 8 Schouler Court, Arlington, Mass.

people

Thomas B. Carvey, asst. head of the design integration department, has been appointed head of the launchers and powerplants department of Hughes Aircraft Co.'s guided missile laboratories. **John W. Withers** will succeed **Carvey** in the design integration post. **Dr. Morris Feigen** has been named senior staff engineer of the design integration dept. **Michael E. Hiehle** has been named project manager for the weapon systems development laboratories. **John R. McCharles** and **Alexander S. Jerrems** were named asst. directors of Hughes' fire control systems laboratories.


Carvey

John E. Lowe, formerly personnel mgr. of American Machine & Foundry Co.'s electronics division, has been appointed director of personnel and public relations of the company's new guided missile launching system plant in Rochester; **U. W. Richardson** has been named defense products mgr.

Autonetics (a division of North American Aviation, Inc.) engineering is now headed by the following persons: **J. C. Elms**, armament control; **D. L. Williams**, flight control; **D. B. Wright**, flight test; **S. F. Eyestone**, guidance; **E. A. Holmes, III**, reliability and standards; and **G. D. Shere**, data process equipment.

David L. Grimes has been appointed president of Narmco, Inc., manufacturer, among other things, of aircraft and missile components.

Edward Hartshorne has been named gen. mgr. of the nuclear fuel division of Olin Mathieson Chemical Corp.

J. S. Warfel is manager of Aerojet-General Corp.'s new Avionics Division, formerly known as Electronics and Guidance Division.

Dr. John L. Miller, director of defense activities for The Firestone Tire & Rubber Co., has been named deputy chairman and a member of the National Council of the Artillery Division of the American Ordnance Assn., in addition to his position as deputy chairman of the Guided Missile and Rocket Division.


Miller

The following persons have recently joined the staff of the Applied Physics Laboratory of the Johns Hopkins University: **Thomas S. Mortimer, Kenneth W. Howard, Jr.**, and **Herndon H. Jenkins, Jr.**, associate engineers, and **George Gebel** and **Jacob L. Herson**, engineers. The Laboratory is engaged in guided missile research and development.

Roger A. Burt has been appointed manager of the systems analysis section of Electronic Control Systems, Inc., an affiliate of Stromberg-Carlson and a subsidiary of General Dynamics.

Lawrence G. Haggerty has been elected president of Farnsworth Electronics Co. **P. E. LaLiberte** has been appointed sales manager for weapon control equipment for General Electric's light military electronic equipment department.

Rod Koutnik has joined the automatic controls division of Clary Corp.

George F. Metcalf has been named general manager of General Electric's new missile and ordnance systems department.

Dr. George Roka has been named director of the semi-conductor division of Marvelco Electronics Division, National Aircraft Co.

L. S. Preston has been appointed chief engineer of the Electronic Engineering Co. of California; **D. R. Proctor** will be his assistant.

Brig. Gen. Howell M. Eates, Jr., asst. deputy commander for weapon systems at ARDC's Detachment No. 1 at Wright-Patterson AFB, has been promoted to major general. This detachment manages the development of USAF missiles and aircraft weapon systems.

Under a major reorganization, Bell Aircraft Corp's Niagara Frontier Division will be discontinued and its activities will be divided into two new divisions—the Aircraft Division headed by vice president **Julius J. Domonkos** and the Weapons Systems Division headed by vice president **Roy J. Sandstrom.** The Weapons Systems Division will be subdivided into four units: Avionics, **John H. van Lonkhuyzen,** mgr.; Rockets, **William M. Smith,** mgr.; Guided Missiles, **Jesse H. Zabriskie,** mgr.; and Research, **John F. Strickler,** Jr., mgr.

Domonkos

Edwin H. Meier, head of the Hughes Aircraft Co.'s guided missile engineering laboratories at Tucson, and **Frank G. Miller,** head of the systems engineering department in the guided missile laboratories at Culver City, have exchanged positions.

Henry A. Boguslawski has been elected vp-engineering sales for Rocke International Corp.; **M. M. Riise** (Cmdr. USN, ret.) has been named exec. asst. to the president. **Boguslawski** was formerly associated with RCA; **Mr. Riise** was with Sperry Rand, in operations for the Defense Department's missile program and guidance system.

Allan W. Jayne will head Gabriel Electronics Division's research and development activities at the Gabriel Company, Needham Heights, Mass. **Dr. Richard J. Burke** has been named head of Lockheed Aircraft Corp.'s Missile Systems division's telemetering department.

David P. Coffin, Jr. has been appointed chief of Hoover Electronics Co.'s Engineering Department, defense projects section; **Robert P. Wehrmann** will head the telemetering section.

Dr. Robert E. Buchele has been named staff assistant to the Western Division manager of Servomechanisms, Inc. **Dr. Earl L. Steele** was appointed chief engineer of the development department, Semiconductor Products Division, Motorola Inc.

Warren E. Milner was appointed to the newly created position of mgr. of the Milwaukee plants of AC Spark Plug Division of General Motors.

8-A-87

Sperry, Alcoa Sign Wage Agreements

Sperry Gyroscope Co., division of Sperry-Rand Corp. has reached agreement with International Union of Electrical Workers on a 4-year pact covering 9,500 employes. It provides a 5¢ per hour pay increase and a cost of living adjustment of 2¢ an hour effective November 1.

Aluminum Co. of America and United Auto Workers signed a 3-year, no-strike contract providing benefits of about 46¢ an hour over the three years. It covers about 4,200 UAW members at Alcoa plants in Garwood, N.J.; Vernon, Calif., Chicago and Cleveland.

Ex-Northrop Official Forms New Firm

Cybergor, Inc. has been organized under president J. J. Gorman, former Northrop budget director, as a new source of magnetic materials. D. F. White, until now chief engineer of Marchant Research Corp., is v.p.-engineering.

New company is specializing in ferrites and grain-oriented silicon and nickel steel toroids. Offices are at 1705 W. 135 St., Gardena, Calif.

P&W Employment Drive At Half-way Mark

A drive by Pratt & Whitney Aircraft division of United Aircraft Corp. to add 3,000 technicians to its payroll by December 31 has reached the midway point, according to company officials.

P&W payroll in October moved beyond 38,500 toward a goal of 40,000 by the year end. Employment drive is aimed at virtually all job categories—machine operators, tool and die makers, sheet metal, welding and assembly technicians, engine test house operators, mechanics and inspectors.

Its current missile activity includes production of J57 engines for the Northrop *Snark*.

Marquardt, Bendix Get Tax Write-offs

Marquardt Aircraft Co. has been granted an accelerated tax amortization of 60% by Office of Defense Mobilization covering new $3,295,475 facility at Ogden, Utah.

Bendix Products Div., Mishawaka, Ind. was granted a rapid tax write-off at 40% for new missile facilities valued at $316,275.

Avco Leases Denver Office

Avco Manufacturing Corp. has leased 3,000 sq. ft. of office space in the Mile High Bldg., Denver presumably in connection with its ICBM nose cone development work.

Avco is one of two firms working on the critical nose section for the *Titan* missile which Martin will build near Denver.

The company expects some 35 employes will be assigned there.

Aerojet Sets Up Nuclear Department

Aerojet-General Corp. has established a Nuclear Projects Department at its Azusa, Calif. plant in a move to promote application of nuclear science and engineering to its rocket engines and other developments.

New office is headed by D. A. Young, asst. chief engineer of Aerojet's Liquid Engine Division.

Navy Lets $31 Million Contracts for *Sidewinder*

Navy last month let two new contracts totaling $31 million for production of guidance and control units for its *Sidewinder* air-to-air missile.

An award of $17 million went to General Electric Co. and another for $14 million to Philco Corp.

West Coast Gets New Electronics Firm

Dr. J. V. N. Granger, former head of Stanford Research Institutes radio systems laboratory, has formed Granger Associates, a new California corporation for development and production of aircraft electronics equipment.

In addition to Granger as president, other officers are R. M. Leonard, secretary, and R. J. Halk, treasurer. Temporary offices are at 801 El Camino Rd., Menlo Park, Calif.