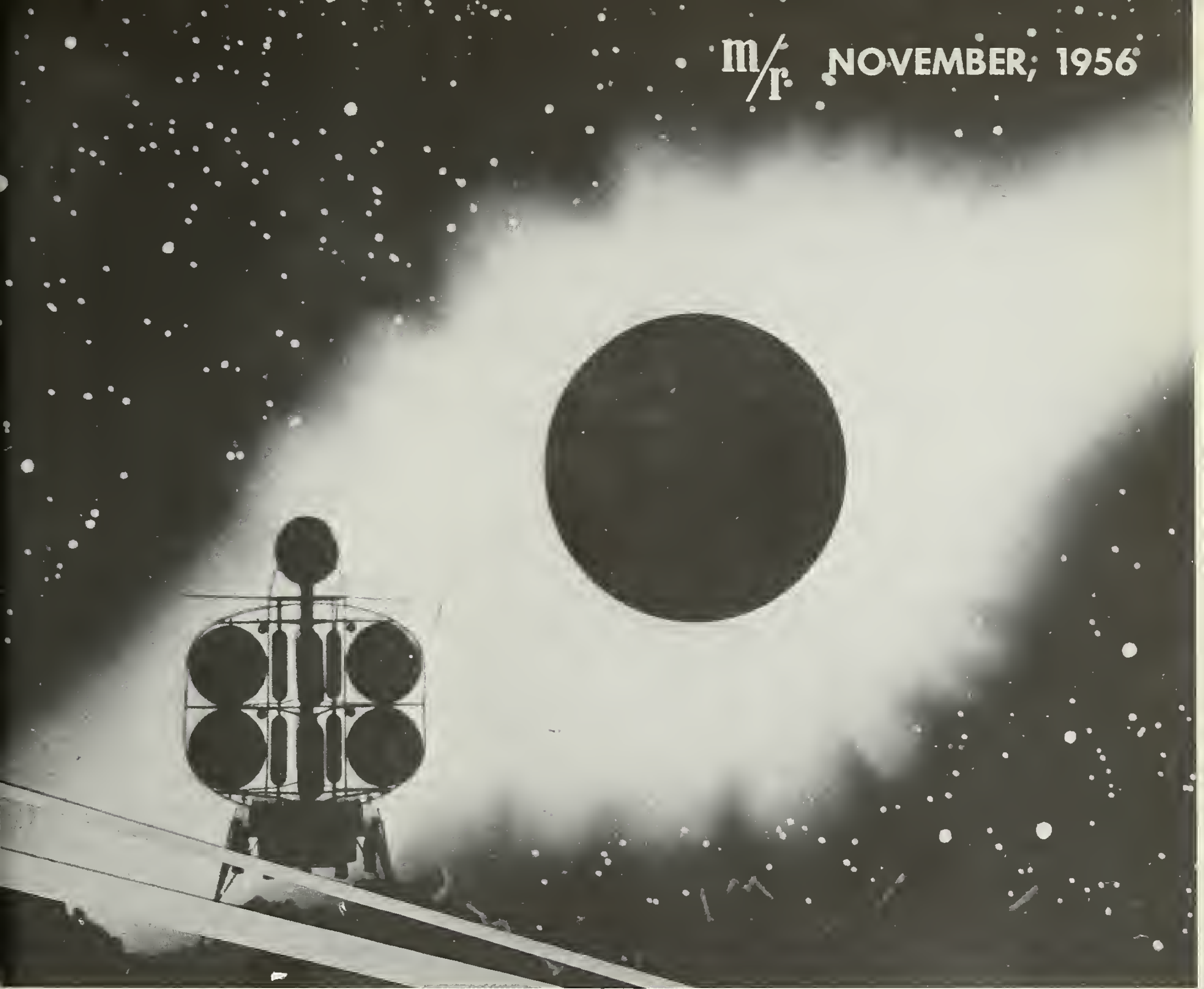
m/r NOVEMBER, 1956



missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS

AN AMERICAN AVIATION PUBLICATION

IN THIS ISSUE: Army Missile Power • General H. N. Toftoy • Krafft Ehricke • Comdr. George Hoover • Fred Durant • Vanguard 1st-Stage Engine in Pictures

missiles and rockets

Magazine of World Astronautics

November, 1956 Volume I, No. 2

MISSILES AND ROCKETS is published monthly by American Aviation Publications, Inc., 1001 Vermont Avenue, N.W., Washington 5, D.C., U.S.A. Telephone: Sterling 3-5400. Cable: AMERAV.

Subscription Rates:

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

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

Subscription Service Manager
Missiles and Rockets
1001 Vermont Avenue, N.W.
Washington 5, D.C.

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

Advertising correspondence should be addressed to Director of Advertising, Missiles and Rockets, 17 East 48th Street, New York 17, N.Y.

REGIONAL OFFICES:

New York City: 17 E. 48th St., New York 17. William H. Pearson, director of advertising; Edward D. Muhlfeld, assistant director of advertising; M. Michael Cerick, Paul Kinney, and Robert Weston, regional adv. mgrs. Phone: Templeton 8-5446.

West Coast: 8943 Wilshire Blvd., Beverly Hills, Calif., Fred S. Hunter, manager. John Ball, Jr. and Walton Brown, regional adv. mgrs. Phones: Bradshaw 2-6561 and Crestview 6-6605.

Chicago: 139 N. Clark St., Chicago 2, Ill., Laurie S. Seward, regional adv. mgr. Phone: Central 6-5804.

Detroit: 509 Stephenson Bldg., Detroit 2, Mich. Phone: Trinity 5-2555.

London: The AAP Company, 17 Drayton Road, Boreham Wood, Hertfordshire, England. Phone: Elstree 2688. Cable address: STEVAIR, London.

Paris: Jean-Marie Riche, 11 Rue Condorcet, Paris (9e), France. Phone TRUdaine 15-39.

Other American Aviation Publications:

American Aviation Magazine
American Aviation Daily
Official Airline Guide
(North American, World-Wide Editions)
World-Wide Aviation Directory
Who's Who In World Aviation
Air Traffic News
Airports

Publishing Corporation: Wayne W. Parrish, president; Leonard Eiserer, executive vice president and treasurer; William H. Pearson, vice president and director of advertising; Albert H. Stackpole, and Eric Bramley, vice presidents; E. J. Stackpole, Jr., secretary.

missiles and rockets

Magazine of World Astronautics

• •

WAYNE W. PARRISH,
President and Publisher

ROBERT H. WOOD,
Editorial Director

• •

ERIK BERGAUST,
Managing Editor

• •

Department Editors

ENGINEERING: Joseph S. Murphy
AEROPHYSICS: Seabrook Hull
ELECTRONICS: Henry P. Steier
MILITARY: Henry T. Simmons
PROPULSION: Alfred J. Zaehringer
ASTRONAUTICS: Heyward E. Canney and Frederick I. Ordway III
MANUFACTURING: Fred S. Hunter
INTERNATIONAL: Anthony Vandyk
LONDON: James H. Stevens
PARIS: Jean-Marie Riche

• •

ART DIRECTOR: William H. Martin
PRODUCTION MANAGER: John Walen
RESEARCH DIRECTOR: A. J. Newfield

• •

Manuscripts that are not negotiated should be submitted to the Managing Editor for consideration. In the event the subject matter of the manuscript is considered to be in a classified area, the manuscript must be cleared by the proper security review office of the Department of Defense. Responsibility for security clearance rests with the author.

• •

LEONARD EISERER,
General Manager

WILLIAM H. PEARSON,
Director of Advertising

LARRY BRETTNER,
Manager, Publication Sales

ELLEN COAKLEY
Advertising Service Manager

• •

Publishing Information: Published every month by American Aviation Publications, Inc., Washington, D. C. Printed at The Telegraph Press, Harrisburg, Pa. Application for second class mail privileges is pending at Washington, D. C.

• •

Army Help For ICBMs?

COULD IT BE THAT THE NATION'S two Intercontinental Ballistic Missile programs—the *Titan* and the *Atlas*—would be much farther along today if the Army had been brought in to assist the Air Force?

So successful has the Army become in the missile field that one wonders if the ICBMs wouldn't be nearing completion, rather than being in their initial stages as they are now, if the programs had been under joint sponsorship.

There's no denying the impressive record being built by Army Ordnance in the Intermediate Range Ballistic Missile programs. In view of the performance to date, one can well begin to ask where the intermediate range leaves off and the intercontinental range begins.

Admittedly the original division of responsibility seemed quite natural and logical. The Army is the artillery agency and, as such, should be concentrating on anti-tank missiles, short-range ballistic missiles, anti-aircraft and battlefield attack rockets. The Air Force, with its responsibility for long-range strategic bombers, seemed the logical agency to assume responsibility for ICBMs.

The recent IRBM test flights at Patrick AFB, however, indicate that the Army's *Jupiter*, which has been scheduled as a 1,500-mile weapon, might well be capable of 3,000 miles. Thusly it will have practically intercontinental range and is, possibly, the most advanced ballistic missile in the free world today.

Since the Army already has three fully-proven operational missiles, namely the *Honest John*, the *Corporal*, and the *Nike*, with three more systems to be put in operation shortly (the *Little John*, the *Dart* and the *Redstone)*, it is perhaps a little puzzling why an agency with such experience and versatility has not been called upon by the Defense Department to help the Air Force in developing its two ICBM programs.

Certainly we don't propose that the Air Force should be excluded from ICBM projects. Far from it. But a joint Army-Air Force program might get faster results.

Three major articles pertaining to various phases of the Army's record in missiles appear in this issue. They testify to the extent and depth of the Army's activity.

WAYNE W. PARRISH

Correction and Clarification

A most unfortunate error, attributable solely to the printer in revising this page, crept into the last paragraph of the editorial in the October issue. As it appeared in type, a sentence read "To ensure *political* quality, we have support without peer." The sentence should have read "To ensure *editorial* quality . . . " (Italics are ours.) No problems of space flight are more baffling than those pertaining to printers who can magically change "editorial" to "political" with all the devilish implications that such an alteration implies.

W. W. P.

missiles and rockets
VOL. 1 NO. 2 NOVEMBER 1956

CONTENTS

FEATURES

ROCKET ENGINEERING

•

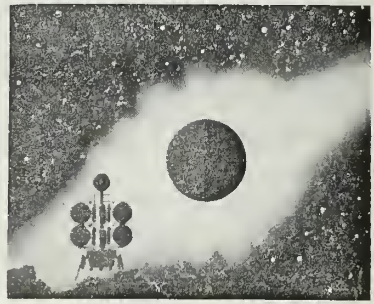
NEWS AND TRENDS

•

INDUSTRY SPOTLIGHT

IN THE NEXT ISSUE

M/R for December will feature Air Force Missile Power • Complete round-up on Air Force missiles • Air Force missiles research and development • Tabulated data on Air Force missile arsenal • Feature article authors include Dr. S. Fred Singer, University of Maryland; Dr. Peter A. Castruccio, Westinghouse Electric Corporation; Colonel William O. Davis, Office of Scientific Research, ARDC; and others.



Cover Picture

M/R's cover picture shows an eclipse of the sun by the earth as seen from the moon. Increasing interest in astronautics in Japan has been highlighted by a series of photographic compositions by Yasumasa Miyazaki and Toshihiko Sato, produced by the Yomiuri Press for a serial of astronautics entitled "Columbus of Space." A report on Japanese astronautics is given by Frederick C. Durant III, page 48.

COLUMNS

DEPARTMENTS

PHOTO CREDITS:

U.S. Air Force, pp. 14, 15; Moscow NEWS, p. 18; Sovphoto, p. 19; Department of Defense, p. 22; U.S. Navy, pp. 26, 27; General Electric, pp. 26, 62, 63; Radioplane, p. 27; Chrysler Corp., p. 31; U.S. Army, pp. 31, 34, 35, 36, 38, 39, 40, 42; Convair, p. 45; Miyazeki, Sato, pp. 48, 50; A. C. Robotti, pp. 54, 56; NACA, pp. 59, 82, 86, 88, 92; from an R.A.S. report, p. 60; Minneapolis Honeywell, pp. 70, 72; Brooks & Perkins, p. 72; Vickers, p. 78; Aerojet, pp. 90, 91; Martin, p. 124.

Letters

Guidance For Would-Be Missile Engineers

To the editor:

. . . Heartiest congratulations on the first issue of MISSILES & ROCKETS! At last the burgeoning guided missile industry has a voice to reach the interested layman as well as the professional.

I was particularly sympathetic to the problems of 17-year-old Jimmy Blackmon in the article "A Boy and His Rocket." It seems to me that the educational institutions of this country and, to a lesser extent, the Department of Defense, owe this young would-be guided missile engineer an answer to his questions, "Where do I start? What school should I attend? What books should I read?"

The writer is presently serving as Navy Technical Director for the *Jupiter* IRBM and thus is closely associated with Dr. Wernher von Braun, Jimmy Blackmon's advisor and inspiration. I share Dr. von Braun's concern for the proper education of such young men. These are the prospective engineers who will assure the defense of our country and one day turn guided missile technology to the conquest of space. We should leave no stone unturned to whet their intellectual appetites....

Grayson Merrill
Captain, USN

Bureau of Ordnance (Sp)
Department of the Navy
Washington 25, D.C.

To the editor:

. . . Congratulations on your excellent first issue of MISSILES & ROCKETS and best wishes for the continued success of this new venture.

In regard to the comments on page 43, we are attempting a solution with an IGY training program which the RRI has started in Sacramento. Recently a student section was formed for fellows like Jimmy Blackmon. Based on our experiences here, we hope to start similar training programs in other parts of the country within a year or so . . .

George S. James, Director
Rocket Research Institute

3262 Castera Avenue
Glendale 8, California

To the editor:

. . . Having just seen your fine publication for the first time last night, I just want to let you know that I feel you have done a wonderful job in bringing forth such an excellent trade publication in so vital a field. The content of the first issue of MISSILES & ROCKETS reflected a vigorous, successful effort on the part of the AAP staff, and all of us will be looking forward to the subsequent issues . . .

Harry S. Baer, Jr.
Aeronautical Training Society
1115 Seventeenth Street, N.W.
Washington 6, D.C.

To the editor:

. . . Congratulations on the first issue of MISSILES & ROCKETS, which is bound to become "top money winner" in your fine stable of outstanding aviation publications.

I think the outstanding article was the one on "Teamwork" by our mutual friend, Dr. Wernher von Braun, who I believe has done more to wake up the American people to the "Age of Rockets" than anyone else. Certainly, his timely article on the importance of working together and also doing something concrete about interesting young men in the fine future this field holds, will be seconded not only by industry, but also by those of us in aviation education . . .

Gene Kropf
Assistant to the Dean
Saint Louis University
Parks College of Aeronautical Technology
East Saint Louis, Illinois

Satelloid Up There Already?

To the editor:

. . . Congratulations on an exceedingly fine first issue of MISSILES & ROCKETS. How many first-issues can boast of 152 slick pages?

I found your article querying "Army to Launch 'Satellite' Before Vanguard?" of noteworthy interest. One cannot help but wonder at times if an orbital satelloid may not have already been established . . .

Max B. Miller

1420 South Ridgeley Drive
Los Angeles 19, California

Russians Ahead?

To the editor:

. . . My congratulations on the new magazine. The first issue was terrific and I sincerely hope you will be able to maintain the caliber of this.

In speaking with our John Streeter I suddenly had an idea and it is simply this. I think the time has come for a thinkpiece concerning the visibility of the satellites we are going to put into the sky. We find that the Project *Vanguard* satellite cannot be seen with the naked eye. However, for less payload than the twenty-two pounds for the instrumented satellite, the inflatable balloon idea can be consummated to yield significant geodetic information and be quite visible to the naked eye. We can all be assured that the Russians are going to put a satellite into the sky before us, or if it is after us you can bet it will be readily visible. This is one advantage we should not let go by default. Again my very best wishes in this new venture . . .

I. M. Levitt, Director
Fels Planetarium
Franklin Institute

Philadelphia 3, Pennsylvania

M/R Appearance Praised

Cablegram:

. . . Your new publication, MISSILES & ROCKETS, is a wonderful job and a great contribution to this up and coming industry. The appearance, typography and content are a tribute to you and your organization . . .

E. Theodore Stern
Mannie Berlinrut
Douglas Aircraft Company

New York City

To the editor:

. . . Congratulations on an excellent first issue; I'm looking forward to the next ones. I especially enjoyed the short "News Section" for current information . . .

Robert W. Garner
Project Engineer
John I. Thompson & Company

Washington 6, D.C.

NEWS and TRENDS

U. S. AIRCRAFT ROCKETS—HOW GOOD?

Pilots Prefer 2.75-inch *Mighty Mouse* to Heavier Weapons; Better Fuses and Computers Sought

By Henry T. Simmons

Yuma, Ariz. — Should an air attack be launched against the U.S. this minute, the nation's first line of defense would NOT be a potent array of airborne guided missiles.

Despite the years and the hundreds of millions of dollars poured into development of the smart birds, a small, unpretentious and unguided rocket is still the nation's principal air weapon against enemy attack. It is the MIGHTY MOUSE, a 2.75-inch rocket developed by the U.S. Navy.

The importance of the small "FFAR" (Folding Fin Air Rocket) was amply illustrated at the Air Force interceptor competition, staged at Vincent AFB here. The FFAR was the only weapon used by the nine USAF interceptor teams battling for first place; more than 5,000 of the small rockets were fired at the 9 by 45-foot nylon banners towed at various altitudes across the firing range during the course of the meet.

First place was taken by the 94th Fighter Interceptor Squadron, representing the Eastern Air Defense Force. Flying the North American F-86D, the unit racked up 13,800 points out of a total possible score of 24,000. Second place went to a team representing the Western Air Defense Force. Using the Northrop F-89D—the only other interceptor entered in the meet—it accumulated 11,400 points.

Pilots Disagree on Effectiveness

There was considerable disagreement among the pilots over the relative effectiveness of their weapons, even after the scores were all in. The F-86 pilots felt that the direct 90-degree rocket firing system made possible by the location of all rockets in a retractable tray beneath the F-86 cockpit gave them an edge over the converging type of rocket firing necessitated by the wingtip pods of the F-89D. But pilots of the latter aircraft did not feel this provided the F-86D with superiority since the Northrop machine can launch up to 104 rockets in a salvo from the wing pods against only 24 from the F-86D. During the meet, however, all pilots were restricted to salvos of 24 rockets, regardless of the capability of their aircraft.

One thing the pilots did agree on was the effectiveness of the 2.75-inch FFAR as an air weapon. Declared one competitor: "I don't think you can find a better rocket than the 2.75. Even if a fin hangs up, you get a barrel-rolling effect so the individual rocket won't oscillate more than 10 feet from a straight line."

The principal of the small rocket is that of the shot-gun. If enough of them can be fired into a given volume of space, it is almost mathematically impossible that an intruding aircraft or target banner can escape at least one hit by the contact-fused rockets. Since each one packs a wallop equivalent to a 75 mm cannon shell, it is doubtful whether even the largest aircraft could survive a single hit.

FFAR measures 48 inches in length and 18.5 pounds in weight, of which 3.5 pounds is allocated to the warhead. Powered by a double-base solid propellant, it is capable of a maximum velocity of about 2,600 feet per second (Mach 2.7 at altitude) and has a burnout time of about 1.5 seconds. The thrust during this brief period is about 800 to 900 pounds and the acceleration is on the order of 50 gravities. Exact performance specifications remain classified, however.

Navy developed the FFAR dur-

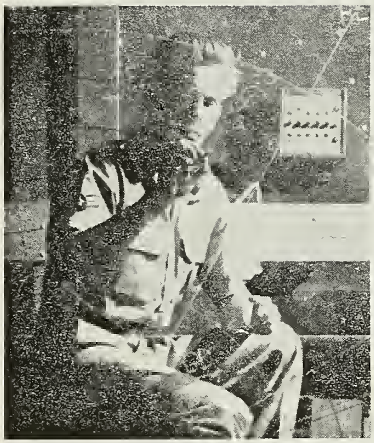
"The gun is about finished as a primary fighter weapon, although it may be useful in an auxiliary role. Its duties for the most part will be taken over by the guided missile, with assistance from the free rocket."

Speaking is a veteran pilot instructor stationed at Nellis AFB—the fountainhead of Air Force fighter tactics and doctrine. While his view may not reflect the official position of the Air Force, it is nevertheless significant because Nellis for many years has been the principal support of machine gun and cannon armament for fighters within the USAF.

"Guided missiles would probably take over the whole shooting match if they were not subject to enemy countermeasures," he observes. "In the case of radar-guided missiles, large bombers have a distinct advantage over small fighters. They can generate far more powerful interference than the radar guidance signals from the fighter."

"Because of this, I believe that infra-red homing weapons like the *Sidewinder* stand a better chance than the radar-guided *Falcon*. But the *Sidewinder* can be fooled, too; in fact, I suppose any air-to-air missile we develop can be jammed.

"For this reason, I believe the free rocket and, to a lesser extent, the gun will stay with us as secondary weapons. Although less accurate than missiles, they are immune from jamming and might spell the difference between success and failure in the event of superior jamming ability by the enemy."



All rocketry work at the Vincent AFB interceptor competition was out of sight, so plotting boards like this were used to keep team members abreast of the meet. "Judy" occurs when the interceptor's radar "locks on" the target.

Careful handling of the 2.75-inch rockets is necessary to prevent cracks in the propellant which could cause uneven burning or even premature burnout. Metal cans ground the firing mechanism to prevent accidental ignition.

Ground radar controllers maintain a continuous plot of the area, vectoring the fighters into the targets with course instructions. Aircraft crew takes over when the interceptor's own radar picks up the bogie.

ing the early days of the Korean War, and it was put into production at the height of that conflict. Present production rate is much lower than the initial rate, with only three principal contractors slated to remain in the program, according to the Navy, They are Aerojet-General Corp., Azusa, Calif., which manufactures the rocket motor and ingenious folding fin assembly; Hunter Douglas Aluminum Co., Riverside, Calif., which makes the tubes, and Heintz Manufacturing Co., Philadelphia, which produces the warheads.

In the past, components for the 2.75-inch rocket have been produced by at least eight other manufacturers. Manufacturing motors were Tecumseh Products Co., Tecumseh, Mich.; Muncie Gear Works, Muncie, Ind.; Colson Corp., Elyria, Ohio, and Landers, Fary and Clark Co., New Britain, Conn. Tubes were provided by Reynolds Metals Co., Phoenix; Aluminum Company of America at New Kensington, Pa., and Norris Thermador Corp., Los Angeles, while C. D. Cottrell Co., Westerly, R. I., manufactured warheads.

Simple Rocket in Complex System

Despite its high performance, the basic simplicity of the weapon holds its price to a reasonable level. Its price tag is on the order of $65, and this has prompted some air crewmen to call them "Car Payments" instead of using the too-cute popular name or the overly-formal military designation.

In actual interception operations, the FFAR is only one part of a complex weapon system which involves the use of elaborate ground control radar installations to vector interceptors to their targets, airborne radar permitting the attacking aircraft to detect and lock on to targets at close range, computers which automatically calculate and represent the course the aircraft must fly to achieve a 90-degree collision intercept and which fire the rockets at the proper instant, and, in some aircraft, equipment which actually takes the aircraft controlls and maneuvers for the intercept. Hughes Aircraft Co., Culver City, Calif., is the exclusive supplier of radar fire control systems for AF interceptors at the present.

This year's meet at Yuma may be the last which the FFAR will dominate exclusively. Next year it is hoped that the *Falcon* GAR-1 missile can be introduced, along with the Convair F-102A interceptor. Should this be possible, it is likely that a separate event will be established for the *Falcon*-armed aircraft which would employ jet-powered drones like the Ryan Q-2 *Firebee.*

Next year's gunnery meet will see guided missiles in action. Weapons to be used will be FALCONS and possibly SIDEWINDERS. The latter, which is shown in this picture, has aroused the Air Force' interest, although missile is developed for the Navy.

Simultaneously with the Vincent AFB interceptor competition, the Air Force conducted its annual day fighter and fighter-bomber competition at Nellis AFB, Las Vegas, Nev. This included air-to-air gunnery as well as air-to-ground events with guns, bombs and rockets, plus a Special Weapons Delivery competition featuring the use of toss-bombing and over-the-shoulder bombing techniques for the safe delivery of nuclear weapons.

2.75-inch Rocket Superior, New Fuse, Computer Sought

Winner of the day fighter phase of the meet for the sixth year in a row was Nellis' own Air Training Command team, flying North American F-86H *Sabrejets,* while a USAFE team flying the same aircraft captured the Special Weapons competition.

Although rocketry was only one small portion of the day fighter meet, Nellis pilots favored the small 2.75-inch rocket over the larger air-to-ground weapons which would be available to them in combat. While conceding that the small warhead of the FFAR lacks enough beef to penetrate heavy armor, even with shaped charges, they find its accuracy far superior to that attainable with the heavier but much slower 5-inch rocket.

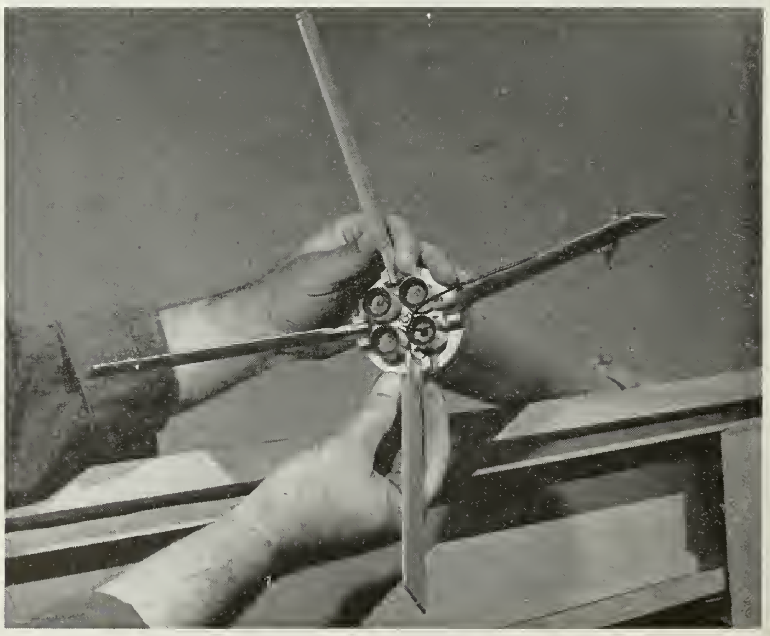
"The 5-inch rocket is too slow and it drops too fast," commented one pilot. "The 2.75 has a much flatter trajectory that the larger rocket, and therefore we can score more hits."

Asked what improvements he would like to see in the small rocket, he replied: "A VT (proximity) fuse to get air bursts over personnel would be a first rate improvement, although I haven't heard of the development of a VT fuse of that size yet. And a computer which would assure accurate air-to-ground rocket fire at any speed and approach would also be a big help."

Like Vincent AFB, Nellis is also looking forward to big changes in the make-up of its competitions. It expects to receive its first Lockheed F-104 day fighters shortly. Ultimately these would be equipped with *Sidewinder* missiles, so that any competitions in which they are involved will require the use of jet drones if realism is to be obtained.

The 2.75-inch MIGHTY MOUSE rocket with fins in the folded position. A small electric impulse traveling from the contact plate through the wire to the base of the motor ignites the rocket.

North American F-86D all-weather interceptor launches a stream of 24 2.75-inch rockets at a tow target high over the Arizona desert near Yuma. Note retractable rocket launching tray beneath cockpit.



MIGHTY MOUSE with fins in flight position. Pushrod, located on base of rocket between the four barrels, is forced to the rear by the expanding gases, engaging lobes at the base of the fins and pushing them into the slipstream.

Rocket Trends

By Erik Bergaust

Apparently, Lockheed's X-17 test vehicle, which is supposed to aid ICBM researchers in their study of heat problem, has not yet reached the high re-entry velocities required. (See page 43).

No. 13 *Viking* rocket is being readied at Patrick for launching on or about the 20th of this month. Experiment has dual purpose: long-range missile people hope to get some data on re-entry problems, *Vanguard* personnel are in the market for launching experience.

You'll be hearing more about Grand Central Rocket Company. A group of ambitious rocket engineers are working on highly advanced solid-propellant applications, some of which are believed to be "tremendous" high-efficiency boosters.

Little publicized fact is that NACA has launched several step-rockets—with as many as four stages—to 200 miles altitude over the Atlantic Ocean. Highest velocity obtained is 7,000 miles per hour. New Navy research missile, the *Iris*, also will climb to 200 miles. Atlantic Research Corporation holds development contract.

U.S. hopes to get permission to use Brazil's Gernando de Noronha and Trinidad Islands (600 miles out into the South Atlantic Ocean) for missile tracking stations.

The Rocket Technical Committee of the Aircraft Industries Association has been subdivided into Liquid Propellant and Solid Propellant Divisions, reflecting increased importance of solid-rocket propulsion.

Northrop's *Snark* isn't quite dead. Mid-Air Equipment Corporation has been awarded a contract for design of check-out facility and test cell for the *Snark*. Built at Hawthorne as part of Northrop's *Snark* production contract, the new facility will be ready for use early next year.

First-stage *Vanguard* engine is operating satisfactorily; one unit already has been shipped to Martin. Gasoline has been dropped as fuel. Special kerosene mixture will be used.

Air Force might be blasting off something real big from Patrick next month: the *Thor* IRBM prototype. Powerplant phase of the program is believed to be in good shape.

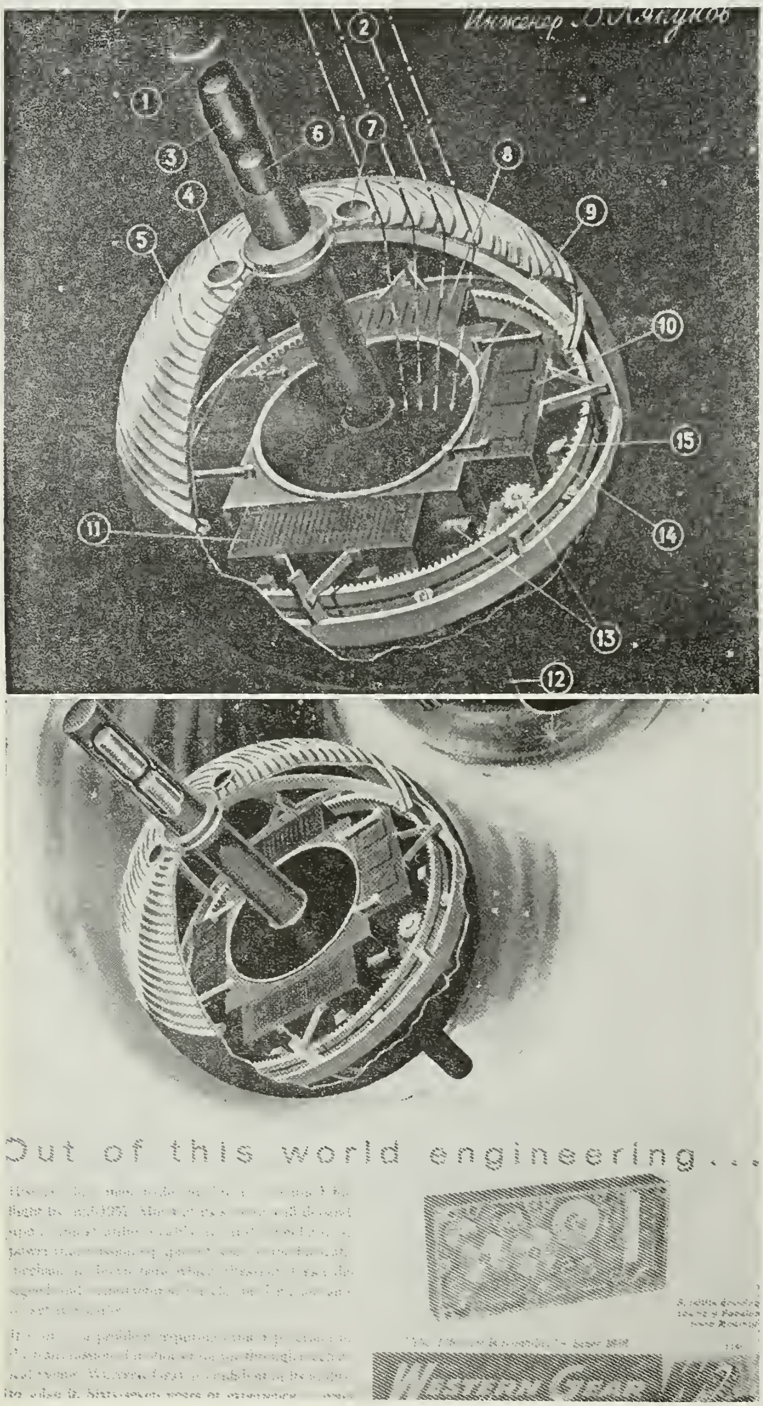
Army has activated its first *Redstone* battalion. This indicates the huge missile has been accepted and will be operational shortly. Chrysler is ready for mass production.

Scaling up a liquid fuel rocket is still an art that results in a debugging test program. Cal Tech is working at eliminating scaling troubles, particularly oscillations in rocket motor during combustion.

Fulton-Irgon Corporation is latest entry into rocket business. New firm, with headquarters at Bernardsville, N. J., will act as consultants in the field of rockets, propellants, escape systems, cartridge devices, launchers and liquid-propellant guns.

RUSSIANS HAVE PROBLEMS:

SATELLITE SCIENCE NOT SO SIMPLE



Here's what the Russian public think their IGY satellites will look like. Illustration (top) bylined "by N. Antonov" in Russian magazine is exact copy of Dr. S. F. Singer's early MOUSE (1954), frequently displayed in this country (bottom).

U.S. Satellite Designs Copied?

By Erik Bergaust

A couple of Russians have tried to convey to the Soviet people how advanced Red scientists are in the art of satellite science. Engineer B. Lyapunov has impressed millions of Russians with a brilliant article on details of what is understood to be the forthcoming Russian IGY satellites. And artist N. Antonov has taken credit for a cross-sectional schematic satellite drawing in the same popular Russian magazine NEWS. What the Russian people don't know is that they have been fooled—the satellite that must have made comrades Lyapunov and Antonov heros overnight, is American.

As can be clearly seen from the illustration on the left, the Russian satellite is a true and exact copy of one of Dr. S. Fred Singer's early MOUSE versions, discussed in Popular Science in July, 1954, and frequently used in Western Gear advertisements. No reference whatsoever is given to any American source.

In his caption—where Lyapunov explains how the automatic artificial earth satellite will "be arranged," he says:

"Its upper side will always be turned to the sun, and the sun's rays (2), passing through the transparent lens (5), will be concentrated on the solar battery (9), which serves to recharge the storage cells (10). The pin (1), serves as the antenna for the radio transmitter (11). The following instruments are installed in the artificial satellite: for studying gamma rays (3), the sun's ultraviolet radiations (4), free electrons (6), X-rays (7), magnetometer (8), measuring device (recorder) for studying the aurora and cosmic rays (12). The readings of all these instruments are recorded on the magnetic tape of the drum (14), which is revolved by the motor with reducing gear (13). The recording hear

(15) controls the recording." Dr. S. F. Singer certainly will recognize this design.

Some details on the forthcoming Russian IGY satellites have been compiled by MISSILES & ROCKETS during the last few weeks from Russian radio broadcasts and from an analysis of several Russian trade journals and magazines.

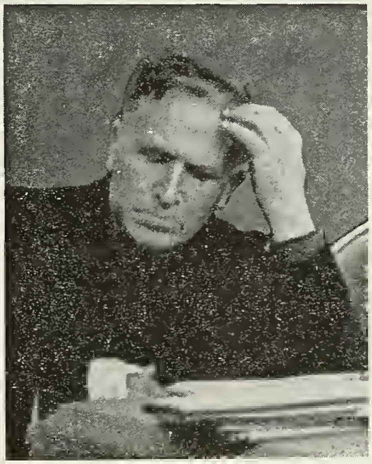
Although the Russian satellite will be of the same size as the American (Professor Georgi Pokrovsky, writing in MOSCOW NEWS, says it will be 20-24 inches in diameter), the Red scientists won't make their orbiter a light-weight device such as the VANGUARD. Russia's satellite will weigh almost 100 pounds, five times as much as the American.

The Soviet carrier vehicle will be tremendous in size compared with the VANGUARD vehicle. Some of the Russian write-ups indicate their vehicle will weigh 150 tons. Pokrovsky said this is approximately 10 times greater than the largest existing rocket. Although Pokrovsky has indicated some sources think the satellite carrier rocket can be made somewhat lighter, he admitted "enormous technical difficulties have to be overcome."

Russian IGY Committee Chairman Professor I. P. Bardin and astrophysicist Professor Leonid Sedov also have admitted the satellite job is formidable. "It is going to take some thinking," Bardin was quoted as having told IGY delegates in Barcelona this fall.

Furthermore, it looks as if the Russians are beginning to realize that the only solution to some of these problems lies in international cooperation. This trend was proposed recently in an article in the Russian magazine NEWS by professor Kirill Stanyukovich, Moscow Bauman Institute of Technology; who states that space flight can be accomplished in the not too distant future "if the world's major scientific powers cooperate in developing and financing the project." However, the Soviets have a powerful 265,000 pound thrust engine, according to well-informed U.S. sources.

Incidentally, Stanyukovich said "calculations suggest that interplanetary craft will be in the form of atomic rockets. To overcome the pull of gravity, a 100-ton rocket would need 96 tons of conventional fuel. But since the tanks, the shell, and the control mechanism will obviously weigh more than 4 tons, this is not feasible. Chemical fuels cannot do the job. But nuclear fuels can. They can impart the required speed without involving such prohibitive loads. Thus a 100-ton rocket will need from 70 to 80 tons of inert propulsion agent, leaving 20 to 30 tons for effective load."



PROFESSOR I. P. BARDIN

it takes some thinking.

101st Airborne Division Gets Honest John Rocket

The first separate tactical unit of the Army to be armed with the 21-ton *Honest John* rocket developed at Redstone Arsenal, Huntsville, Alabama, is the recently reactivated 101st Airborne Division, based at Fort Campbell, Ky.

Named after the famous World War II outfit that distinguished itself in Holland and the Battle of the Bulge, the 101st is termed "the forerunner of divisions of the future."

Trimmed down to 11,500 men and discarding tanks and heavy equipment, the paratroopers of the 101st will serve as trouble shooters and can be completely airlifted on a few hours notice to any part of the world in only half the number of planes required for the 17,500 officers and men of present divisions.

The revamped division is composed of five combat groups of five rifle companies, each with supporting rocket artillery, instead of the conventional organization of three regiments with three battalions.

Recruiting Program Launched by Redstone

The Army's Redstone Arsenal at Huntsville, Ala., has set out resolutely upon the jungle trail that it, in common with most organizations dealing in aircraft, missiles and rockets, hopes will lead to the recruitment of capable young engineering graduates.

Restricted as it is by regulations that prevent a government agency from competing too directly with private industry, Redstone is slanting its engineering recruiting pitch toward only 20 young men who will be simultaneously accepting Army Ordnance Reserve commissions and receiving engineering degrees in the next few months from a handful of colleges.

To underscore the advantages of combining the required term of military service with a broad education in the intricacies of missile and rocket engineering, Redstone has produced a 28-minute color film that will be premiered tbis month before engineering students of LaFayette and Lehigh universities in Pennsylvania and shown later to interested students at those engineering schools whose Reserve Officer Training courses specialize in Ordnance and to other selected military colleges offering engineering courses.

Prospects are shown how they can combine military training with post-graduate instruction in missiles and rockets to become eligible for either continued military service in the field or for attractive Civil Service positions, with individual options for choice of specialties available at several points along the program.

Top Redstone Officials Attend Manpower Clinic

The deputy commander of the Army Ballistic Missile Agency, Huntsville, Ala., and two of the agency's top scientists represented the Army at a conference held Oct. 24 and 25 at the U.S. Naval Postgraduate School, Monterey, Calif., under auspicies of the International Science Foundation of San Francisco.

Brig. Gen. J. A. Barclay, Dr. Wernher von Braun, director of development operations, and Dr. Ernest Stuhlinger, director of the research project office, represented ABMA.

Washington Spotlight

By Henry T. Simmons

Fiscal 1958 looks like the big year for the guided missile. Key Pentagon officials report that a junior-sized "New Look" is now being taken at the nation's defense establishment in connection with the fiscal 1958 budget request. Key element in this appraisal is a determination by Missile Czar Eger V. Murphree of the extent missiles can replace aircraft, particularly in the tactical area. Watch for a reduction in the USAF goal of 137 wings of manned aircraft and greater reliance on such weapons as the USAF *Matador* and the Army *Corporal* and *Redstone.*

Government is taking significant interest in the principle of the rocket glider. The National Advisory Committee for Aeronautics is studying the idea, and this is usually a harbinger of military interest to follow. NACA believes a winged rocket vehicle could attain an appreciable fraction of orbital velocity at very high altitude, then use the aerodynamic lift of its wings to coast to its destination. Most likely military application: a globe-girdling bomber.

Big shakeout in the number of thermonuclear delivery vehicles now under development by the Air Force appears to be in the works. The airmen are developing eight separate systems—three aircraft and five missiles. They are the Convair B-58 bomber, the Boeing/North American WS-110A chemical bomber, the Convair/Lockheed WS-125A nuclear bomber, Northrop *Snark,* NAA *Navaho,* Douglas *Thor* IRBM and the Convair *Atlas* and Martin *Titan* ICBMs.

All of the new systems have technical merit, but the cost of developing them is staggering. Pentagon estimates a price tag of $200 million plus for each of the new systems, and this is too great an outlay for the USAF to carry. Therefore, it is virtually certain that some of the systems will be abandoned or "stretched out" in connection with the fiscal 1958 budget. Which will get the axe is the big question.

In the area of the ballistic missiles, the USAF development effort will certainly be reduced to two programs and possibly to a single program, depending on the progress of development. The *Atlas-Titan* effort will be narrowed to a single missile, while the *Thor* may give way to the Army's *Jupiter* IRBM. But it seems unlikely that any concentration will be undertaken in the ballistic field at this stage.

Missile Czar Murphree may move into the satellite field. Air Force interest in the so-called *Big Brother* (Air Force never revealed the true project name) satellite for gathering reconnaissance data is one force in that direction, but an even stronger persuasion may be the interest of satellite proponents outside the government in obtaining ICBM vehicles to launch earth-circlers up to 1000 pounds in weight. A moon-circling rocket using ICBM vehicles to reach escape velocity has been proposed.

Missile Training Schools Needed

Splendid cooperation between the Services has been experienced in the operation of our missile ranges, missile Czar Eger V. Murphree told a recent meeting of the American Management Association. "The management of a testing range in itself is quite a job," he said. "The range contains very complicated and normally quite new types of instrumentation which must be maintained and kept in good operating condition.

"In a case such as the one starting at Cape Canaveral, the range consists of a number of instrumented stations at rather remote locations," Murphree said. All ranges have much work to do and the most efficient schedule of this work is of utmost importance. Safety is quite a consideration since the missiles are experimental in nature and every precaution must be taken to see that any malfunction of the missile which may result in an explosion of considerable magnitude on or near the ground will not cause unavoidable damage to personnel or equipment.

"Before a launching of the missile can be made, the range, out from the launching point, must be cleared of people, vehicles or ships, as the case may be. The missile must be closely tracked and if it starts to deviate sufficiently from its prescribed course to approach the range boundaries, it must be destroyed."

MISSILE CZAR MURPHREE
Splendid cooperation between services.

Missiles, along with their ground equipment, in general represent really complicated equipment, Murphree emphasized. He mentioned the large numbers of electronic components involved. Because of their complexities, missiles pose real problems in regard to getting a high degree of reliability and also in training troops to use the missiles and to maintain them. It is not generally planned to carry out any real maintenance in the field, he said.

Field personnel will be provided with checking equipment of the "go-no go" type. If a component is indicated to be defective in the missile, it will simply be pulled out and a new component put in its place. The defective part will then be sent back to the manufacturer for repair.

Even with this simplification in maintenance procedures, the training problems are still of large magnitude and it is necessary to set up definite schools involving extensive training periods in order to get operational capability.

Type of management used by the Department of Defense in missile programs differs somewhat, depending on the type of missile involved, since a special management procedure has been set up for the long range ballistic missile program, Murphree explained.

For all types of missiles the basic responsibility for research, development, procurement, and use rests with the Services themselves; but because of the interrelationships of the various programs in the over-all national picture, progress is reviewed and guidance given by the Office of the Secretary of Defense.

IGY Satellite Experiments Named

First IGY satellite experiments have been revealed. They include: Cosmic Ray Observations (State University of Iowa); Satellite Environmental Measurements (pressure, temperature, meteoric incidence, skin erosion) (Naval Research Laboratories); Measurement of Solar Ultraviolet Intensity in the Lyman Alpha Region (Naval Research Laboratories); Measurement of Ionospheric Structure (Ballistics Research Laboratories, Aberdeen Proving Ground); Measurement of the Earth's Cloud Cover and Albedo (Signal Corps Engineering Laboratories); Measurement of Interplanetary Matter (Air Force Cambridge Research Center); Measurement of Meteoric Dust Erosion of Satellite Skin (University of Maryland); and Determination of Flux of Primary Cosmic Ray Nuclei with Atomic Number Larger than Eight (Research Institute for Advanced Study (Glenn L. Martin Co.) and Barton Research Foundation).

All of the above experiments are judged by the U.S. National Committee-IGY to be significant scientifically. First four experiments are in a more advanced state of development and are considered at this time to have the best expectancy for successful execution. All experiments continue under periodic review, and it is possible that some changes in the foregoing may be made. Several other proposed experiments are under active consideration. (See chart on page 120).

Record Attendance For ARS Meeting

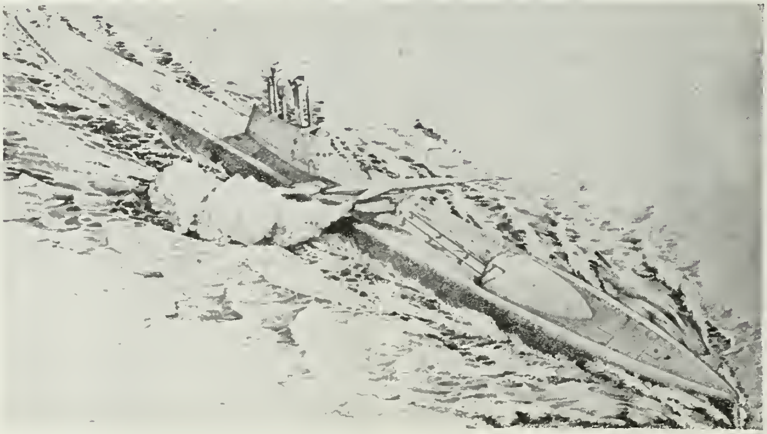
At press time American Rocket Society Secretary A. C. Slade could confirm to MISSILES & ROCKETS that a record crowd of between 1,500 and 1,600 had signed up for the Society's annual meeting. This is a substantial increase from last year's annual meeting, which had an attendance of 1,100. The ARS annual meeting will be held from Nov. 25-30 at the Henry Hudson Hotel in New York City.

Missile-Launching Subs Under Way

Navy's first real start towards tomorrow is this nuclear-powered missile-launching sub. With a length of 346 feet and a beam of 29 feet, this vehicle has been requested as part of the Navy's 1957 construction program. By comparison with what is planned to follow, it is but a primitive beginning. Last summer, under the auspices of the Office of Naval Research, a three months-long conference was held at Woods Hole, Mass. There, day after day, Navy scientists and strategists were host to a steady stream of the finest brains in industry. Unknown to the thousands of tourists vacationing on Cape Cod and nearby Martha's Vineyard, these men were reshaping the Navy to fit the concept of a world of nuclear power, missiles and rockets. Everything was welcomed and considered from blue-prints and top secret data books to dream and off-chance ideas. From this meeting, the rate and pattern of development of the Navy for the next decade was charted.

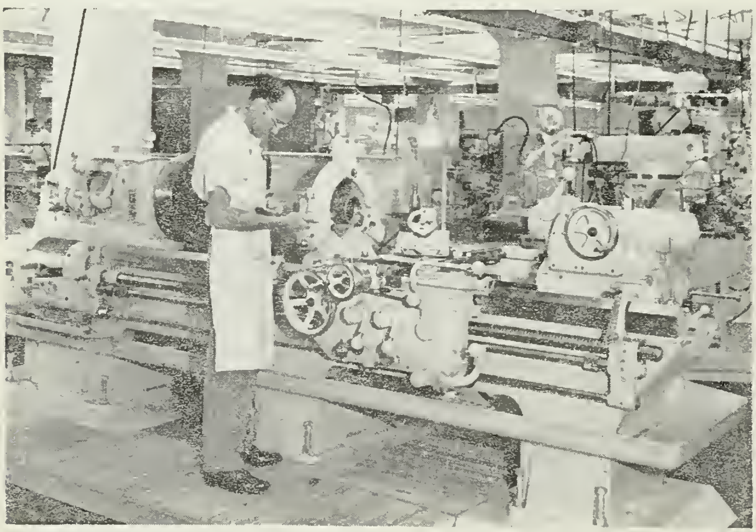
The artist's drawing of the proposed submarine is a close rendering of the vessel to be. The missile itself probably comes more from the artist's than the missile engineer's mind. But this much is known. First models will be guided by the sub. This surface-to-air guidance system already has been worked out. The missile itself, is surface-to-surface.

After this concept will come the underwater-to-surface long range guided missile—launched from a mother sub well under the surface, it will then break through into the atmosphere and proceed to perform like a conventional ballistic or super glide missile.



Artist's drawing of proposed nuclear submarine is said to be close rendering of the vessel to be. Missile will be guided from the submarine against surface or air targets; system already has been worked out.

Building the ICBM nose cone prototype



General Electric's Missile and Ordnance Systems Department has completed setting-up of an ultra-modern machine shop in its headquarters building in Philadelphia. Conducting model and prototype work on Atlas ICBM nose cone, MOSD's machine shop will be moved to facilities at Valley Forge, Pa., in 1958.

$50 Million For BuAer Avionics

Major change in the recent reorganization of the Research and Development Dept. of the Bureau of Aeronautics is the formation of a new Avionics Division with a commitment budget of $50,000,000, consisting of three major staff branches and four line branches. Avionics will be under the direction of Capt. W. E. Sweeney, USN, and will be responsible for all avionics and astronics gear for aircraft and missiles used in locating targets, maneuvering for attack and delivery of the weapon.

$5 Million For Army Missile School

A $5,000,000 program to provide additional buildings and equipment for the Army Ordnance Guided Missile School, Redstone Arsenal, Huntsville, Ala., is nearing final approval and should be started in the near future, it is learned.

Already the size of a small college with two-score buildings, 400 students and a faculty of 40, the Guided Missile School will be expanded to provide study facilities, housing and equipment for detailed instruction in several new missile weapons systems.

Since the first class was graduated in 1952, the school has trained more than 5,000 Army officers, enlisted men and key Civil Service personnel assigned to missiles work.

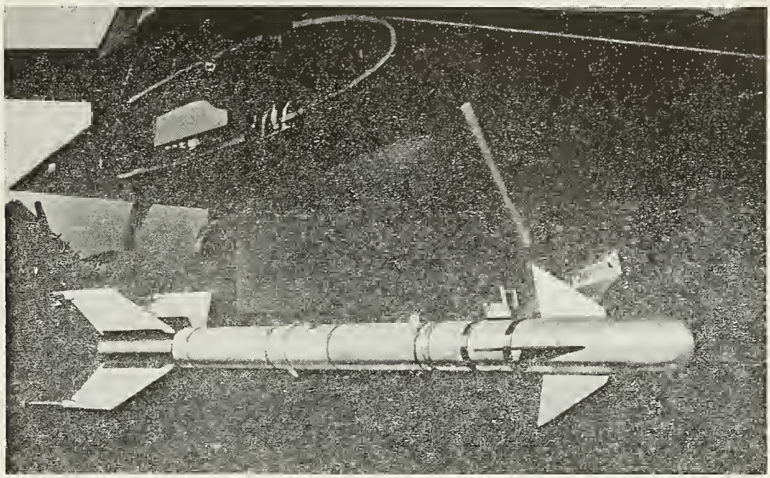
Sidewinders for U.S. Air Force' F-104?

Small and light enough to be carried in quantity by single-seat interceptor planes, the Navy's new *Sidewinder* may be fired singly or in salvos. *Sidewinder* requires no complex launching equipment but is fully maneuverable at supersonic speeds. It has an unusually high single-shot "kill" reliability. Air Force is believed to be considering *Sidewinder* for the F-104.

Although details on the missile's guidance system have not been disclosed, the Navy says *Sidewinder* requires no special pilot training. It may be launched well beyond reach of an enemy aircraft's defense.

Philco's Government and Industrial Division which played an important role in assisting the Naval Ordnance Test Station, China Lake, California, in the research and development program of *Sidewinder*, is now manufacturing the missile and has begun scheduled deliveries.

Sidewinder is basically a defensive weapon and will be used to augment the protection of our men and ships at sea from attacks by enemy aircraft, thereby enhancing the position of the fleet in maintaining freedom of the seas for all nations. *Sidewinder* also will be employed in air defense of the continental United States.



SIDEWINDER heat-seaker bird can change its course to account for tactical movement of an enemy target. Although time of interception is very short, SIDEWINDER has displayed extreme deadliness during recent tests.

Oh Deer! Redstone Cattle Are Contented—and Clear

Several thousand cows and sheep at Redstone Arsenal enjoy privileges denied to most of the 50,000 inhabitants of nearby Huntsville, Ala. They can rove at will through some of the nation's most closely guarded rocket and missile territory under an arrangement whereby grazing and haying rights are leased on 16,000 of the Arsenal's sprawling 41,000 acres. The Alabama quadrupeds have developed instincts similar to those of the many wild deer at Aberdeen, Md., Proving Ground which thoughtfully absent themselves as regular firings begin each afternoon. The Redstone livestock noticeably make tracks when missiles and rockets are brought out to test stands for firing.

NEW RADIOPLANE TARGET MISSILE

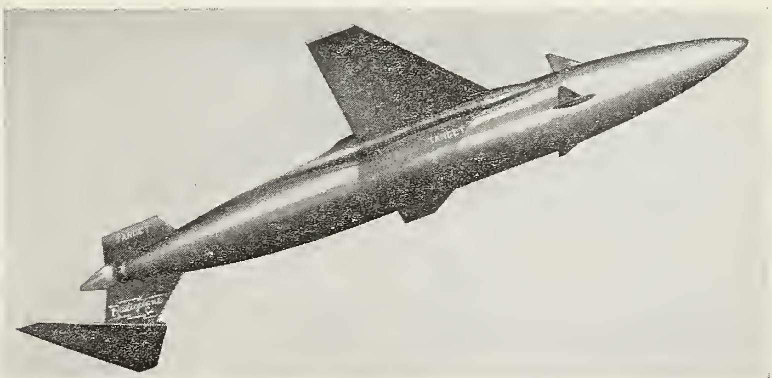
Powered By Solid Rocket

Radioplane Company has announced the development of a new rocket powered target drone series designated the RP-70 type. Designed for weapon system evaluation and training in the Mach 0.9 class at 50,000 feet, the RP-70 is powered by a solid-propellant rocket with a flight endurance of eight to ten minutes.

Airframe, weighing 300 pounds, is specifically designed for high volume production. It is slightly over nine feet in length with a wing span of five feet. With the exception of the steel rocket motor case, which makes up the mid section of the fuselage, all other primary structures are made of glass fiber and plastic.

The plastic wings, horizontal and vertical stabilizers are fixed surfaces. Control of the drone is accomplished by small canard-type vanes located just forward of the wing and linked directly to the flight control system.

Payload capabilities are sufficient to accommodate the special tracking and scoring equipment required by the Armed Services in training, evaluation and the development of tactics for their various defense missile systems.



RP-70 target drone missile built by Radioplane Company can operate at altitudes as high as 50,000 feet; flight endurance is eight to ten minutes. Solid rocket gives the bird Mach 0.9 velocity.

World Astronautics

By Frederick I. Ordway, III

The Brooks and Perkins Co. of Detroit will perhaps be making the Vanguard IGY satellite sphere in quantities up to 35. Smaller satellites of 6 or 12 inch diameters may be constructed in addition to the planned 20-inch variety. Skin thickness of the larger ones will be 0.03 inches, a third greater than originally contemplated. The shell will weigh about 4 pounds and will be made as follows: Magnesium, 95%; Aluminum, 3-3½%; and Zinc about 1%. Interior bracing will be provided by magnesium tubing and Kel-F low thermo-conductivity plastic.

There has been some talk about an "expanding satellite" which, upon entering orbit, would increase in size. Fired along with conventional types, it would hold the same orbit for a certain period of time. Because of its larger size, however, its orbit would slowly decay to circularity and finally the satellite would enter the dense atmosphere and be destroyed. Comparing the orbital characteristic of conventional and "expanded" satellites, scientists would find data on conditions at extreme altitudes, particularly on densities.

Broadcasts from Moscow hint at coming Russian moon rockets. It is known that a specific moon rocket study has been completed, and that the Russian scientists plan on launching satellites during the IGY.

We are to have spaceship plays, or so we are told in an article in the *New York Times.* Arch Obeler's "Night of the Auk" will reach Broadway next month with an all-male cast. In it we shall learn all about the "troubles that beset the first spaceship to be launched from earth to the moon."

Some interesting items on the Mars studies include: (1) polar caps seem to be evaporating more rapidly than usual, (2) violent sandstorms are in evidence, about 3,000 miles long, (3) a 50-mile diameter bright spot was discovered, (4) Mars, at closest approach, has a lemon-color rather than a characteristic orange-red color, (5) a violet halo or veil appeared to surround the planet, (6) this violet was accompanied by a yellowish haze, (7) as planet moved away from Earth, color seemed redder than usual, (8) due to reduced reflectivity of atmosphere, the planet seemed fainter than usual, (9) like Venus and Jupiter Mars emits radio signals, and (10) Naval Research Laboratory reports indicate temperature readings average just below the freezing point of water on Earth. Mars, apparently satisfied that Earthlings still have a long way to go before landing on its surface, moved outward into space as September closed.

Operation Tan Glove will be of help to satellite geomagnetic studies. A KC-97, carrying a 1500 pound cosmic ray monitor is taking an irregular circum-terrestrial trip to determine the Earth's magnetic field at high altitudes.

Redstone Quantity Production Started

Production of *Redstone* missiles for Army Ordnance is in full swing at Chrysler Corporation, Detroit. Announcement that the medium-range missile is to become operational shortly is expected soon. First battalion is being readied now.

Officer Training Course

The Ordnance Corps' most advanced class of officer trainees has concluded a one-week course of study at the Ordnance Guided Missile School, Redstone Arsenal, Huntsville, Ala. This is the first time that such a class has received on-site instruction at the huge missile and rocket development center and is thought to foreshadow regular instruction here for succeeding classes in the Ordnance Officer Advance Course of 30 weeks at Aberdeen Proving Ground, Md.

Seven members of the staff and faculty of the Ordnance School accompanied 47 student captains and majors for instruction at Redstone. The group received detailed training on the *Nike I & B*, the *Redstone*, the *Corporal II, Hawk, Dart* and *Lacrosse* missiles, worked at the Army Ballistic Missile Agency test ranges and studied work in progress at the highly secret Fabrication Laboratories.

Reliable Weapon

The *Redstone* missile is termed "rugged" in that it has been designed for rough handling and for typical GI surface transportation and environment. Army missile authorities have praised Chrysler Corporation in its effort to make the *Redstone* a most reliable weapon in spite of the fantastic amount of complex systems and wiring that go into this type weapon.

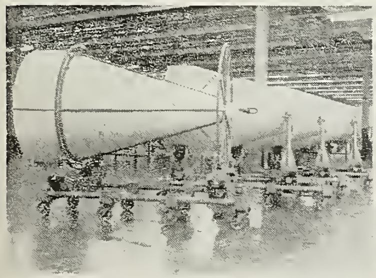
Missile-Carrying Satellite

Dr. Wernher von Braun, development operations chief of the Army Ballistic Missile Agency, suggested the possibility of launching a satellite station into outer space during a talk to the Association of the Army at the Sheraton-Park Hotel, Washington, D. C. Photo indicates the orbit of such a satellite station around the earth. The inner arc is the trajectory of a guided missile which could be directed by the crew of the satellite directing it. At the speed of missile and satellite, the missile would traverse a distance equal to three-fourths of the earth's circumference. It would be under control of the satellite station crew at all times.

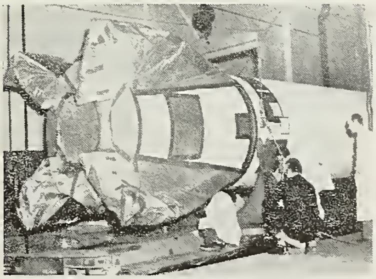
Chrysler Corporation cannot reveal its production output for *Redstones;* nor will DOD or the Army tell anything about how much money is being allocated for the program. Says one Army spokesman: "For obvious security reasons, the American public simply must accept the fact that we've got a missile that's really hot—and it's being mass produced."

The *Redstone* missile has been termed the most potent current U.S. missile. The *Redstone* rocket engine, built by North American, yields a thrust of 75,000 pounds and is considered the most proven U.S. liquid rocket.

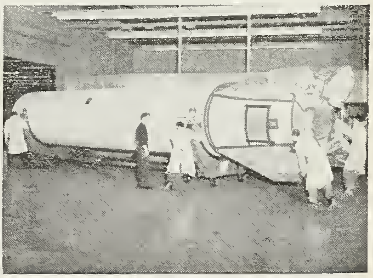
The *Jupiter,* in the meantime, "is definitely and certainly on time; each milestone fixed a year ago is being met, and some guide posts are being surpassed," declared Maj. Gen. John B. Medaris, commander of the Army Ballistic Missile Agency at the recent Army Association's Annual Meeting in Washington, D. C. Even so, and since the *Jupiter* could not possibly become operational for another two or three years, the *Redstone* will continue to be the Army's big-punch weapon for some time to come.



REDSTONE nose cones on assembly line at Chrysler Corporation's plant in Detroit. Production in full swing.



Wrapping-up of REDSTONE control section at the factory. Most REDSTONE missiles are shipped to Huntsville by truck.



Huge missile is transported on special dollies; weapon is designed to take rough handling and transportation.

VOL. 1 NO. 2
NOVEMBER 1956

missiles and rockets

OUTSTANDING ARMY ROCKET RECORD

A spectacular new distance record for rocket flight was racked up by Army scientists in September when a three-stage *Redstone* assembly was fired from Patrick AFB, Fla., 3,000 miles into the South Atlantic.

The new range and altitude marks represent convincing proof of the Army's progress in its all-out drive to develop the *Jupiter* before the U.S. Air Force can get its competing *Thor* IRBM into shape. Both services are working out IRBM versions with the understanding that only one will be ordered into production. Preliminary tests on the *Thor* are scheduled at Patrick next month.

Here are the components of the record-setting vehicle:

First stage was a standard *Redstone* rocket, which employs a mixture of liquid oxygen and alcohol for combustion. North American Aviation, Inc., supplies the rocket motor, while Chrysler Corp. manufactures the 69-foot airframe.

Second stage of the vehicle consisted of a cluster of solid propellant rockets, while the third stage was a single solid-propellant rocket of the same type. They were said to resemble the *Recruit*, a scaled-down version of the *Sergeant*. Both rockets were designed by the Jet Propulsion Laboratory of California Institute of Technology and are produced by the Thiokol Chemical Corp.

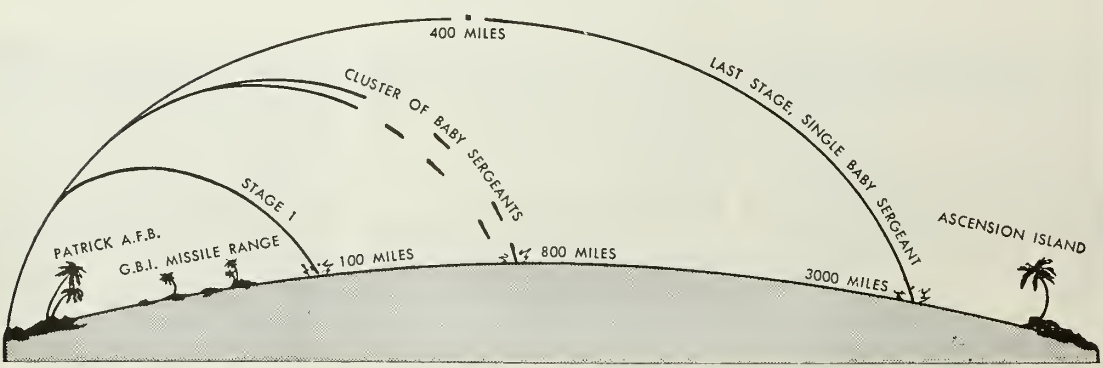
Here's how the test vehicle worked in flight:

The *Redstone*, which normally has a range of more than 200 miles, burned out, separated and fell into the sea approximately 100 miles from Patrick. The second stage cluster exhausted itself and fell into the sea about 800 miles from the launching site. The final stage coasted to an altitude of 400 miles after burnout, then fell into the South Atlantic at a point 3,000 miles from Patrick.

It is interesting to note that the final stage of the vehicle encountered something of a re-entry problem on its downward trip through the atmosphere. It evidently surmounted the effects of aerodynamic heating, however, because it managed to fall into the sea without burning up.

The significance of the range achieved by the *Redstone* assembly is not merely the fact that it is a new record. The Army's ability to shoot a rocket 3,000 miles was forecast last spring by Maj. Gen. John B. Medaris, commander of the Army Ballistic Missile Agency at Redstone Arsenal.

But he also said the Army could do much better. In testimony before the Symington airpower subcommittee, he declared: "By no great stretch 5,000 miles could be achieved."



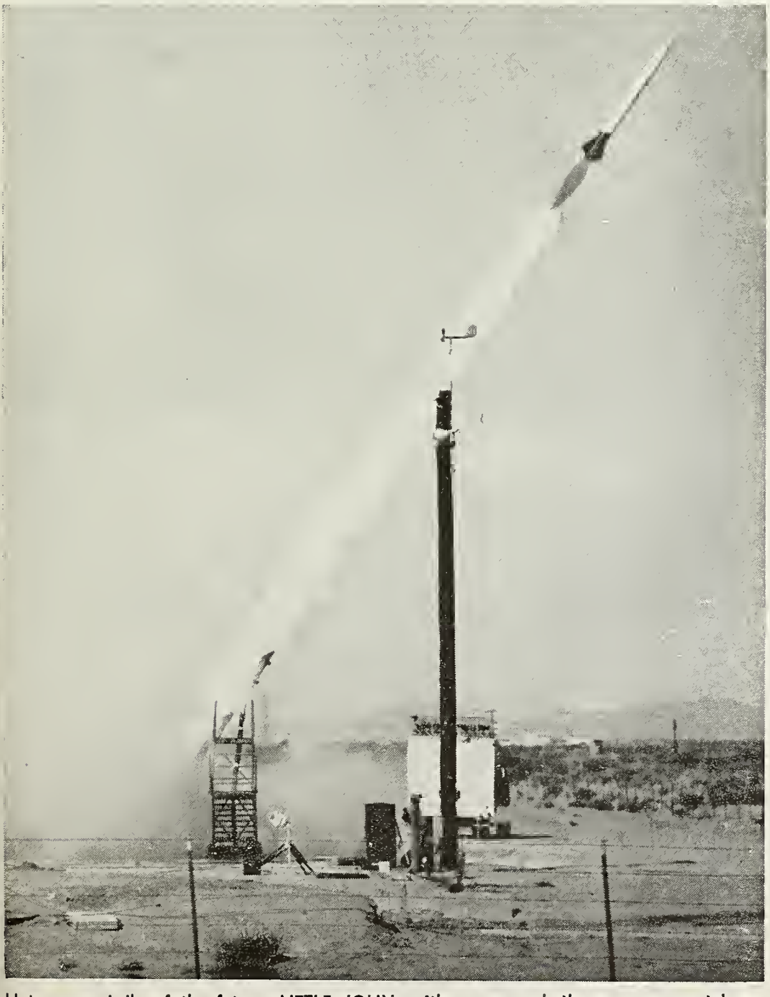
ARMY missiles of *TOMORROW*

UNITED STATES Army has some hot missile projects in the works. And some of these will be operational within months, while the more sophisticated weapons—the anti-missile missiles—are in their early stages.

Next four Army missiles to be included in the current weapons arsenal are the *Redstone, Little John, Dart,* and *Lacrosse.* According to Wilber M. Brucker, Secretary of the Army, *Redstone* development is so advanced that Army units will be equipped with this missile shortly.

"The Army's arsenal must continue to be stocked with a well balanced variety of weapons, each fully adapted to a particular function, and each the best of its kind that modern technology can provide," the Army Secretary said.

Other advanced Army missiles include the *Little John* and the *Dart.*



Hot army missile of the future: LITTLE JOHN—with more punch than many current large-size weapons.

For Redstone's 400-man Rocket Development Laboratories, *Little John* was a manifold triumph. The 12½ inch, 318-millimeter rocket, about 12 feet long and packing the explosive power of heavy artillery, was successfully produced and demonstrated in a crash program that started only last February. It was test fired in June, only a matter of months after initiation.

Redstone's experts term *Little John* the second "unconventional weapon"—i. e., one not dating from World War II—to be considered for the Army's missile arsenal. The first was the *Honest John* rocket, initially fired in August, 1951, and now in the hands of U.S. troops in this country and abroad. *Honest John* represented the need for a free flight rocket artillery weapon with high accuracy, simplicity of design and operation, extremely high mobility, no electronic controls and a range equivalent to medium to long range artillery. It weighs several tons and is about 37 feet long.

The dimensions of *Little John* are about one-third and its weight one-sixth that of its predecessor. It can be carried in a helicopter.

Little John thus represents perhaps the growth of a new family of rocket weapons that ease logistical problems and give Army field commanders a wider choice of warheads for use against combat targets.

Little John recently was demonstrated to ordnance experts at Aberdeen in a driving rain storm, showing its all-weather capabilities and achieving a "remarkable accuracy on target."

For another, it was determined that if the Rocket Development Laboratories, a part of Redstone's Ordnance Missile Laboratories, directed by Col. Miles B. Chatfield, conducted the *Little John* program, as though they themselves were the prime contractor, they would thus acquire invaluable experience in the painstaking coordination essential to development and manufacture of today's complex weapons systems.

Under the direction of OCO (Office, Chief of Ordnance), the task force itself provided the necessary research and development work and guidance in design control, aerodynamics, metal parts and powerplant. The Allegany Ballistics Laboratory at Cumberland, Md., supplied propellants. Powerplant metal parts were fabricated by Consolidated Western Steel of Los Angeles. Emerson Electric of St. Louis manufactured the air frame. Army Ordnance's Rock Island Arsenal, Ill. provided the launchers. Proof testing was assigned to White Sands Proving Ground, N. M. and by Redstone's own staff. Warheads came from the Army's Picatinny Arsenal at Dover, New Jersey.

First firing tests that saw the *Little John* prototypes burying themselves in the sands of White Sands Proving Ground thus represented careful coordination of effort. Since the production of *Little John* is conducted at Redstone, the Army is able to exercise detailed supervision over all phases of manufacture.

Maj. Gen. H. N. Toftoy, Redstone commander, said the new rocket "should prove to be very important in the Army's new mobile 'fire brigade' concept in the air age."

Details revealed about the anti-tank *Dart* missile indicate it is "a simple but effective weapon" approximately five feet long with a configuration characterized by fins crossing its waistline. Started in 1953 *Dart* was developed by Aerophysics Corp. of Santa Barbara, Calif., under Redstone Arsenal supervision.

Missiles such as the *Redstone*, *Little John* and *Dart* are forerunners for some truly sophisticated weapons now being studied intensively by the Army, yet these missiles are rather indicative of the Army's missile power potential for the next few years. Under development are anti-missile missiles and long-range ballistic missiles—the latter will have pin-point accuracy and a striking range of several thousand miles. The anti-missile missiles will be designed to knock any enemy guided weapon out of the sky, a truly formidable engineering task. But missile experts and Army authorities believe it can be done.

Army anti-tank DART missile zooms away towards target. At recent public demonstration at Aberdeen Proving Ground DART made impressive bullseye hit at small target over 2100 yards distance. Quantity production is now under way.

DART is wire-guided, praised for simplicity, accuracy and ease of handling. Design is based on German and French concepts; Germans used wire-guided missiles in the last war.

GI training program for DART familiarization is underway. DART will be operational soon.

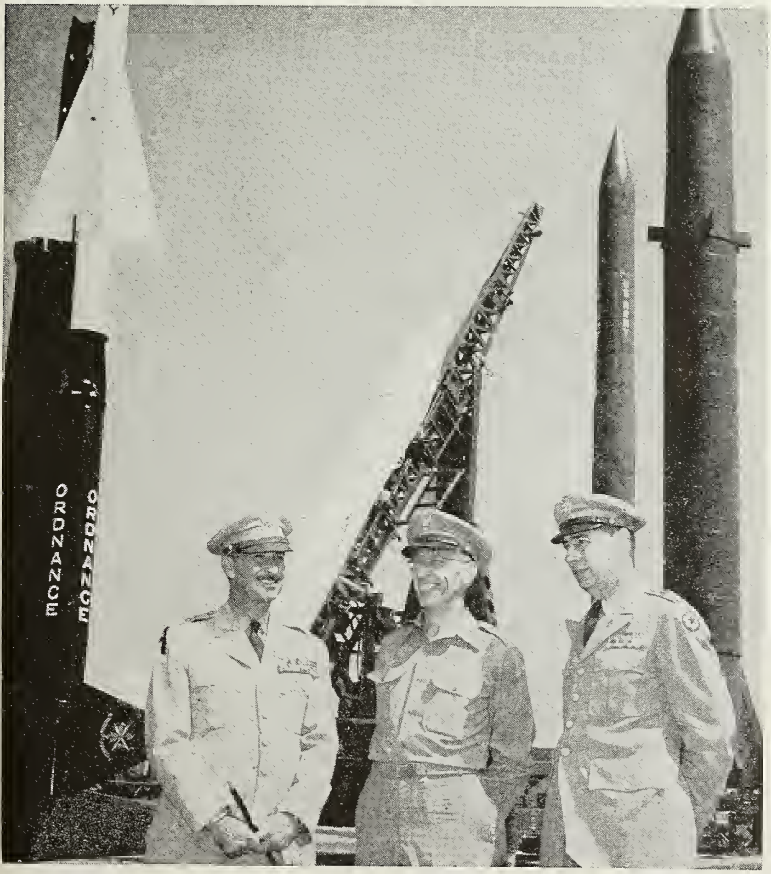
ARMY'S role in guided missiles

• Progressive New Guided Weapons Program

By Major General H. N. Toftoy

STATE of the art indicates that guided missiles will, in the near future, be able to reach any place on the surface of the earth with reasonable accuracy and reliability. Today, guided missiles, incorporating different combinations of propulsion, guidance, and warheads, are available for various tactical, strategic, and air-defense uses.

This is truly amazing progress when it is considered that only 15 years ago, when the Japanese attacked Pearl Harbor, the United States did not have a single service rocket or guided missile.



Army missile leaders pose in front of Nike, Honest John, Corporal and Redstone rockets. From left to right, MAJ. GEN. JOHN B. MEDARIS, commanding general, Army Ballistic Missile Agency; MAJ GEN. H. N. TOFTOY, commanding general, Redstone Arsenal; and COLONEL HENRY S. NEWHALL, commandant, Ordnance Guided Missile School.

It is a tribute to the determination of the Armed Forces, the imagination of the scientists and the ingenuity of industry that there now are many successful missile weapons in operation. And the Army has played a leading role in the nation's overall program.

For centuries wars were fought on land and on the sea. Then, in a relatively few years, man's ingenuity extended the elements of warfare under the sea and into the air and thereby created new factors to be reckoned with in determining the strategy and tactics necessary for victory. These new elements, along with technological advances, have greatly altered the scope and nature of conducting war—but they have not changed its basic nature. Sea and air power are essential components of our military strength. The nation could not survive without them any more than it could survive without adequate land forces. To debate which armed service is the most important is nonsensical.

One kind of power may temporarily become more important than another during certain stages of a war, but in the overall consideration, they are all equally important. They are not, however, equally decisive. It is the fighting man with his feet on the ground and armed with superior weapons who defeats the enemy's ground force, seizes his land, and holds it. These are the climactic actions which cause the enemy to decide that resistance cannot continue.

Nevertheless, the sea and air forces contribute indispensable operations before and during such actions.

Our national security, then, depends on the proper teamwork of a combination of combat-ready forces from all the services. The United States Army, capable of winning land battles and controlling land areas, is the final and decisive element of United States military power.

It is obvious that the development of new weapons is bound to change the manner an Army carries out its missions of ground combat. Through the ages there has been a gradual evolution of military science, but modern technology has expedited this evolution.

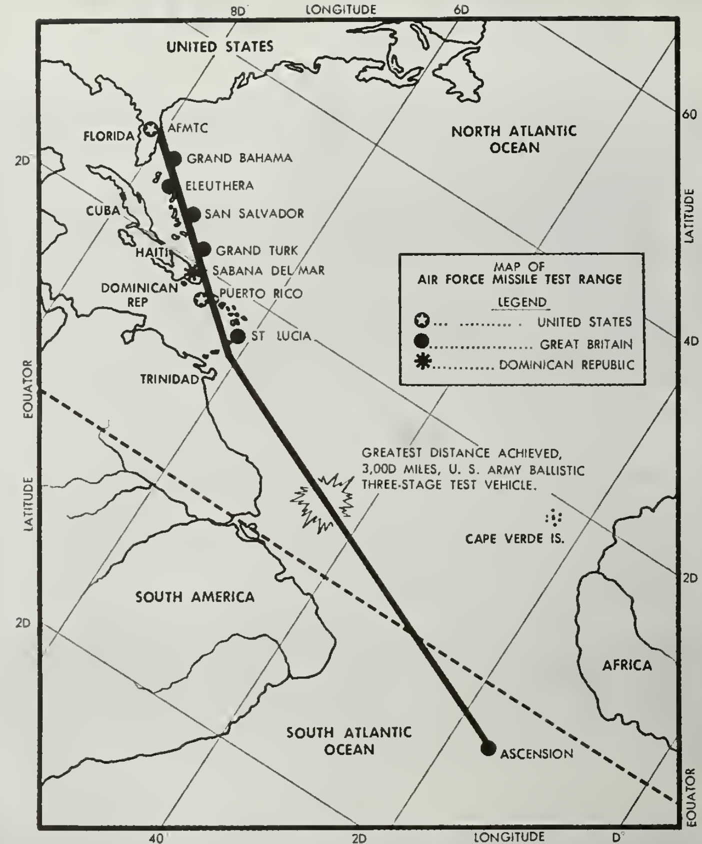
Our Army is keeping abreast of changing conditions by continually evaluating new weapons and techniques and adopting those weapons (new, old, or combinations thereof) which best meet the requirements of its missions.

Atomic Warfare

The Army requirements for supersonic surface-to-surface missiles also came about by changing conditions. The range and firepower of conventional guns were being outstripped by greater mobility and the more "fluid" tactics of modern warfare. The use of atomic weapons in land warfare has forced greater dispersal of ground troops and created much wider and deeper combat zones.

No longer are there clearly defined lines between battle and support zones. A ground commander must be capable of supporting his operations by atomic firepower having a wide variety of ranges and yields—short range for assault and demolition, medium range for supplementing and extending his artillery, and range capable of supporting deep penetrations and airborne operations.

As was experienced during the battle of the Bulge, tactical support aircraft were too often hampered by adverse weather; they were not the answer. What the Army needs is a family of all-weather, supersonic guided missiles which can be used effectively, day or night, and without air superiority, and against which there are no known countermeasures.



That, in brief, is the reasoning behind the Army's expanding guided missile program.

When the Army guided missile program was initiated in 1943 it was realized this would involve pioneering in a field new to U.S. technology. A long range program was carefully planned and included the necessary research to provide the basic knowledge required for the successful development of supersonic guided missiles. At that time little was known about supersonic aerodynamics, the sound barrier, thermal barriers, or the environment of flight. Man's fundamental scientific knowledge had to be quickly extended.

The Ordnance Corps was assigned the cognizance of developing and producing the Army's guided missiles. It was well qualified, having had years of aerodynamic and ballistic work with projectiles and long experience with complex fire control systems.

Recognizing the technical complexity of the development problems and the need for utilizing the best talent in the country, the Army Ordnance Corps early established a policy of contracting an entire weapon system with the most capable civilian scientific and industrial organizations available.

In 1943 the Jet Propulsion Laboratories, operated by California Institute of Technology, and the Ballistic Research Laboratories each was requested to investigate the feasibility of developing ballistic type guided missiles. Impressed by the favorable reports from these studies, Ordnance placed the oldest of its contracts with JPL for research on guided missiles, with emphasis on rocket propulsion and supersonic aerodynamics.

In less than a year, two more contracts were negotiated. These established the *Hermes* project of broad scope for the development of missile weapons with the General Electric Company and the *Nike* project with the Bell Telephone Laboratories of the Western Electric Company for all the necessary work required to develop an anti-aircraft missile system. Douglas Aircraft Company, although a sub-contractor, was a full partner in this effort.

As the program developed, many other industrial firms, educational institutions, and research organizations became members of the Army team of contractors. Special facilities were required before much progress could be made.

Long-range Concept

The Army, from the beginning, was thinking in terms of guided missiles having ranges of 1000 miles or more. In fact, the original program included preliminary work on a proposed 500-mile missile. It was apparent that a proving ground having a test range much longer than any previously conceived would have to be provided.

In order to obtain technical data pertaining to flight tests, it would also be necessary to devise and install a complex system of range instrumentation. Since it was important to recover spent missiles for study, an overland test range was decided on. Accordingly, White Sands Proving Ground in the New Mexico desert was authorized in 1944. Being the only overland guided missile range in the country, this Ordnance Corps facility is jointly used.

Thus having established projects with highly qualified contractors, and provided them the necessary tools-of-the-trade and proving ground service, the Army was, by 1945, seriously engaged in the guided missile business.

The Ordnance Corps also recognized the achievements of the German V-2 scientists and engineers. They were the most experienced ballistic missile group in the world, and the American program could profit by their specialized technical knowledge. Accordingly an integrated team of 130 key specialists was selected and brought to Fort Bliss, Texas. There they were organized to conduct studies and perform development work on medium range guided missiles, translate captured documents, and assist with the assembly and firing of V-2's at White Sands.

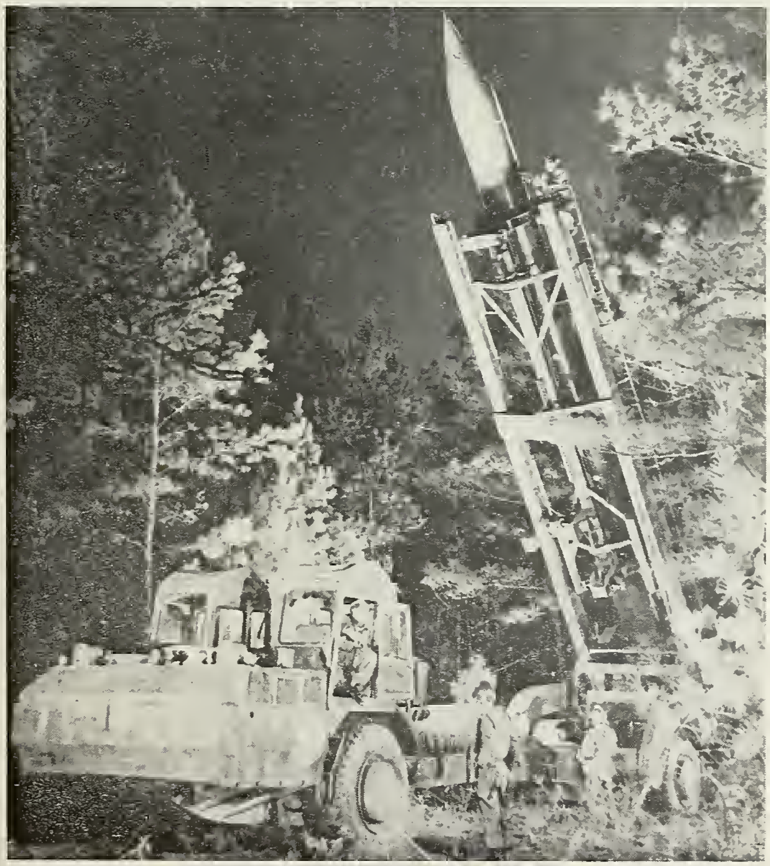
The German scientists were extremely cooperative and provided technical information of interest to all agencies engaged in the National program. They were later transferred to Redstone Arsenal where their work has been outstanding, and they have become highly respected citizens of their community and of the United States.

Rapid technological progress was made from the beginning. Information of importance to missile designers was being developed at the various projects and distributed to all interested agencies.

Out of the many early rocket programs emerged the Army's present operational missiles. *Nike*, the first operational and extremely effective air defense guided missile, is being used to protect this country's most important cities and industrial areas. *Corporal*, the faster than sound surface-to-surface guided missile, and the *Honest John* rocket have provided our ground forces, in the United States and overseas, unprecedented firepower.

Other missiles, including the longer range *Redstone*, the IRBM *Jupiter*, the anti-tank *Dart*, and the more advanced anti-aircraft missiles are well on the way to taking their places in this Nation's arsenal of truly modern weapons.

By 1949 the program had grown to the extent it became necessary to decentralize its management from the Pentagon to a field installation. For this purpose Redstone Arsenal was designated the permanent Ordnance Corps commodity arsenal for rockets and guided missiles and assigned the responsibility of conducting the

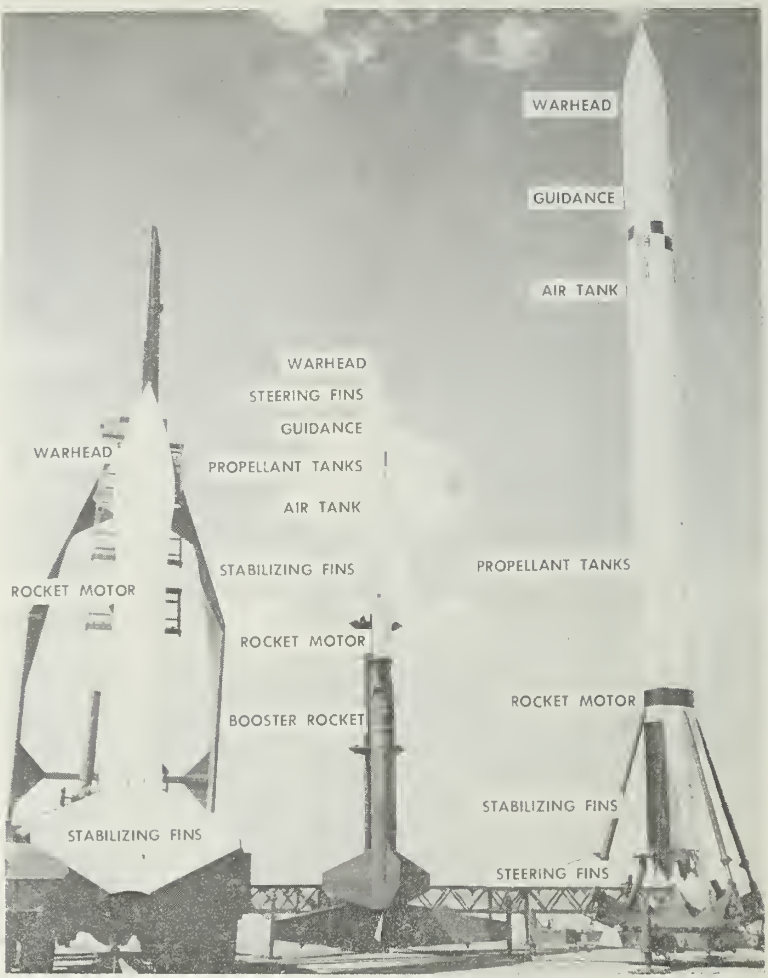


Army Corporal guided missile in typical tactical position with personnel of 601st Field Artillery Missile Battalion. Versatility of this missile is indicated by the fact that GIs now operate Corporal weapons system at night and under all weather conditions. Corporal is in service here and abroad, substantiating U.S. Army's atomic striking capabilities.

nationwide Ordnance activities in this field. The Ordnance Missile Laboratories, which performs research and development on solid propellants, rockets and guided missiles, and the Ordnance Guided Missile School, which trains personnel in missile maintenance, were also established at Redstone.

The arsenal built up highly competent groups which carry assigned rocket or guided missile projects through from preliminary design to final test—then manage the procurement and the storage, issue and maintenance of these weapon systems, as well as conduct the Ordnance training in this field. In addition, important research and development work is being performed in the arsenal laboratories on solid propellants and their application by two contractors—The Thiokol Chemical Corporation and the Rohm and Haas Company.

The integration of the former German scientists into its organization gave Redstone Arsenal a uniquely qualified and experienced guided missile team. The Guided Missile Development Division, under Dr. Wernher von Braun, drew nationwide recognition for its competence in developing the *Redstone* missile. In February 1956 the personnel and facilities of this division were transferred to the new Army Ballistic Missile Agency, specifically established for the expedited prosecution of a program to place the intermediate range ballistic missile, *Jupiter*, and the shorter range *Redstone* in operational status as rapidly as possible.



Honest John, Nike and Corporal missiles represent Army's family of operational missiles; Little John, Dart and Redstone soon will be included.

While the three services have conducted separate guided missile programs suited to their individual needs, there has been a full free exchange of technical information, and excellent cooperation between the various projects of the Army, Navy and Air Force. The Army, for instance, developed and produced rocket motors used on the Air Force's air-to-air missile, FALCON, and booster rockets for its MATADOR, and in turn used an Air Force power plant for its REDSTONE missile. A Navy solid propellant was used in the Army's HONEST JOHN rocket.

In an interesting experiment in 1947 the Army cooperated with the Navy in firing a V-2 from the deck of the U. S. S. Midway, and proved that large ballistic missiles could be successfully launched from ships at sea.

Among its contributions to the national program was the Army's pioneering work in connection with an earth satellite program. Ordnance personnel at Redstone Arsenal made extensive studies into the problems involved and was largely responsible for establishing the feasibility and laying the groundwork for the current U. S. satellite project recently initiated under the cognizance of the Navy.

We can all be proud of the achievements of the Ordnance-Science-Industry team which pioneered in the art of rocketry and produced this country's first supersonic guided missile weapons in a relatively short period of time.

The Army is proud of the performance of its missile weapons, and the public would be too, if the facts could be disclosed without jeopardy to the security of our nation. The frontiers of science are being pushed ahead at an unprecedented rate. The Army is continuing a progressive program on a new family of guided missiles which will better meet the various military requirements imposed by modern warfare.

The future presents an exciting challenge—and we of the Army look forward to it with great anticipation. The development of guided missiles, especially when combined with the progress in atomic weapons, is a tremendous step toward a truly modern Army ready to contribute a formidable defense to the free world. END.

ARMY'S missile arsenal today

Three versatile high-power missile systems are in actual operation with the U.S. Army. They have helped streamline our defense on a global basis. While waiting for newer weapons,* Honest John, Nike *and* Corporal *form the core of the GI missile arsenal.

By Captain Patrick W. Powers

THE U.S. Army now flexes its missile weapons system for the defense of Europe as well as the defense of the continental United States. In Germany's Black Forest farmers often have witnessed a *Corporal* missile battalion occupying a position during a tactical maneuver designed to strengthen the NATO defenses of Europe.

At the same time, on the outskirts of Chicago, radars of the Army's third operational missile system—the *Nike I*—track high flying jet aircraft on practice runs designed to sharpen the missile battery's twenty-four hour alert status. In a world-wide glance at our country's defenses we see that missiles are taking an active part.

The three systems mentioned are operational now—ready for hostilities. They have been organized into conventional-sized artillery organizations and operate with the same traditions of efficiency and confidence. To maintain a high level of proficiency they continually train and are integrated with the other conventional weapons of war.

Honest John System

This missile system is composed of the missile, a self-propelled launcher and an anemometer to measure the speed of the surface winds. The rocket is approximately 27 feet in length and 30 inches in diameter. It consists essentially of a warhead and the solid-propellant rocket motor with large tail surfaces for flight stability. The launcher is a movable, 25-foot rail mounted on the chassis of a regulation Army truck. The wind determining equipment is pole-mounted to register the velocity of the surface winds that effect the initial flight of the missile.

Honest John ballistic rocket roars aloft from White Sands Proving Ground.

The *Honest John's* trajectory to the target is determined by the elevation and azimuth of the launcher prior to firing. The effect of the direction and speed of the surface wind at firing is considered in a final setting of the launcher. The missile is fired remotely by an electrical signal that initiates the burning of the solid propellant. As the rocket leaves the launcher a slow spin is imparted to it by small spin rockets which give a more stabilizing effect to the trajectory.

After a few seconds of powered flight, the *Honest John* assumes a free-flight or ballistic trajectory to the target. Finally, the warhead system detonates the warhead at the target. Here, in reality, is the baby brother to the mighty 1500 mile ballistic missile—*Jupiter*—that the Army is now developing.

Nike System

It is a long technological jump from unguided rocket to the *Nike* system and its vast complexity. The system consists essentially of a two-stage missile and elaborate control equipment requiring approximately 1,500,000 separate parts. The *Nike I* is about 20 feet long and one foot in diameter with two sets of fins for guidance and steering. Its weight is more than one-half ton.

Inside the *Nike* are an explosive warhead, a guidance unit, and a propulsion system consisting of two propellant tanks, an air tank, and a rocket motor. When the missile takes off, the initial seconds of flight straight up are powered by the solid propellant booster rocket which drops off before the *Nike* turns and heads for the target at a supersonic speed. After the booster falls away the missile's own rocket motor begins to generate power and the second stage of the trajectory begins.

Control equipment consists mainly of three radars, an electronic computer, and automatic plotting boards. This is the combination of intelligence that detects approaching enemy aircraft and directs the *Nike* to the spot in space where they will meet and the warhead will be detonated.

First of the radars, the acquisition radar, detects a target aircraft at long range and alerts the battery control area. A second radar, called the target tracking radar, picks up the aircraft at a closer range. Then this information of the target's position and speed is continually fed to an electronic computer whose job is to keep track of the target and the missile, when launched, so that it can determine the commands to be sent for optimum interception.

In the meantime, the third radar which follows the missile supplies information on the *Nike's* position to the computer. Commands to direct the flight are determined by the computer and transmitted to the missile's guidance components which in turn cause the steering fins to move in the proper direction and the proper amount. Any evasive action by the target is instantly detected by the target-tracking radar and transmitted to the computer. The computer re-evaluates the trajectory of the missile to meet this new change of direction of the target and appropriate steering signals are transmitted to the *Nike*.

All of this happens—automatically measured—in thousandths of a second. The entire operation from determining the changes in the aircraft's flight path to the receipt of the steering commands for intercept by the missile are accomplished electronically.

U. S. Army Missile Arsenal

Type	Manufacturer	Powerplant	Remarks
		Surface-to-Surface	
REDSTONE	Chrysler	North American liquid rocket	Can carry atomic warhead.
JUPITER	Chrysler	North American liquid rocket-booster	IRBM weapon; derived from Redstone.
HONEST JOHN	Douglas/Emerson	Hercules solid rocket	In service; unguided artillery rocket.
LITTLE JOHN	Douglas/Emerson	Hercules solid rocket	In operation soon.
SERGEANT	Redstone Arsenal (?)	Solid rocket	In operation.
CORPORAL E SSM-A-17	Firestone	Liquid rocket (Jet Propulsion Laboratory)	Gilfillan beam guidance; also Corporal F; in production and in service.
DART	Aerophysics Development	Solid rocket	Wire guidance; anti-tank.
LACROSSE	Martin	Thiokel solid rocket	Anti-pill box; Marine Corps interested.
		Surface-to-Air	
TALOS L	Bendix/-McDonnell	McDonnell ramjet—booster	In production.
LOKI	Bendix	Solid rocket	In production.
NIKE SAM-N-7 NIKE B	Douglas/Western Electric	Aerojet liquid rocket — solid rocket booster	In service, also overseas; Nike B is a slightly larger more effective version.
HAWK-SAM	Raytheon	Liquid rocket	Production begun.
SHRIKE	?	Liquid rocket	Nuclear warhead.

Corporal System

The *Corporal* represents this country's first ballistic guided missile. System-wise, there is the long pencil-like rocket and several mobile vans and trucks of guidance and firing control equipment. The missile itself is about 45 feet long with steering fins located on the very ends of the large stabilizing fins. It weighs about 5 tons fully fueled and ready for launching.

The missile body contains the same elements as the *Nike* arranged in a slightly different order. There is a warhead, guidance compartment, air tank, propellant tanks, and the liquid rocket motor. The missile is fired vertically from a small mobile launcher.

The *Corporal* is launched into a radar beam in the direction of a distant target. The radar furnishes missile position information to an electronic computer which, combined with data from a special radio set, determines the correct trajectory for the missile to follow. After termination of powered flight by the rocket motor, the *Corporal* follows an essentially ballistic path to the target where the atomic warhead is detonated for the maximum effect.

The trajectory problem for the *Corporal* is somewhat simpler than that for the *Nike*. Here, the missile system is concerned with a fixed ground target so that the resulting computing equipment is not as complex. Before the missile is fired, basic firing data is computed for the guidance equipment and entered as "dial settings" in the various vans. Then, after the rocket is launched, minor corrections are made to the trajectory to insure an accurate impact.

Preparations for Firing

The *Honest John* missile travels to a launching site which has been prepared for the firing. The launcher-truck is emplaced and the launcher is turned to the firing direction or azimuth and to the proper elevation for the required range. The elevation and azimuth have been determined by a fire direction center which considers such factors as the weight of the rocket, the temperature and density of the air, rotation of the earth, and the burnout velocity of the missile. The effect of these factors on the range and direction to the target is computed and the settings are sent to the launcher.

Final checks are made, the effects of the surface wind computed, and the firing crew retires to a protected firing pit to wait for the designated time to fire. At the pit a final continuity check is made and the firing switch closed at the correct moment.

Nike & Corporal on the Alert

Bridging the Atlantic back to the outskirts of Chicago, we find a *Nike* battery rehearsing their deadly trade as they prepare to go through a practice alert. Every operation is performed as it would be in a "hot" engagement except for the launching of the missile.

The battery control officer sits in his control van located in the same area as the three radars and computer. He is responsible for the execution of the entire operation and he alone makes the final decision to fire. Information is constantly fed into the control console to enable him to make this crucial decision.

He has been notified by early warning radar networks of an unidentified aircraft approaching his defended area—the great population complex of Chicago.

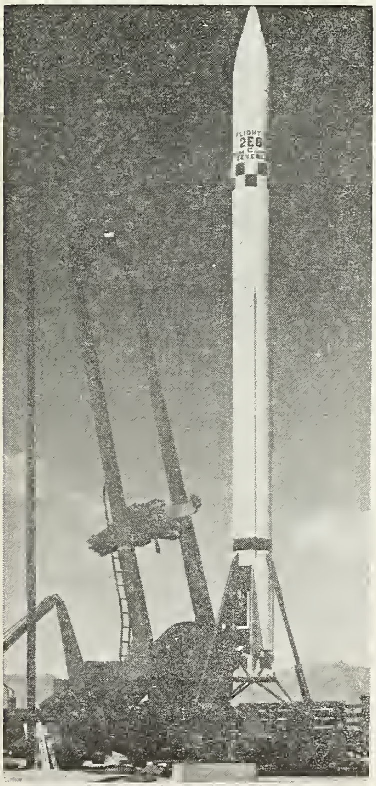
Given the information that an attack is imminent, he immediately orders "Battle Stations!" and the crews move swiftly into action. Previously prepared missiles and boosters are raised to the ground surface on elevators from the underground launcher installation. These two-stage rockets have already had their propulsion and guidance components checked, propellant tanks filled with acid and JP-4, and the warhead installed. *Nike's* are loaded on the four launchers associated with each underground installation and final tests and checks completed.

The "hostile" aircraft comes into the range of the acquisition radar and this information is presented on the scopes in the battery control van. Still the target is far away and out of sight of everything but the searching beam of the radar. The word is flashed to the control officer from the operations center to "Engage!" and the command is relayed to the launchers. Everyone scrambles into the underground installation and the missiles are erected to firing position.

Now comes that decision of the battery control officer . . . when to fire. Hesitation or a mistake might let the bomber slip in close enough to drop his atomic weapon. The battery is placed under its final "red" alert status and the missile tracking radar slews and locks on the first missile to be fired.

As the target approaches the maximum range of the *Nike*, the firing button is pushed. The "engagement" is ended, a few more commands are given and the nation's first operational anti-aircraft guided missiles disappear into their underground lairs waiting for the next alert, hot or cold.

As we return to the German Black Forest, the *Corporal* battalion is under way in the occupation of its forest position. The missile is erected on its launcher by a large transport vehicle called the erector. Previous to this the propulsion and guidance components have been thoroughly checked for proper functioning, the propulsion tanks have been filled with acid and aniline, and the warhead attached.



Corporal on launcher.

Guidance equipment vans have been emplaced somewhat to the rear and they are being warmed up and checked for the proper electronic indications that will guide the *Corporal* to its target.

In this guidance area, the battery commander has established his communications for control of the firing. Here, also, the fire direction center has computed and determined the firing data for the target located many miles behind the "enemy" lines. Since the missile has been erected and final preparations completed, the commander orders all stations to stand by for the countdown to firing time.

The firing crew takes cover in the firing pit. In order to coordinate the sequence of operations before the missile is fired, the remaining time to fire or countdown is announced over a common telephone line or "hot loop" connected to each critical station. All operators follow sets of procedures that insure complete coordination between the ground equipment and the missile as its internal components begin to warm up and prepare for the flight to the target. The commander follows the action of the operational sequence on the hot loop.

As the last few seconds are called, tension has mounted even though this is a "dry run". Finally: *FIRE*! A, B, C, D, Missile Away! And now, as plus times are chanted, operators closely monitor their meters and dials because the guidance equipment still registers this as an actual flight. After the timed sequence of the trajectory has terminated, a report is made to headquarters as to the effectiveness of this atomic blast.

The 1956 silhouettes of the three Army missile systems set the pattern for the future. They are established weapons standing guard and furnishing us with the initial experience and knowledge that will be applicable to the Army's future missile systems. END.

PRELUDE TO THE ICBM

An important and unique element in the Air Force's gigantic program to develop the intercontinental ballistic missile (ICBM) is the X-17 research vehicle, provided by the Missile Systems Division of Lockheed Aircraft Corp., Van Nuys, Calif.

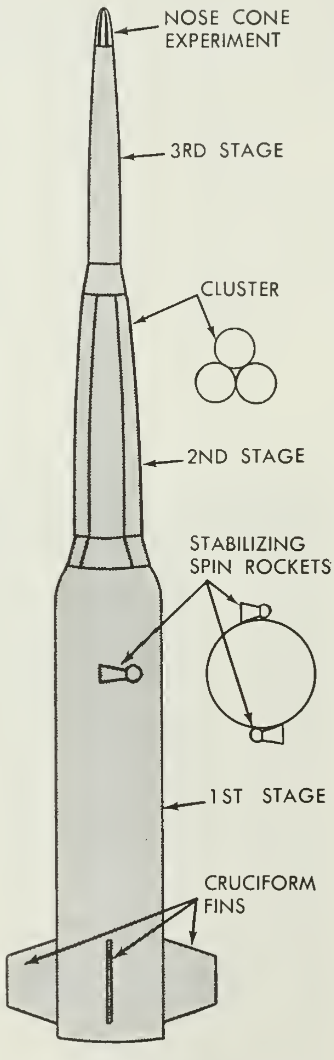
The X-17 is a lash-up of existing missile and rocket components, all of them modified to the extent necessary for the vehicle to accomplish its peculiar task. First stage is believed to be either a *Redstone* or *Corporal* liquid-propellant rocket. The former is made by Chrysler Corp., while the latter is supplied by Firestone Tire & Rubber Co. Second stage is a cluster of three solid-propellant rockets, reportedly *Sergeants*, which are supplied the Army by Thiokol Chemical Co. Third stage is a single solid-propellant rocket, also said to be a *Sergeant*.

The X-17 is now in use at Patrick AFB, Fla., to gather data on nose cone re-entry problems. First two stages carry the third into the ionosphere and detach. The third stage rises to the peak of its trajectory and, as it begins the long fall back to earth, it ignites and roars downward at hypersonic speeds. Information gathered from thermocouples and other instruments mounted in the nose section is telemetered back to Patrick during this portion of the flight.

Tremendous Speed

The existence of the X-17 was first revealed in August at the Air Force Association convention in New Orleans, although even then the designation was not revealed. Here is what Lockheed was permitted to say at the time:

"The test missile hurtles out through the earth's atmosphere at speeds far in excess of the velocity of sound. Within seconds after it is fired, the missile blasts through the sonic barrier and pierces the ionosphere—a layer of very thin air starting some 50 miles above the earth and extending to about 250 miles. Lockheed's missile scientists designed the vehicle to plunge at tremendous speeds from the ionosphere into the earths' heavy blanket of air.



Artist's drawing of Lockheed's three-stage X-17 nose cone research vehicle. Assembly supposedly is capable of reaching velocities and aerodynamic heat levels in the neighborhood of those confronting the ICBM warhead on its return trip to earth. Note the small auxiliary rockets mounted high on the first stage to spin-stabilize the finless second and third stages.

"Although the results of the project cannot be disclosed, it was revealed that the missile division's scientists and engineers are investigating atmospheric heating effects, suitability of various metals, and other important factors contributing to the design of missile nose cones."

Test results with the X-17 to date have apparently been inconclusive. The vehicle reportedly has not achieved anything like the enormous Mach numbers (18-plus) which are in store for ICBM warheads. Highest speed for the rocket assembly so far is said to be Mach 4 or 5—on the order of 2500 mph. While this may seem disappointing, it is obvious that a vehicle with as much beef as the X-17 should eventually be capable of much greater speeds.

NACA Goes to Mach 10

In this connection, it is interesting to note that the National Advisory Committee for Aeronautics has achieved some enormous velocities with relatively modest four-stage rockets at its Wallops Island, Virginia, research station. (See article, page 82.) One assembly has achieved a Mach Number of 10.4, and still greater speeds have probably been attained but not yet released. Like Lockheed's X-17 program for the USAF's Western Development Division, the NACA program is designed to secure detailed information on the problems of aerodynamic heating.

Lockheed is one of three prime contractors selected by WDD to handle the nose cone phase of the ICBM program. The others are General Electric Co. and Avco Manufacturing Co., both of which are working on competing nose cone design proposals for the ICBM. Lockheed is responsible for securing test data and passing it on to General Electric and Avco.

SOLAR POWER for spacecraft

This outstanding technical article investigates some aspects of space operations by hydrogen in high-specific impulse solar power drives. The interesting concept of pressure-stabilized spherical reflectors for water-oxyhydrogen conversion in space, and the solar power drive itself, not only seem feasible, but such a system can be constructed without too much effort.

By Krafft A. Ehricke

CONSIDERING density, specific impulse, design parameters and flight performance, light, high-specific impulse propellants for space vehicles have advantages.

Light-weight propellants are combinations of hydrogen-oxygen, hydrogen-fluorine, methane-oxygen or methane-ozone. By comparison, medium propellants are ammonia, gasoline or hydrazine with oxygen, ozone or fluorine. Heavy propellants are hydrazine with acid or with chlorine trifluoride.

In the atmosphere, and at relatively lower levels of flight performance, high density is preferable even at the expense of high specific impulse. In space where few, if any, shape requirements exist, but where high flight performance is usually required, light propellants of high specific impulse are more desirable. These propellants are liquid gases which require protection from intense solar radiation by double-walled or light multilayer tank construction. This is not difficult and also does not seriously affect the mass ratio, if the containers are sufficiently large.

Chemical space vehicle proposals have usually been based on medium or heavy propellants, mainly because supply ships were assumed to operate with such combinations. It is entirely feasible to base upper stages of a supply vehicle on light propellants.

For nuclear pile heating, hydrogen is most attractive since it is suitable for porous cooling, has a high heat content and a very high specific impulse. It does not become radioactive when passing through the pile and does not contaminate the launching site.

Finally, long-duration astronautical operations suggest considering the manufacture of hydrogen in space, using materials which may be more readily transported from the earth. The manufacturing process could be based on electrolysis of water or on the thermal decomposition of methane.

By transporting water the energy is supplied in 2.5 times as concentrated form as if the components were supplied separately.

Hydrogen-manufacturing satellites could rely on concentration of solar power in power collectors. The manufacturing process could be completely automatic, requiring only occasional human supervision and maintenance.

Solar Power Collector

Because of the low concentration of solar energy in terrestrial space, large radiation collectors are required to yield an adequate energy concentration. The resulting large dimensions of a solar-powered vehicle require very long pipelines from tank to heater and back to the exhaust nozzle. Elaborate insulation of these lines is not practical for weight reasons. Regenerative cooling is not feasible because of insufficient quantity of working fluid in view of the length of pipelines and because of excessive pressure losses in the cooling jacket.

For this reason the working fluid in a solar-powered system must operate at temperatures which are sufficiently low to permit uncooled hot-gas ducts of high-temperature material, such as Inconel X. This consideration limits working temperatures on the hot side to some 1,000°K (1,340°F).

As a result, no spectacular increase over chemical drives can be expected by any type of working fluid. By selecting hydrogen, however, a maximum of energy can be stored at the above mentioned temperature limit, because of the high specific heat of this medium. Therefore, a quite attractive specific impulse can be obtained at high expansion ratio. (Assuming an expansion ratio of 15/0.1 atmospheres and an initial temperature of T_c=1,000°K, the theoretical specific impulse is 478 sec., or about 450 sec. as practical value, considering losses in the nozzle only).

Dominant factor in the layout of the reflector system will be a compromise between reflector size and thrust power, leading to low thrust and large reflectors.

Therefore, lowest possible reflector weight is the dominant consideration in solar-powered space ships. Parabolic reflectors, because of their shape, cannot be built sufficiently light under the stresses involved. Furthermore, they tend to concentrate solar energy in too small a focal area for the heating of the working fluid.

A solution to the collector problem is the use of a pressure-stabilized spherical collector, one half of which is sprayed with silver or aluminum. The sphere can be stabilized at a very low pressure. The stress is minimized and permits a collector of record low weight. At the same time, the spherical reflector produces a larger focal area than does the parabola. More desirable heat transfer for propulsion conditions are thus achieved.

The collector sphere must consist of transparent, low-weight material. Polyester (polyethylene terephtalate), a highly transparent plastic, could be used. At 0.001-inch thickness the material has adequate tensile strength. A pressurization of 0.01 psi is sufficient under space conditions to lend adequate rigidity to the sphere proper. Perforation of such a sphere by micrometeors is not considered critical. Due to the size of the sphere, practically no reduction in reflectivity is caused by individual perforations and the resultant holes would yield only negligible pressure losses, at the volume involved.

Assuming 90 percent light transmission through the transparent portion of the collector, 90 percent reflectivity (a conservative value if silver is considered) and 90 percent efficiency in energy transmission from the heater to the expansion nozzle, one obtains an efficiency of 0.729.

Solar-Powered Space Ship

A prototype solar-powered space vehicle might consist of two collector spheres (128 ft. in diameter), with the hydrogen sphere between them. The three spheres are connected by the axis of rotation.

The Author . . .

is Chief of Preliminary Design and Systems Analysis Group Convair Astronautics Division, builders of the Atlas ICBM. He is a member of M/R's Editorial Advisory Board. This article is a condensed version of a paper presented at the IAF Congress in Rome in September.

Normal to this axis are the optical axes of the reflectors. Connected rigidly to the hydrogen sphere are the exhaust nozzle and the crew gondola, forming the thrust axis normal to the axis of rotation.

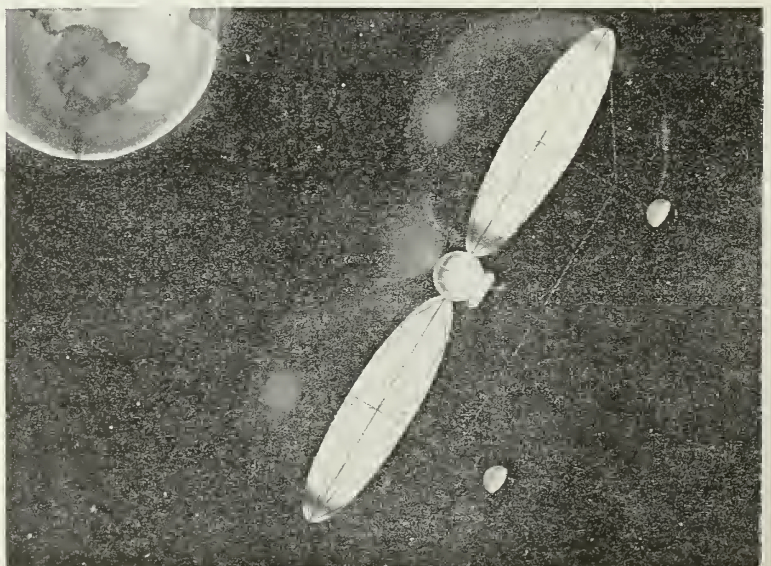
The two collectors are braced by guy wires so that they rotate together, but independently of the hydrogen sphere. The whole vehicle, being fully symmetrical, can rotate about the thrust axis (roll). Thus the thrust axis and the optical axis may be directed independently.

Hydrogen is pumped from the container to the heat exchanger and ducted back to the exhaust nozzle. Even at low acceleration aluminum cross-tubes which form the axis of rotation and which are very light would be deflected about 51 ft. at the outer ends if the structure were not properly rigged by spring-tensioned Inconel X wires.

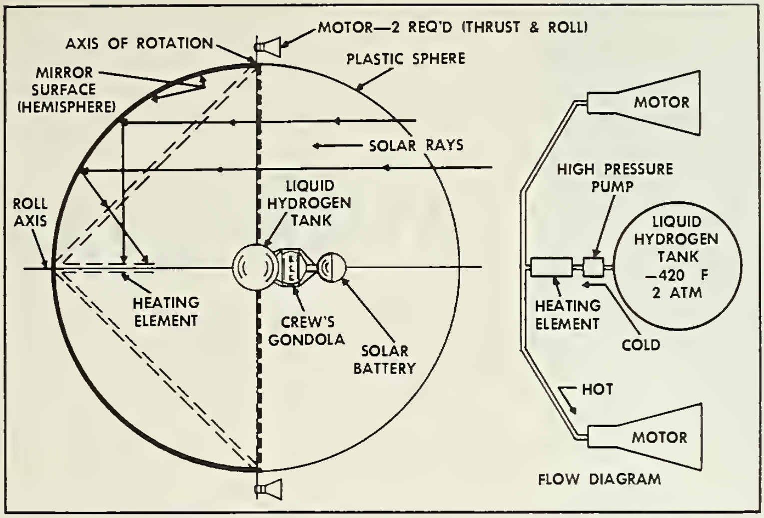
The rigging is three-dimensional and may be seen more clearly in the artist's illustration of such a vehicle. High heat-resisting material has been selected for the wires, because they may get into the path of the exhaust jet. Spring tension is necessary because of temperature variations.

The prototype carries 11,000 lbs. of liquid hydrogen. In a chemical rocket an additional 45,000 to 50,000 lbs. of oxygen would be required to produce a specific impulse of about 380 sec. under equal conditions of expansion ratio and losses in the nozzle. Instead of oxygen weight, the solar-powered vehicle uses only 1,000 lbs. in the form of radiation collectors. In this fact lies the potential logistic advantage of the solar-powered space ship over the chemical rocket for cislunar operation.

However, the solar-powered system also has a number of severe problems which make the development and operation of such vehicle anything but straightforward. Its enormous size certainly exposes it to more damage by meteors and cosmic dust. With the present lack of accurate knowledge regarding the density and density variations of small meteors and cosmic dust, it is impossible to predict how long a collector sphere of the above-described type can be maintained in adequate condition. This time, disregarding maintenance, may be disappointingly short.



Artist's conception of solar-powered spaceship.



Schematic drawing of hydrogen-powered solar-driven space vehicle and flow diagram showing motors and tank position.

On the other hand it is possible to patch up holes in the spherical polyester shell easily and the thin material coating of the reflector part can be renewed periodically.

Another problem area is the starting and operation of the propulsion system. The structure will tolerate only very low accelerations. Thus the static head in the hydrogen tank is practically negligible. It will be necessary to provide displacement bodies or solid-propellant starter rockets to produce some pressure at the tank outlet. Fortunately, the fuel consumption is very low (about 0.35 lb/sec).

Much hydrogen must be pumped into the long pipelines before the system begins to work. In the prototype vehicle the total volume of the cold tubing is about 1.1 ft.^{3}, corresponding to about 4.5 lbs. hydrogen. To this must be added the hot tubing with 15 ft.^{3}, containing about 0.3 lb. hydrogen; the resulting total is more than 13 times the consumption per second.

Friction losses in the long pipelines is another important consideration. Not much practical experience is available in this respect with hydrogen. In order to keep these losses down, low pressure flow (3 to 4 atm) is assumed in the lines leading from the tank to the center of the collector sphere. There the hydrogen enters a high-pressure pump to increase the pressure to supercritical values of 17 to 20 atm, to intensify the heat transfer.

Thus the pressure at the high pressure pump outlet has been assumed to be somewhere between 17 and 20 atm, to maintain 15 at the expansion nozzle inlet. Bubble formation in the pipelines due to the low acceleration, especially at the low pressure of the cold lines, may cause an upward revision of the pressure. Fortunately, again, the reflector must be turned away from the sun to protect the heater. In space this will keep the feeding lines exceedingly cold, thereby greatly reducing or even eliminating the danger of vapor lock.

Additional problems result from the material selection for the collector spheres. The polyester plastic has considerable tensile strength at room temperature and at least 10,000 psi at 150°C (300°F). But it will be necessary to test the material against temperature variations and, above all, against the more intense and active solar radiation before a final decision as to its application can be made.

Operationally, the crucial problem will be the dynamics of the orientation and alignment of thrust axis and optical axis, respectively. In view of the size and fragility of the structure, extremely careful balancing of the collector weights and their content is necessary. This again underlines the need for low thrust values. Even so, large moments could be produced, which adversely affect the autopilot operation; hence the accuracy of flight.

The flight mechanics of a low-thrust vehicle, such as a solar-powered space ship, differs from that of a high-thrust vehicle, such as the conventional chemical rocket. A flight under low-thrust conditions involves longer burning times and greater changes in potential energy than in the chemical rocket. Chemical vehicles in an orbit generally must have an initial acceleration of at least 0.25 *g*. Burning times are measured in minutes.

Initial acceleration of the low-thrust vehicle is four per cent or less than that of the chemical rocket. Burning times are measured in hours or days. Thus, propellant is lifted to considerably greater altitudes before it is consumed. This lifting of propellant mass is comparable to a non-isentropic thermodynamic process and, like such processes, carries a penalty in the form of an energy (gravitational) loss.

In powered ascent from the surface, minimization of the loss plays an important role and leads to trajectories which deflect from vertical direction as rapidly as aerodynamic considerations permit.

The question of what maximum collector size can be manufactured is separate from the operational value of the solar power drive. The conditions under which this drive is attractive should be established first. The author feels, however, that if the need arises, industrial research will make the fabrication of 200- to 300-ft. diameter spheres practical. These spheres would be made on earth, inflated under protection from wind loads and silver-coated.

The tensile strength of the material permits pressure stabilization on the surface of the earth. Thereafter the collector is deflated and folded for the transport into space where it is carefully re-inflated and the equipment installed.

Theoretically, the construction of solar-powered space vehicles seems within reach—indeed, the design parameters are rather simple—but it remains to be seen and done. The basic requirement for realization of the job must be experimentation with models, plus a greater knowledge of space. END.

En route to another galaxy, visualized by artists Miyazeki, Sato.

ASTRONAUTICS in JAPAN

By Frederick C. Durant III

GREAT interest in astronautics has developed in Japan in the past few years. One popular exhibition on space flight at the Inuyama Amusement Park last year pulled in an average attendance of 10,000 each weekday and 30,000 per day on weekends and holidays. The exhibition ran for only 2½ months—total attendance topped one million. For a nation of about eighty million this is rather dramatic evidence of popular interest.

Focal point of astronautical interest is the Japanese Astronautical Society (JAS). The Society's chairman is a respected and experienced radio science-commentator, columnist, author and lecturer—Mitsuo Harada. In a manner belying his age (66 years), Harada has been fascinated with the possibilities of space flight since Robert Goddard's famous Smithsonian paper of the early twenties.

Orbital vehicles over Japan.

JAS is governed by a board of nine directors and a commission of trustees numbering perhaps fifty. The directors are closely concerned with society activities such as the various exhibitions and lectures. Among them are impressive titles and affiliations, such as:

Dr. Hideo Itokawa—Professor Tokyo University; Chairman, Sounding Rocket Panel, Japanese National Committee (IGY)

Dr. I. Yamamoto—President, Yamamoto Observatory

Dr. T. Hayashi—Professor, Keio University (Physiology)

Dr. T. Asada—Professor, Osaka University (Nuclear Physics)

Dr. H. Kimura—Professor, Nihon University (Aerodynamics)

Dr. Y. Niwa—Professor, Tokyo University (Communications)

Dr. N. Nishiwaki—Professor, Tokyo University (Engineering Dept.)

Dr. T. Hatanaka—Professor, Osaka University (Astronomy)

Another director, Mr. M. Tokugawa, is one of the oldest and best known radio actors in Japan. He advises on public relations.

Since the organizational meeting of JAS in September 1953 membership has passed the 1,000 mark. About one-half of this number represents students. Much effort has been directed towards Japanese youth, describing and interpreting basic rocketry and postwar missile developments in other countries. As might be expected the directors hope that one day Japan may be able to make positive contributions to the science and technology upon which space flight will be based. In the meantime, youth is developing an interest and a desire to understand and study in related scientific disciplines. JAS attempts to further this interest on the basis of scientific knowledge.

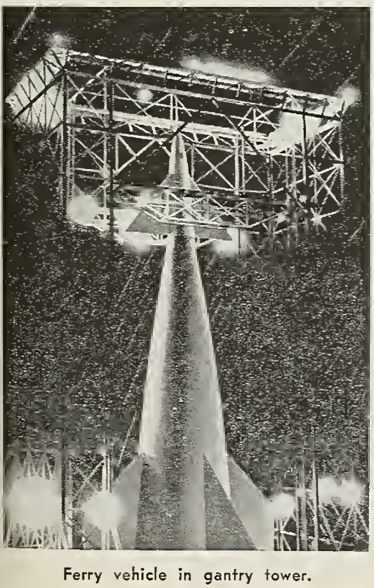
In all, six exhibitions have been arranged under the technical direction of Harada or other directors during the past three years. Contributing to the outstanding success of the Inuyama exhibit, mentioned above, was a rocket and perisphere, each some 85 feet high, through which the audience was conducted. The Chubu Nihon Press and Nagoya Railroad Company were sponsors. An exhibition was held in January 1954 near Tokyo under the sponsorship of the Yomiuri Press and the Tokyo Express

Line. Another was at Osaka in October-November 1954 under the sponsorship of the Kei-Han-Shin Kyuko Railway Company, Ltd. The major exhibit this year was at the Korakuen Amusement Park.

The Japanese Astronautical Society is actively spreading an interest in the fundamentals of space flight to youth and to the public. The popular response has been great. As pointed out in the earlier story on Japanese Rocket Research (M & R October 1956) Japan has commenced and is making rapid strides in small scale rocketry. JAS is not itself engaged in rocket experimentation.

In 1954 a rocket research society was organized by Professor Nishiwaki of Tokyo University. Known as the Rocket Kenkyu-Kai, its membership was small. Late this summer Dr. Hideo Itokawa organized the Japanese Rocket Society along the lines of the professional American Rocket Society. Industrialists, scientists and representatives of both houses of the government were present.

It is understood that this society encompasses the Kenkyu-Kai. This professional activity is essentially non-competitive with the aims of the Japanese Astronautical Society and both organizations may be expected to play an increasingly important role in future Japanese rocket development.



Ferry vehicle in gantry tower.

BRITISH MOVE AHEAD

At a recent meeting of the British Interplanetary Society in London, Prof. H. S. W. Massey of University College, London, discussed the part the British upper-atmosphere rocket *Skylark* will play in the forthcoming IGY program.

The solid-propellant rocket is designed to reach about 100 miles altitude. The British program is to be a selective rather than an all-embracing one, and each item chosen for investigation will be treated very thoroughly. Upper atmosphere temperatures and winds, for example, are to be studied by means of firing grenades from the rocket at regular intervals, measuring the time which both flash and sound require to reach the ground.

Difference in mean sound velocities from various heights will give a measure of the variation of temperature, and the angle at which the sound reaches the ground microphones will allow the speed of the wind at various altitudes to be calculated. This is not a new technique, having been previously used by U. S. Naval Research Laboratory, but a refined version of it will be applied.

A more spectacular experiment is the releasing of metallic sodium at about 40 miles altitude at twilight. This will form a luminous cloud, the examination of which by spectroscopic means will give local temperatures. The experiment was first suggested by Prof. Bates of Belfast University, and has already been successfully carried out at White Sands. However, a better method of dispersing the sodium by means of thermit has been developed at Belfast, and this technique will be used in the British experiments.

•

Britain's Largest

Royal Aircraft Establishment's Westcott, England, propulsion center has designed and built a 50,000 lb. rocket. Combustion chamber and nozzle are of the skin-cooled type made from thin-gage 18/8 stainless steel with longitudinal ducting for kerosene fuel coolant.

The spherical combustion chamber and divergent nozzle form an integral unit welded together from 32 narrow longitudinal segment consists of two thin blades—like a cavalry saber in shape—which are superimposed and edge-welded together, with a further seam weld along the centerline for most of their length. To the front of the blades (the saber "tip") is a thin stainless-steel tube, which is used to pump fluid into the assembled blade and swell it into a mold, so giving the blade a "quilted look" and forming it into two longitudinal ducts. The "tip" of each blade for about nine inches is perforated with microscopic holes on one side, the inside after assembly.

There are two types of blade; one is hollow throughout its length, the other has a barrier between the perforated tip and the longitudinal ducts. When assembled, the blades are welded alternately. The roots, which form the lip of the divergent nozzle, are joined by a circumferential passage and the forward part at the maximum circumference of the combustion chamber by an external duct welded to it.

Kerosene is delivered to the duct, from which it passes up the barred blades, through the lip duct and down the adjacent blade to squirt into the chamber. LOX is injected from the base of the chamber through the holes in the barred blades. The layout segregates the kerosene and LOX until it unites in the chamber. Combustion pressure is 500 lbs/sq in. and the kerosene is therefore pumped into the hollow skin at 800 lbs/sq in. The Wescott unit is stated by the Ministry of Supply to be the largest bi-propellant rocket to be designed and made in Britain.

International News

By Anthony Vandyk

After working under wraps for several years France's Ouest-Aviation (formerly SNCASO) has disclosed details of its activities in the guided missile field. Company has confirmed that its *Trident* research aircraft is actually the prototype for a surface-to-air missile. The first "pilotless *Trident*" will start its test program shortly. The French nationalized aircraft company also has developed a missile "to complete and perfect the efficiency" of the *Vautour* twin-jet bomber's armament. Ouest-Aviation also has under development various types of strategic missiles with "a completely new" navigation system. Most of Ouest-Aviation's missile work has been financed by the company on a "private venture" basis.

•

What's wrong at Britain's missile range at Woomera in the Australian desert? Chapman Pincher, the highly respected science reporter for the LONDON DAILY EXPRESS, estimates that the range is costing about $30 million a year to run but only $3 million worth of useful work is coming out of it. One reason for the slow progress is that the difficulties of using a range 12,000 miles from home base were badly underestimated. Furthermore Woomera was set up with the understanding that British missile firms would transfer much of their work to Australia which would become the arsenal of the British Commonwealth. The companies have refused to uproot themselves and there is no engineering industry in Australia to support a project of this size.

•

Japan expects to build its first tactical guided missile about the end of this decade. Meanwhile the Defense Agency is stepping up its program for research work on missiles. A missile experimental unit is to be established within the agency's Technical Research Institute. For fiscal 1957 this unit will have 600 million yen at its disposal, according to the present budget program. Meanwhile, Japan is well advanced in experimental rocket construction. The first firing test of the TMB (Test Missile B) rocket is scheduled for this month. The TMB is manufactured by Shin Mitsubishi. It uses a rocket motor built by Fuji Precision Machinery and a guidance system supplied by Mitsubishi Electric Co.

•

First official mention that British defense policy has abandoned liquid oxygen as an oxidant for manned vehicles has come from S. Allen, Chief Engineer of Armstrong-Siddeley Motors' Rocket Division. He told the Royal Aeronautical Society that "liquid oxygen would probably be an unsuitable oxidant for defensive weapons because such weapons could not be kept ready for instant use." For offensive weapons, liquid oxygen is quite suitable, specific impulse being of major importance in reaching extreme altitudes—even at the expense of some engine weight—and, therefore, great range, he added. Allen noted that his company's Screamer 3,000-9,500-lb. thrust rocket motor differs from Reaction Motors, Walter and SEPR units in being single chambered and truly controllable (by varying the propellant supply).

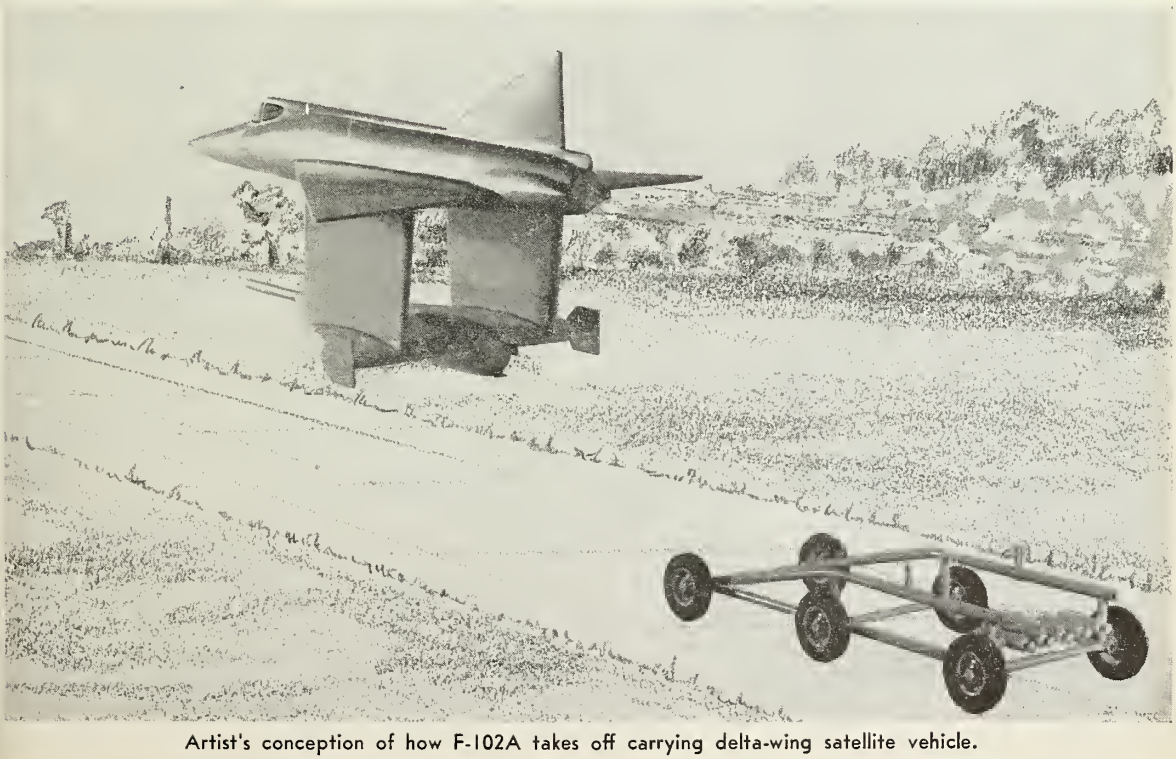
SATELLITE LAUNCHING from an F-102

By Aurelio C. Robotti

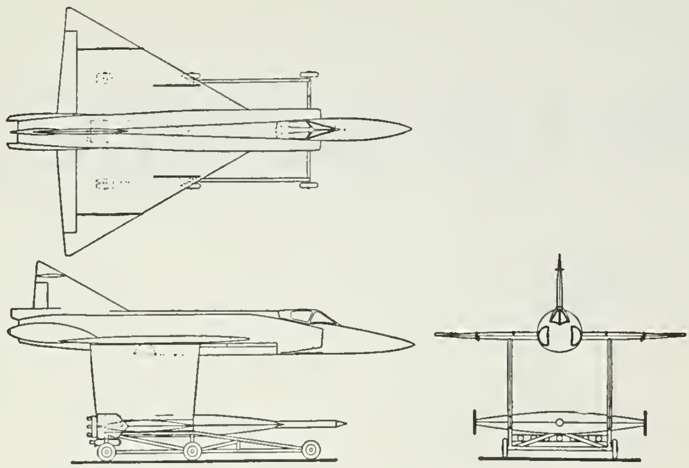
THE concept of bringing a small satellite into orbit by the airplane-launching method is as inexpensive as it is feasible. Airplane-launched satellite proposals to date have been hypothetical and rather difficult to realize because the hardware, as well as the scope of the proposals, have been too gigantic and complex.

However, the feasibility of carrying a two-stage, modified BUMPER type vehicle (A-4 plus WAC Corporal) to 42,000 feet launching altitude by a current airplane, such as a Convair F-102A fighter, has merit. And, furthermore, such an experiment is indicative of what can be achieved when considering new high-energy propellant rockets. When launched at an altitude of 42,000 feet, even the old-fashioned BUMPER will easily reach orbital velocity.

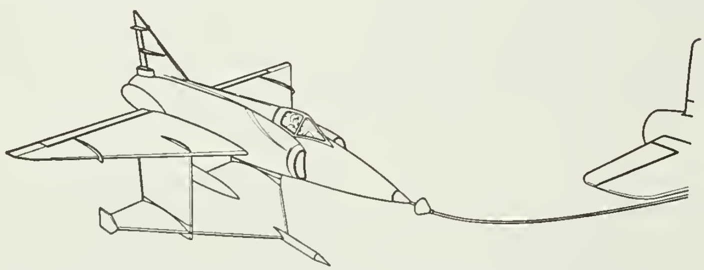
The *Bumper* was launched from White Sands in 1949. At first-stage burnout the altitude was 20 miles. The WAC *Corporal* came into action and reached a maximum velocity of 6,800 feet per second. The



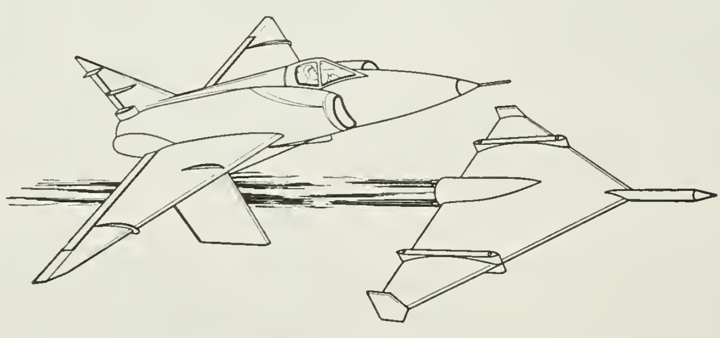
Artist's conception of how F-102A takes off carrying delta-wing satellite vehicle.



General three-view layout of F-102A with delta-wing Bumper type rocket vehicle mounted underneath. Takeoff dolly is fitted with JATO units for extra boost.



F-102A takes off with very little fuel. Rocket vehicle and plane are refueled at altitude. LOX might be dropped as oxidizer because of refueling hazards.



At 42,000 feet pilot releases satellite vehicle. He ejects struts and returns to base. WAC Corporal or similar rocket will be brought into orbit carrying payload.

maximum altitude was 242 miles.

Assuming that a *Bumper* type vehicle is carried to 42,000 feet and launched with an initial velocity (the velocity of the F-102A at moment of launching) of 450 feet per second, a maximum speed of 8,350 feet per second, instead of 6,800, will be obtained for the second stage WAC *Corporal*, and a maximum height of 367 miles instead of 242 miles will be achieved, i.e. an increase of about 50 per cent.

If the *Bumper* is lifted to 42,000 feet with a residual velocity —at that height—of 450 feet per second, by means of a booster, and if the climb is carried out in the most economical way, the booster itself would have to develop a total impulse of 2,600,000 lb. sec. Specific impulse of 185 sec., and a gross weight of about 20,000 pounds are encountered.

The *Bumper* would be transformed into a three-step rocket whose first stage would weigh ten tons. This first stage is represented by the delta-wing F-102A.

Considering the total weight of the *Bumper* and the performance of the F-102A, it is easily understood that the plane could not take off with an overload of more than 12 tons. Furthermore, it would be practically impossible to obtain a reasonable hook-up device between the two structures.

Delta-Wing Rocket

To solve these problems, it is necessary to give the rocket a lifting feature—possibly a delta-wing with a base and a height of about 27 feet. The *Bumper* would then have a total weight of 27,000 pounds and a wing load of 60 pounds per square foot. The WAC *Corporal* rocket will be partially lodged in the nose of the delta-rocket.

The approximate weight distribution of the A-4 in the original

The Author . . .

is a recognized aeronautical engineer and a key Italian rocket personality. He is Technical Consultant to Italy's well-known Fiat concern. This article is based on a paper presented by the author at the 7th International Astronautical Congress.

Bumper configuration was:

Structures	827.5	pounds
Engine	191	"
Pumps	150	"
Propellants	82	"
Servo mechanism .	113.5	"
Ethyl alcohol and water	1630	"
Liquid oxygen	2432	"
Total	5426	pounds

A delta-winged A-4 has the same distribution of weights, spaced cylindrically in the middle of the structure.

The delta-winged A-4 can be attached to the "mother" plane by means of two vertical frames, linking the wings of the plane to those of the rocket. The rocket rests on a takeoff dolly which will remain on the ground when the plane takes off. The tanks of the A-4 are empty, which means that the whole structure has the modest average wing load of 28 pounds per square foot.

At a suitable altitude a tanker will refuel the A-4 by pumping into its tanks 1,200 gallons of fuel and 1,400 gallons of oxidizer.

At 42,000 feet the pilot will ignite the first-stage rocket engine and, as soon as the thrust has reached its proper level, will actuate the launching of the missile and start its teleguiding. The two-step rocket, under the action of its guidance and graphite fins, will bring the vehicle into the trajectory that will take the rocket into an orbit around the earth. Once the separation has been effected, the pilot will jettison the frames joining the rocket to the plane and return to his base.

This proposal is an invitation to the study of the general problem of carrying large rockets to high altitude by means of aircraft.

Most obvious aeronautical problems that would be met in applying this proposition might be:

a) **Aerodynamic interference** between the planes of the biplane configuration. A biplane with wings of aspect ratio lower than 1 has no precedent in the aeronautical proxis and therefore represents a case to be wind tunnel tested.

It is certain that by sufficiently increasing the distance between the planes, the danger of interference is eliminated. This danger is especially serious at takeoff, when the increased angle amplifies the mutual disturbance of the two planes. However, takeoff is the only critical stage of the flight. The climb can be performed at a low angle.

b) **Flight refuelling** is currently used and does not present problems, even in a case where two propellants are involved.

c) **Condensation** on the rocket tank walls creates a problem. In the A-4 alcohol and liquid oxygen were contained in tanks inside the missile. In the delta-rocket proposed here, the use of the body covering plates as tank walls might save weight. However, it is likely that the atmospheric humidity will condense on the outside of the tank walls, producing an ice formation during the climb to 42,000.

Obvious remedies are two: either to employ an oxidizer different from liquid oxygen or to insulate the tank walls. A reverse problem, that of the fuel condensation on the inside face of the tank walls must also be considered.

d) **Takeoff gear.** No serious difficulties are involved in making a takeoff gear that remains on the ground when the rocket-carrying F-102A takes off. The same gear can be accelerated by a number of JATO rockets.

e) **Maneuverability.** Of course, the tail surfaces of the F-102A have not been designed to control the biplane constellation discussed here, but the biplane does not have to carry out abnormal maneuvers.

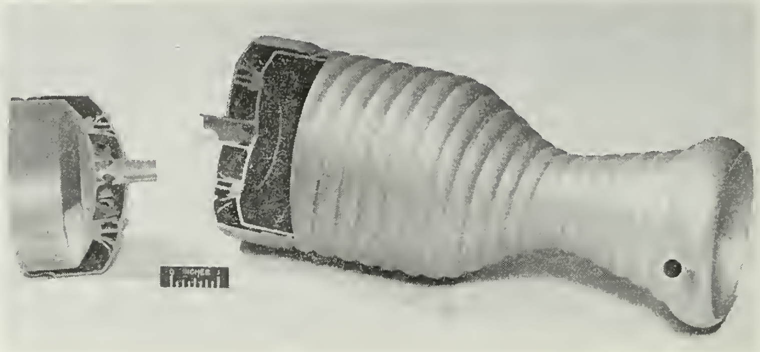
f) **Supporting frames.** The triangular design of the two wing planes offers good possibilities for a strong joint of two interplane struts. All vertical stresses rest directly on the takeoff gear through two strong compression ribs of the lower plane. Naturally, the struts present one of the most important structural design problems, since they have to make possible the launching of the rocket.

It seems obvious that aircraft can be used advantageously as carriers of orbital payloads. It should be emphasized also that the vehicle proposed here may take off from conventional air strips. END.

NEW ROCKET FABRICATION METHOD

Experiments have been conducted with a jacketed rocket combustion chamber that was fabricated by hydraulic forming from sheet metal, according to NACA.* Runs with these combustion chambers have been made at over-all heat-transfer rates of 2.5 BTU per square inch per second with water cooling and also with ammonia as a regenerative coolant.

New fabrication method not only provides chambers with thin walls for combustion and cooling research, but also affords relatively light-weight chamber structure, NACA reports.



Thrust chamber manufactured by hydraulic forming.

Engine involved has a nominal thrust rating of 1,000 pounds at a chamber pressure of 300 pounds per square inch. Thrust chambers of 1,000- and 5,000-pound thrust with operating chamber pressures of 600 pounds per square inch have been made by the same technique.

Coolant jacket comprises an inner and outer sheet-metal skin. Outer skin is shaped to form three or four helically wound coolant passages. In the engine illustrated these coolant passages lead directly into the rocket injection head, thus providing for regenerative cooling of the chamber.

For engines operated at a chamber pressure of 600 pounds per square inch with regenerative cooling (jacket pressures of the order of 800 lb/sq. in.), it was necessary to reinforce the outer shell to prevent ballooning. Such reinforcement was accomplished by wrapping the chamber with several layers of fiberglass cloth, bonded with a polyester resin glue. External valleys between adjacent cooling passages were first filled with a low-strength filler material.

For research purposes, where engine weight is not a primary consideration, the chamber assembly is welded to a flange to permit attaching an injector and to facilitate mounting on the thrust stand.

Thrust chambers fabricated by the hydraulic-forming method have been used in a number of experimental programs. Propellants used include liquid oxygen and ammonia, liquid oxygen with hydrocarbons, and high-impulse propellant combinations. For liquid oxygen with either ammonia or hydrocarbons as fuel, regenerative cooling as well as water cooling has been used. Run duration ranged to 60 seconds.

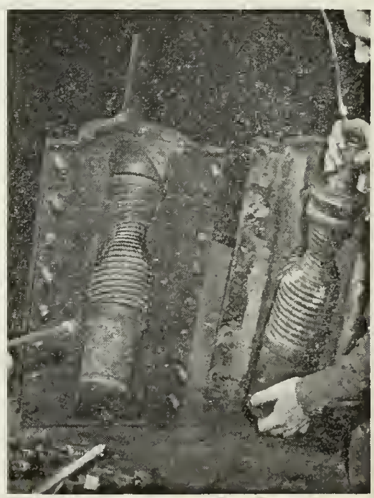
The characteristic length was usually between 30 and 40 inches. In all cases, nozzles designed for expansion to atmospheric pressures were used.

Time and Cost Savings

These engines were proved to be rugged and durable in the tests, according to NACA. Over-all heat-transfer rates above 5 BTU per square inch per second were measured with high-impulse propellants in a 1000-pound-thrust engine without failures. Occasional burnouts were experienced. Some of these burnouts occurred at the throat of the engine. Such burnouts could generally be attributed to the injector design; that is, similar burnouts were experienced with substitute chambers equipped with the troublesome injector. Heat-transfer rates with such injectors have usually been very high.

For the fabrication of more than one rocket combustion chamber, the new technique has resulted in time and cost savings over the contour machining methods that it replaced. The total time for one chamber is about equal to that required for an equivalent machined rocket chamber. But, an additional chamber can be made with a completed die in 10 per cent of the time required for the first chamber.

Thus, it is clear that when several chambers are made, the cost per chamber is greatly reduced. Material costs are also lessened. The procedure produces very little scrap metal. Exclusive of the material in the mandrel and die, 60 per cent of the starting metal ends up in the final chamber assembly.



Removal of 1000 lb. thrust chamber fror lie.

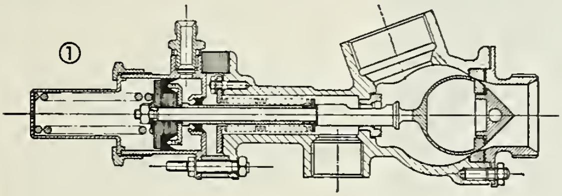
* Technical Note 3827, Experimental Investigation of a Lightweight Rocket Chamber, by John E. Dalgleish and Adelbert O. Tischler.

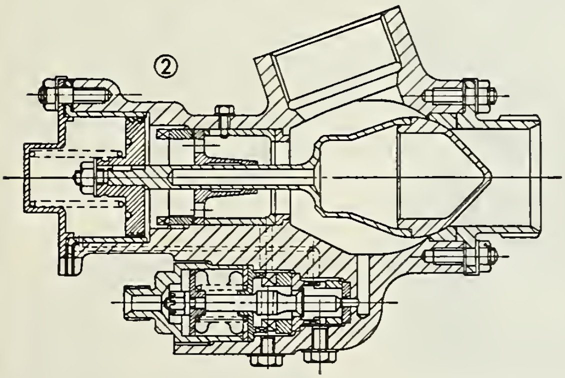
BRITISH LIQUID ROCKET VALVES

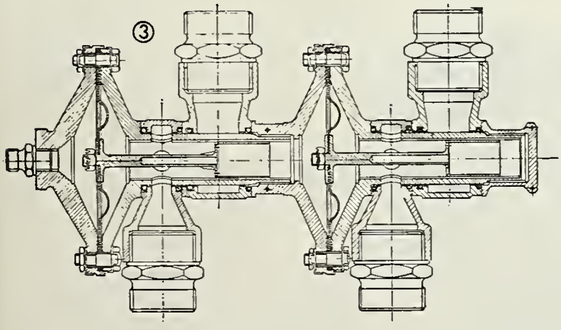
Four outstanding main types of valves used on Britain's *Screamer* rocket, suction valves, stop and by-pass valves, pressure operated air valves, and control valves, represent proof British engineers have accomplished a great feat.

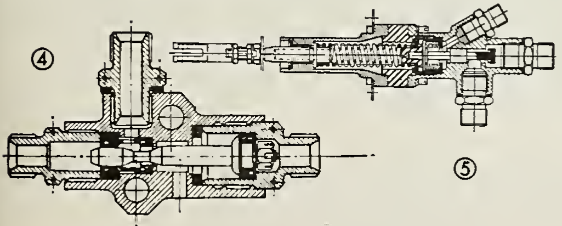
Details on these valves have been revealed by S. Allen, Chief Engineer, Armstrong Siddeley's Rocket Division.

In a R.A.S. report he points out suction valves originally were kept to a minimum in size to give a small resistance to flow. This gave the head of the valve the rather long travel of 0.95 in., and for this reason a long stack of bellows had to be used.









The main *stop valves* incorporated by a *by-pass valve* allowed the pipe lines and valves to be cooled before starting. Allen terms the liquid oxygen stop valve "typical", the original design is shown in Fig. 1. Valve head was operated by gas pressure acting on a bellows. By-pass valve was carried on the stem of the stop valve, passages being provided by flutes. By "masking" the by-pass valve a certain amount of cushioning was achieved during opening of the stop valve. As the stop valve opened, the by-pass valve closed.

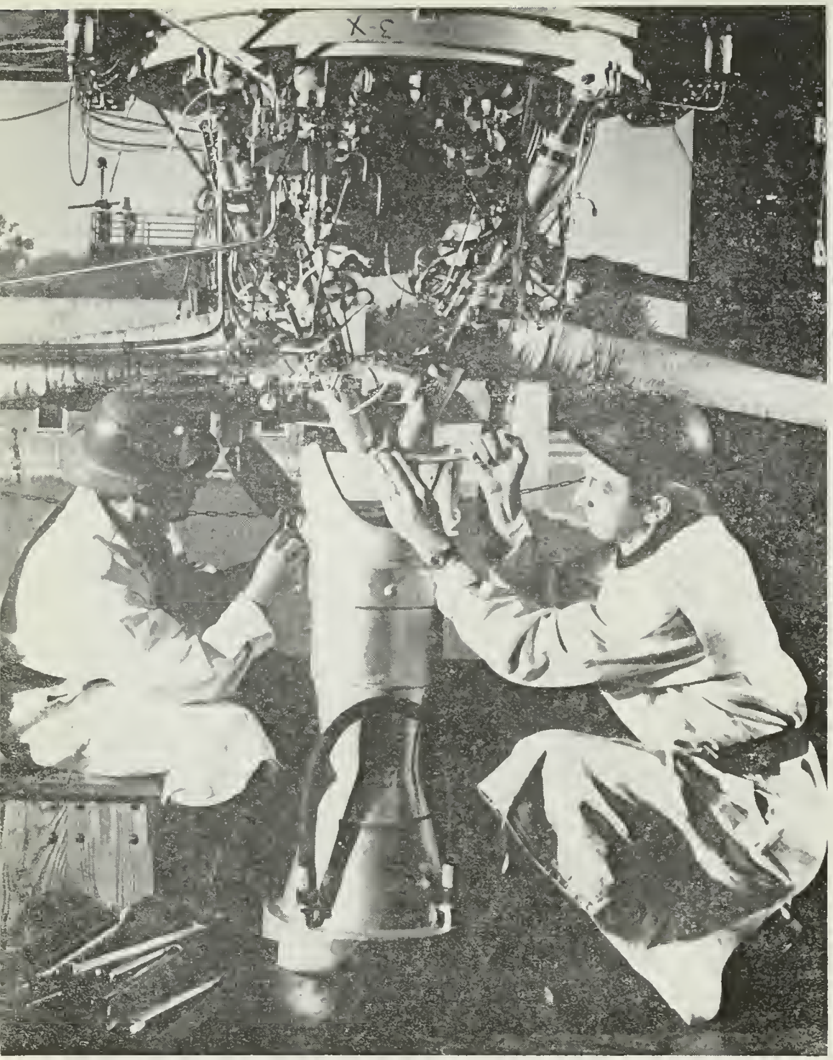
It was necessary to apply a large force to the valve head to move it against a large pressure difference. When the valve opened, the pressure difference disappeared and the force caused the valve to accelerate so rapidly that stress waves were set up in the bellows, causing rupture. For these reasons a different type of valve was developed, as shown in Fig. 2. In this unit a small bellows-sealed servo valve is used to control the pressure behind the main operating piston. When the pump primes, fluid is delivered against a comparatively small back pressure through the by-pass. Both sides of the operating piston are subjected to this pressure; the valve is held on its seat by the force of a "fail safe" spring and by force given by the pressure and area valve head.

Small valves used to control the flow of propellants to the igniter and gas generator were of similar design to that of the pilot portion of the valve illustrated in Fig. 2.

To control the gas pressure necessary to open the various valves, a design of pressure-operated gas valves was developed, as shown in Fig. 4. Signal pressure moves piston against the spring until the cone forming the back of the piston registers on a seat giving a positive seal. This moves the necked portion of the spindle in line with a lip seal, thus providing a passage from the pressurized gas storage to the operating cylinder of the valve to be used.

The *pressure balance valve*, which is illustrated in Fig. 3, consists of two diaphragms each carrying a ported piston. Oxygen pressure acts on one side of the first diaphragm and water pressure on the other. Excess or deficiency of water pressure over oxygen pressure causes the ported piston to slide in its barrel adjusting water pressure to the oxygen pressure by altering the area of the ports.

Thrust variation is obtained by variation of the turbine speed by means of controlling the flow of propellants to the gas generator. LOX flow to the gas generator is controlled by the pilot's throttle valve illustrated in Fig. 5. This essentially is a *variable datum reducing valve*, the datum being altered by compressing the spring by means of a jack operated by pilot's throttle lever.



VANGUARD
READY

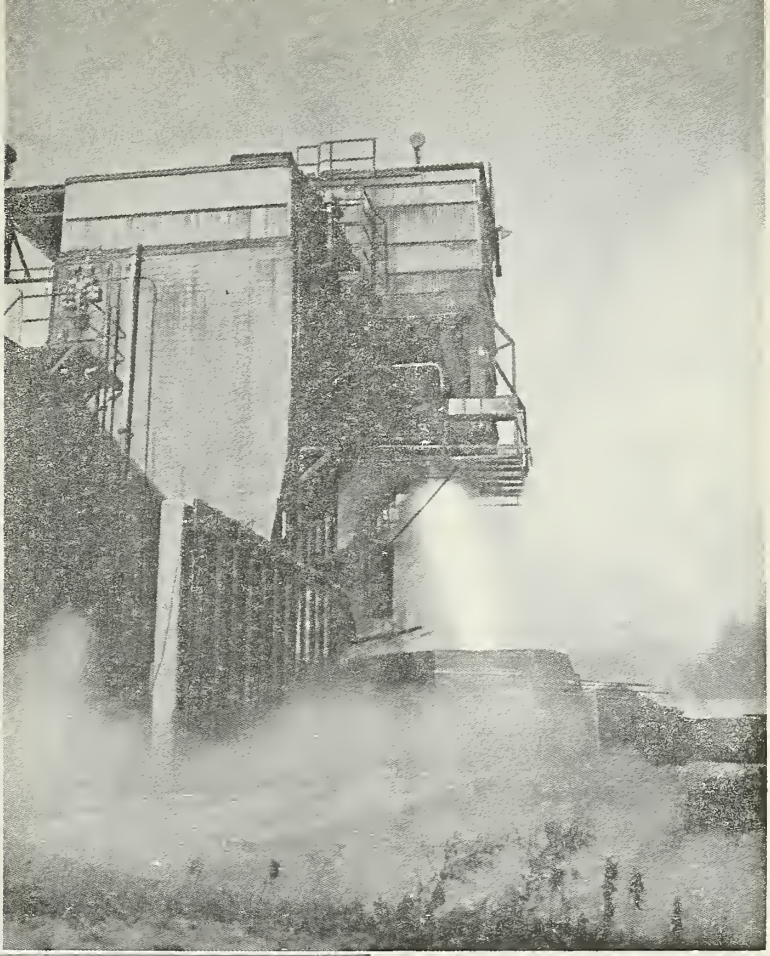
First *Vanguard* main-stage engine has been shipped from General Electric Co., Evendale, Ohio, to Martin, Baltimore. For about one year GE engineers have conducted exhaustive tests leading to numerous modifications. Early burnout problems have been licked, and the engine now is ready for production, with only minor alterations. This picture clearly shows control and pump system details. The two engineers are adjusting the gimbal mounting.

General Electric *Vanguard* main-stage engine developers discuss features of the re-designed injector head, heart of the powerplant. From left to right, Louis Michelson, Rocket Engine Section Manager; George L. Macpherson, X405 Project Manager; Benson Hamlin, Special Assistant to Rocket Engine Section Manager; and Fred I. Brown, Rocket Engine Sales Manager. *Vanguard* engine combustion chamber on table.

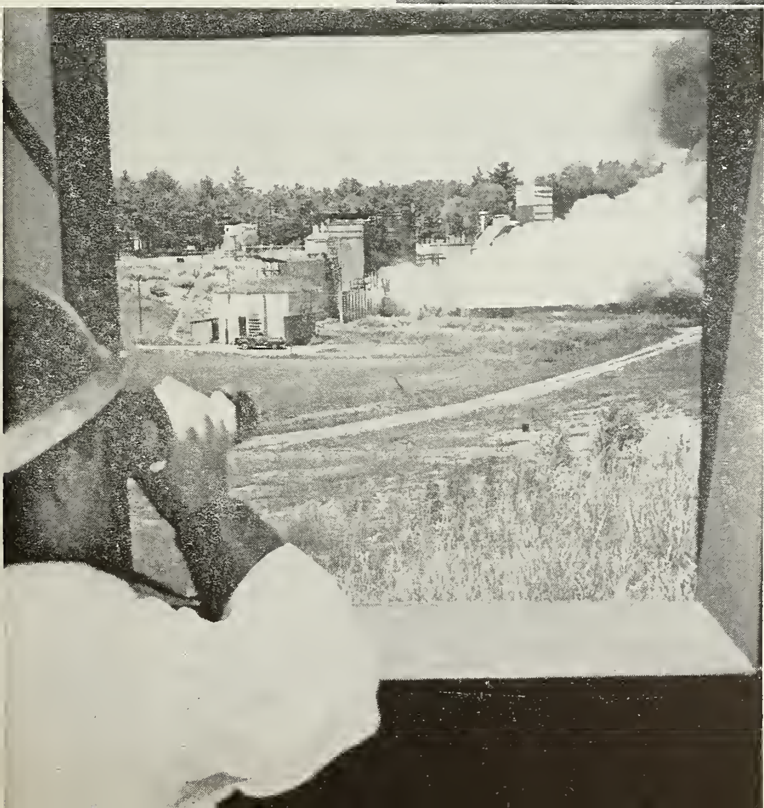
Technicians in the firing station at countdown. Original requirements called for 141-second burning period. At recent tests the engine has performed perfectly, burning time having exceeded 150 seconds. With a thrust yield of 27,000 pounds, the *Vanguard* first-stage engine will propel the satellite vehicle to a velocity of 4,000 miles per hour.

ENGINES

TO GO



GE's *Vanguard* engine under static run at company's Malta test station. Engine designation is X405. Because of early burnout problems, injector head has been redesigned; gasoline was dropped as fuel. Propellant combination used is special kerosene mixture with liquid oxygen as oxidizer.



Control engineer looks at engine through observation window at remote firing station. Developed by GE's Flight Propulsion Laboratory Dept., Evendale, Ohio, the powerplant now is scheduled to go through evaluation tests both by Martin, Baltimore and the Navy. Several actual flight tests will be conducted at Patrick AFB later. The first-stage engine is designed to carry the 11-ton *Vanguard* vehicle to 36 miles altitude.

How to boost RESEARCH and DEVELOPMENT efficiency

By Commander George W. Hoover, USN

RESEARCH and development throughout the country, although certainly productive, is capable of far more positive results. This can be achieved—not necessarily in the form of faster progress—but by making larger steps with fewer blind alley encounters.

Research and development has been too closely associated with the "ivory tower" concept, or with the idea that there is something strange and mysterious about trying to solve a difficult problem. There is also the idea that unsuccessful attempts to solve a problem are positive results rather than negative because in the process one more wrong approach is eliminated. This attitude is not only expensive but indicates poor planning.

There is considerable discussion about the wonderful progress that has been made in aviation in the last 35 years. In some branches this progress is not given enough credit. In others it is questionable.

These statements are not made to criticize the efforts of engineers, but to point out that the growing complexity of our aircraft and missiles indicates that our methods themselves need a little researching. There are many factors contributing to limited productiveness, but a predominant one is the influence of *inhibited thinking*.

Inhibited thinking is a scientific sickness which stems from being so saturated in knowledge that we "cannot see the forest for the trees." However, inhibited thinking has many known causes and is therefore a curable disease. One cause of this knowledge-bound thinking is the lack of imagination and the resultant loss of foresight.

Constant fear of ridicule from colleagues when there is any deviation from the accepted path or theory is another factor.

The overwhelming desire of individuals to become inventors also must be considered. In addition to the pleasant thoughts associated with receiving royalties and possible promotion, there is the inclination of an inventor to press his own ideas—sometimes to the exclusion of facts.

Furthermore, there is the threat of deadlines to be met and the continuous drive to cut costs. This is an emotional effect brought about by management's subtle reminder—no successful bids, no need for engineers.

The last and perhaps most important cause of inhibited thinking is the methodology employed in carrying out a major part of our research and development.

Fundamental Terms

Projects are started often without making a complete statement of the problem. This results in a partial solution which we justify by calling it a compromise.

Therefore we must think uninhibitedly and seek an adequate solution by stating the problem in its fundamental terms. To think in this manner we must treat each problem as a completely new one.

Many engineers today consider such tactics dreaming. Engineers seem to be objective in their thinking with their feet solidly on the ground. This is certainly a very healthy attitude if their feet don't get stuck too deeply in the mud.

Let us first define research and development and then try to apply this scientific approach to the problem of aircraft instrumentation.

Research is the systematic analysis of a problem consisting of stating the problem in its fundamental terms. Development is the application of these physical phenomena into practical and adequate solutions, not just modifications of an old idea.

By establishing a dual effort, the research is where the uninhibited thinking must prevail with a carry-over to the more practical aspects of the development. Such an approach requires two completely separate groups: one to determine the path, the other to follow it—both working together.

In applying this approach to the instrument problem, for example, we first state the overall problem. Fundamentally the instrument problem involves much more than just the design and development of a group of instruments for installation in a missile control station or an airplane cockpit. The problem in fact is one of creating a man-machine system, the efficiency of which is a product of both factors. The machine we can re-design, the man we cannot. Therefore we must start our analysis with the man.

Of all the sensory systems vision is the strongest in effecting orientation. This being true, it is essential in the man-machine problem to create a display which will not only be adequate but compatible with the other sensory systems.

To bring about a proper display it is necessary to sense certain phenomena. These data must be computed to produce the display.

Display Requirements

In order for the man to respond to the display a control system must be furnished. In addition there must be a means of communication both internally through signal transmission and externally through radiation.

The overall problem—and this applies to almost every type of research and development—falls into five areas: (1) Display, (2) Sensing, (3) Computation, (4) Control, and (5) Communication.

In the case of display for aircraft the primary question to be answered is simply "What does the pilot need to have displayed?"

There are actually two major requirements. These are position in space and geographical position.

Each of the two areas must be further divided into three types of display:

1. Orientation, which tells the man what he is doing.
2. Director, which tells the man what he should be doing.
3. Quantitative, which tells the man how he is doing.

In order to determine the details of these three types of display it is necessary to make a complete analysis of the Information Requirements. The operators must be interrogated to establish the fundamental information necessary to accomplish the task without interpolation or mental computation.

For example, during an air interception the pilot needs range information. The fire control engineers present this information in the terms in which they always define range—in miles and yards.

However, pilots need range data in order to know when to lock on, when to fire the gun or rockets and when to break. Fundamentally range must be indicated as a directory type of presentation to eliminate remembering at what ranges to lock on, fire and break away.

When the questioning reaches a point where the operator states that without data he cannot carry out the task, then X data is the fundamental requirement. These information requirements must be established for each phase of the task from beginning to end.

The next task is to select an adequate yardstick to determine the display requirements. In most instances the yardstick is merely that which is most natural. In the case of orientation, the visual world is the yardstick because pilots do a good job of flying when they have access to the visual world.

By using the visual world as our yardstick it is relatively simple to determine what causes us to react as we do throughout the various phases of flight.

The proof here for a display is by axiom rather than by evaluation. If it is true that we orient ourselves by our perception of the visual world it follows that our display must be adequate if it reproduces the same cues apparent in that world.

Sensing certain phenomena is essential to producing any display. In the past we have chosen to divide the problem into specific types of instruments such as flight instruments, navigation instruments, fire control, landing, engine, etc. As aircraft became more advanced, it became fashionable to include more than just the instrument and refer to the development as a "system." These systems each included sensors, amplifiers, computers, indicators, etc. and were developed for a specific type of aircraft. In stating the overall problem, it appears that each mode is in reality only a repetition of the other. If we solve one, we solve them all.

For example, the only real difference between landing and takeoff is the application of power. The equations are the same. The only real difference between rendezvous and air interception is that in the latter case we release the armament. The only difference between takeoff and rendezvous is the plane of operation. In the final analysis all modes of flight are only variations of navigation.

Necessary Sensors

From the information display requirements we can determine the following necessary sensors.

1) Inertia, 2) Air Density, 3) Temperature, 4) Fuel Availability and 5) Electromagnetic Radiation.

All of the equations related to the flight of any aircraft can be solved by using these five sensors with respect to time. Navigation is a function of velocity which is a function of acceleration. Fuel management is a function of fuel available with respect to time. Position, obstacles, weather, and landing path are some of the information requiring the use of some form of electromagnetic radiation. They are all variables in the equations of navigation and orientation and therefore fit all modes of flight.

Simple Computation

Further analysis of the display requirements establish the variations of the basic equations of motion which must be computed. Only the basic equations must be solved with varying rates and total time the only difference between modes of flight.

An example of this is the difference between rendezvous and air interception. In the rendezvous mode the rate of closure gradually approaches zero whereas in strike it is maintained at some constant optimum rate. The total time in rendezvous is longer than interception. The equations of flight path are fundamentally identical.

With these requirements our computer becomes a rather simple device for solving a relatively simple equation continuously with varying rates and time.

In summary it can be stated that when the fundamental requirements of any problem are established the solution to the problem becomes apparent.

If engineers will take the time to state the problem at hand in its fundamental terms, if they will stop inventing and seek a completely adequate solution, if they will look at the problem not as an entity in itself, but as part of a complete system, if they will work with operators and human engineers as a team, they will be thinking uninhibitedly. Then progress will be made, not in smaller increments, but in a continuous series of major breakthroughs.

END.

[Opinions expressed in this article are those of the author and are not to be construed as official or as reflecting the views of the Navy Dept.]

What Guides the Vanguard?

Minneapolis-Honeywell Builds Complex Gyro Reference System

By Henry P. Steier

A new milestone in the use of the gyroscope will be attempted when the *Vanguard* earth satellite vehicle takes off into space.

Job assigned to the gyroscope in this case calls for guiding an 80-foot rocket vehicle weighing 21,978.5 pounds to a very accurate orientation with respect to the earth.

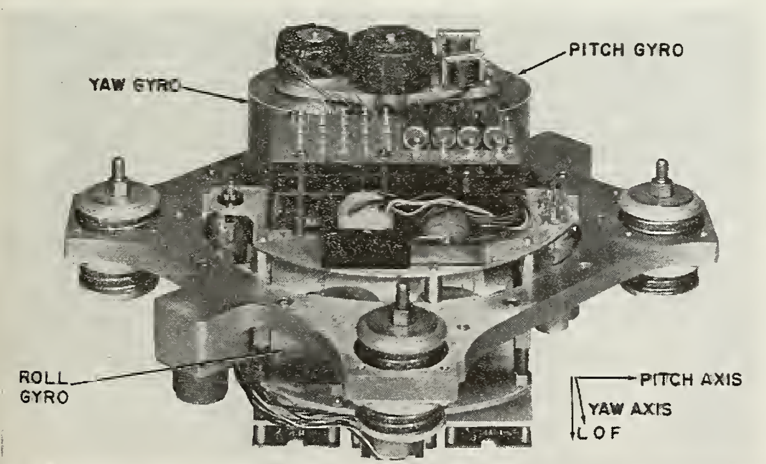
From a vertical position on the ground at takeoff to a horizontal position at about 700 miles from the launching point, a guidance reference system containing three gyroscopes and astrionics gear will tell *Vanguard* what to do and when to do it.

Chosen altitude for the satellite to be released from *Vanguard* vehicle is 300 miles. At the point where the satellite is released the third rocket stage that carries it must be oriented in pitch to an accuracy of 0 degree with respect to the tangent of the earth if the orbit is to be circular. If it is to be elliptical with a 300 mile perigee and a 1500 mile apogee, orientation must be within 2.9 degrees.

The "brain" that generates the commads to direct this imposing orientation job is being built by the Minneapolis-Honeywell Regulator Co.'s Aeronautical Division.

First of the *Vanguard* guidance reference systems has come off a pilot production line at M-H. It will probably be used in one of a series of preliminary rocket systems for test purposes.

Tests are expected to start in a few months at the Martin Aircraft Co.'s *Vanguard* test station being built in Florida. According to C. C. Furnas, Secretary of Defense, Research and Development, the program as it now stands calls for six preliminary rocket systems for test purposes to be followed by six complete rocket control and guidance systems for launching satellites.



Gyro reference system manufactured by Minneapolis-Honeywell for VANGUARD. Vector diagram in lower right corner shows direction of the three axis references. Shock mounts are located at the corners of the platform. Socket lugs for electron tubes can be seen near the center cut-out of the platform.

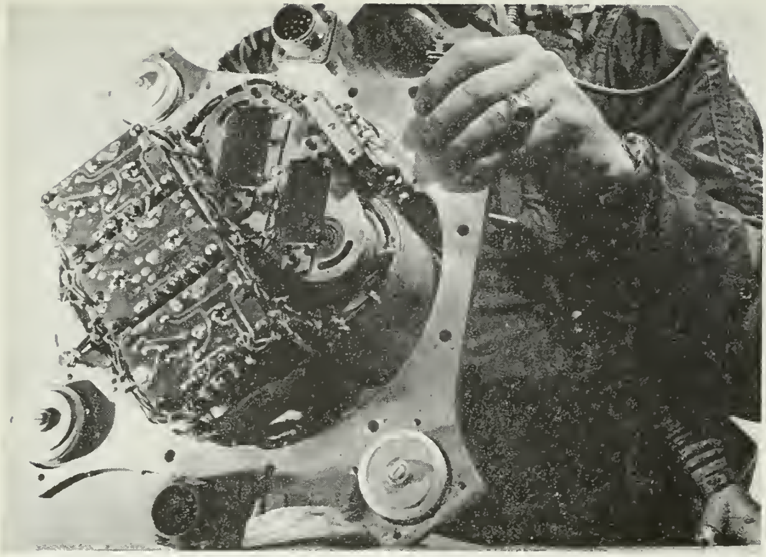
Guidance Program

The guidance system will operate during three periods of *Vanguard's* flight. These are the first-stage powered flight, the second-stage powered flight and the third-stage coasting flight. It will be located near the front of the second-stage rocket vehicle.

The program flight path calls for a vertical takeoff. After that a gradual tilting from the vertical to the horizontal will take place in the direction of the intended orbit. When the first stage burns out, the vehicle will be about 36 miles up and at about 45 degrees to the vertical. During this part of the flight, the M-H 3-axis gyro platform calibrated to control pitch, yaw and roll (line of flight) will command the vehicle.

Its job at the start will be to sense any movement from the vertical. This movement will be picked off the pitch and yaw gyros as an electrical signal. The signal will be sent to an autopilot amplifier. When amplified, the signal will be sent to the servo system that controls tilt of the gimbal mounted rocket thrust chamber at the rear of the first-stage.

This operation has been compared to juggling a broom on the finger. Roll gyro will sense line-of-flight roll that might be induced from sloshing fuel, wind or other forces acting on the vehicle.



Underside of the guidance platform showing two of the gyros and printed wiring boards that will be used for hook-up of the control circuits.

Correction for roll will be supplied by auxiliary off-on jets from the side of the vehicle. These will take their commands from the guidance system and be activated as needed.

While the M-H guidance system is mounted on a platform, it is not a true inertial guidance system. Through its shock mounts, the diamond-shaped platform will be fastened in a fixed position in the vehicle.

Gyros known as hermetic integrating gyros (HIG) will be used. A type made by M-H known as HIG-6 has been chosen for the job. This gyro contains, in a hermetically sealed can, a gyro wheel that rotates at about 12,000 rpm, a gimbal supporting the wheel, a torque generator for changing position of the gimbal, and a signal pick-off potentiometer.

The gimbal is floated in a fluid called Fluorlube. By carefully controlling the weight of the wheel and gimbal combination, its specific gravity is exactly matched to that of the fluid. In this way the bearing friction problem in gyros is reduced.

In a figuratively "weightless" condition, the gimballed gyro in a floated system needs a minimum of bearing surface. Jeweled bearings can be used since they act only as guides for the gimbal shafts and are small enough to be nearly frictionless.

Result is ultra-high sensitivity of the gyro to any movement. Its "memory," or desire to resist changes in gimbal movement is unrestrained by friction forces acting on it.

Variable Memory

Flight plan called for in *Vanguard* requires that the memory of its guidance system be changed in accordance with the maneuvers the vehicle is to make.

Three factors are important in getting *Vanguard* in the right position for establishment of the satellite in a satisfactory orbit. These are speed, altitude and angle.

To the pitch gyro with its supporting astrionics gear falls the very important job of easing *Vanguard* into the correct position for the satellite's kick-off into the orbit.

Shortly after takeoff a clocklike programming timer and accelerometer device will go into action to change the pitch gyro's "memorized" axis. This pitch programmer will cause a signal to be fed to the gyro's torque generator which causes rotation of the gimbal to a new position.

The new position will be picked off the gyro's signal potentiometer and fed through the guidance system to tilt the thrust chamber. As this happens the vehicle will tilt away from the vertical.

At about 36 miles altitude when the first stage burns out it will be separated from the vehicle and dropped. At this stage the guidance system takes over control of the second and third stages.

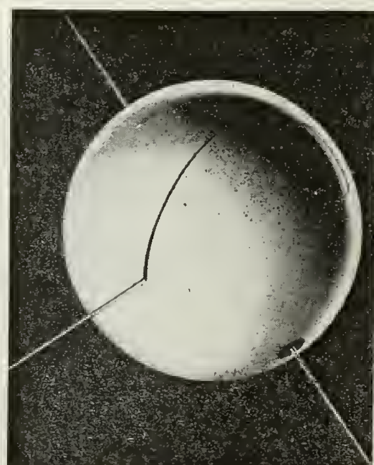
A gradually programmed tilt of the second stage thrust chamber will bring the vehicle to a steadily increasing angle from the vertical until at about 140 miles altitude the second stage burns out.

From then on the vehicle will coast to orbital altitude of 300 miles. It is during the coasting period that the most critical part of orientation takes place. Here the 0 to 2.9 degree parallelism to the earth must be finally achieved.

Control during this period will be transferred to an array of jet reactors. Signals from the guidance reference system will be fed to these to nudge the remaining portion of the vehicle into place.

By the time the coasting period ends at a distance of about 700 miles from the launching point the vehicle is fully committed. No further control of orientation can be made.

Both transistors and electron tubes will be used as part of the guidance reference system. Temperature controllers are used by M-H to keep the gyros at operating temperature through heaters built into the gyros. Six Honeywell H-6 transistors are to be used in an all transistor controller amplifier. It will perform both power and switching functions. No relays will be used because of vibration and shock problems. Tubes will be used for amplifying pick-off signals.



Eleven ton complex 3-stage rocket burning five different kinds of propellants and using intricate guidance is needed to push 20-pound satellite into space.

Astrionics

By Henry P. Steier

A close-up look at a much publicized and photographed "popular" model of an IGY satellite shocked viewers at the recent Instrument-Automation Conference and exhibit in New York's Coliseum. Resistors, capacitors, tubes and "things" aimlessly strung inside the plastic sphere in Christmas tree fashion did not make sense. Fortunately the Naval Research Laboratories' plastic model was nearby to offset any doubts about the project's sanity.

•

The *Terrapin* ionosphere research rocket developed by Republic Aviation Corp. and recently flown to an altitude of 80 miles is considered the cheapest and most portable rocket of its kind. Named after the University of Maryland's mascot, *Terrapin's* nose carried all-transistorized astrionics gear including printed circuits. A Geiger counter was carried to measure cosmic radiation. Dr. Fred Singer of the school's Physics Department, which developed the astrionics, said the instrumentation in *Terrapin* is "so simple" it was built by high school and university students.

•

Singer has set forth a proposal to measure micrometeorite erosion of the satellite surface by placing a radioactive tracer in a portion of the skin. A Geiger counter mounted beneath the skin surface would detect loss of material by erosion as a decrease in counting rate. Another proposal by H. E. LaGow of NRL would use evaporated nichrome film on glass to determine erosion through increase of resistance. Counter would, if practical as a payload, give accuracy badly needed in such measurements.

•

Westinghouse Electric Corp.'s redevelopment of the vibrating rate gyro may prove more practical than the attempted development of the same idea by others a few years ago. The "vibragyro" is another case of the applied science of engineering taking a clue from the pure science of biology. Certain insects use vibrating masses known as "halteres" (leaping weights) for flight stabilization. Mounted in a sort of tuning fork configuration on the insect's back and fastened to its nervous system the vibrating halteres respond to movement about the fork's vertical axis by producing an oscillating torque proportional to the rate of turn. Westinghouse's Air Arm Division is evaluating the latest version in an autopilot it makes.

•

Unsung heroes until last month were the USAF ground-based radar specialists. In a move to provide recognition to the previously unheralded radar controllers on the ground who advise interceptor pilots on the location of moving targets, the Radio Corp. of America awarded individual and division trophies to winning USAF intercept teams competing in the air-to-air rocketry events at Vincent Air Force Base, Arizona on October 18. The former Yuma AFB was officially dedicated as the Vincent AFB at that time. The RCA trophies will be awarded yearly.

The Missile Control Problem

can electro-hydraulic servo systems solve it?

By Jordan E. Johnson

MOST practical approach to missile control is generally conceded to be the use of electrically controlled hydraulic servo systems.

The limited life of a missile has given impetus to the design of very small accessories possessing a high degree of reliability. Because of the short life requirements, accessory manufacturers have been able to utilize hitherto unexplored design techniques in producing unusually compact, lightweight units capable of consistently high performance and reliability.

Reliability is at the top of the list of missile control system requirements because of the "one time" nature of the application of this type of craft. Missile system operation must be right the first time; there is no second chance in the event of system failure.

In most missile applications, weight and space is at a premium. Research programs are geared to strive constantly for more compact, lighter weight missile components. Increased power/weight and power/size ratios usually are the goals.

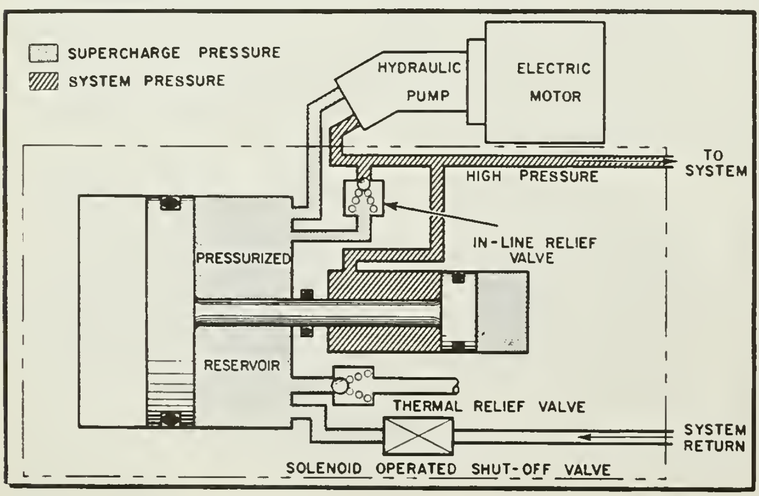
In this regard, high overall mechanical efficiency assumes greater importance because of the resultant minimum power loss. High mechanical efficiency improves power/-weight and power/size ratios and reduces in-flight power drain.

In a system powered by a storage battery, for example, a given battery will be capable of powering a longer flight; or a smaller size battery of lower power rating may be substituted to reduce further system size and weight.

An added requirement has been imposed upon missile systems by the logistic trend toward maintenance of larger supplies of missiles. With contemplated storage for periods of five years or more, missile control systems must possess not only reliability and high performance in actual operation, but unusual shelf life as well.

Missile operation covers a broad temperature range. Hydraulic pump selection, for instance, must be based on the worst possible condition. For this reason, a pump having virtually "flat" temperature characteristics is to be preferred because of the size reduction automatically achieved.

Schematic drawing of packaged hydraulic power source. Pump discharge (system) pressure is directed to small piston causing it to tend to move to the right. Large piston, on common connecting rod, moves in same direction thus pressurizing pump inlet line. In-line relief valve controls maximum pressure and thermal relief valve protects against excessive temperature rise in missile during ground preflight operation.



Where an oversize pump must be used to compensate for reduced performance at elevated temperatures, a vicious efficiency loss cycle is started. The larger pump at lower ambient temperatures produces excessive flow, which raises fluid temperatures, thereby diluting the pump's efficiency and creating the need for a larger one.

Temperature effect on the relief valve setting also must be considered. No appreciable pressure setting sag can be tolerated. Similar considerations apply to all missile hydraulic components.

Packaged hydraulic systems have many advantages to offer—small envelope, reduced weight, minimum of plumbing, simplicity of installation and ease of maintenance. They permit assignment of responsibility for design, manufacture and performance testing to a single reliable source.

This single-source concept insures maximum compatibility of system components, thus simplifying trouble shooting procedures and avoiding a potential trouble source brought on by the inter-action of mismatched components.

Vickers Inc. has developed a packaged missile system of the "plug-in" type. When fitted with self-sealing quick-disconnect fittings, the package can be quickly and easily installed or replaced. Detail troubleshooting therefore can be confined to the bench.

A typical packaged hydraulic power source suitable for missile installation is made up of an electric-motor-driven, miniature, fixed displacement pump mounted to a manifolded valving assembly.

These manifolded valves include a standard in-line relief valve, a solenoid shut-off valve and a thermal relief valve; also, a special, self-pressurizing reservoir matched to the pump inlet pressure and system's fluid capacity needs.

The components used in this package have been tested at elevated temperatures and under severe vibration conditions.

The package is provided with self-sealing fittings for quick connection to the electro-hydraulic, surface control servo system. Primary power in this particular instance is derived from a storage battery. It is quite possible, however, that a ram air turbine, air motor or monopropellant turbine might be substituted for the electric motor in some installations.

The pump used in this typical missile hydraulic power package is a miniaturized version of the Vickers fixed displacement piston unit.

Overall mechanical efficiency when operating at rated speed and pressure exceeds 92 per cent. Volumetric efficiency is approximately 98 per cent. This higher efficiency permits use of a smaller storage battery and related equipment for giving missile applications.

Pump output does not vary appreciably with temperature change, and efficiency loss between normal operating temperatures and 258°F is less than 3%. Therefore, it is unnecessary to over-size the pump at low temperature to insure sufficient flow at elevated temperatures,

Missile pump weighs only 0.9 lbs. delivers 4.3 hp.

In-line relief valve . . .

neither is it necessary to provide a warm-up period. This basic Vickers pump design is approved under Spec. MIL-P-7858.

The in-line relief valve design combines unusually accurate control and fast response with exceptionally "flat" performance characteristics. This component has been vibration-tested in all axes at frequencies from zero to 2,000 cps. Amplitude was such as to produce 25g's acceleration with no malfunction. High temperature runs up to 560°F have been most successful.

The self-pressurizing reservoir used in the package is designed to provide the optimum supercharge pressure required by the electric-motor-driven pump.

The reservoir design utilizes pump discharge oil at system pressure to maintain optimum inlet pressure independently of altitude, temperature and reservoir level. The pressure characteristics are perfectly "flat."

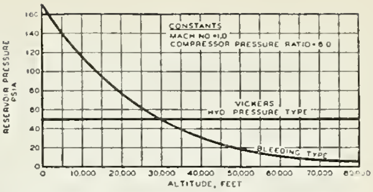
Since this is a "boot strap" operation, using pressure produced to maintain pressure required, spring loading of the piston is avoided and pressurization is initiated only when called for by the system.

This means that during extended stowage periods, the system will remain intact, without leakage or other deterioration. The Vickers pressurized reservoir may be made compatible with all known types of fluids over a temperature range of 65°F to plus 350°F.

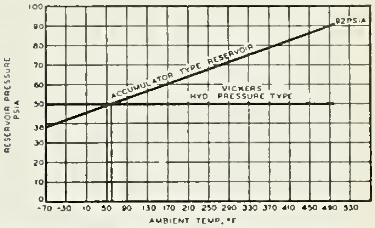
The Vickers packaged system concept for missile hydraulics is a simple and effective method for achieving design goals. Weight, size, performance and reliability are improved by the manifolding of valves and integration of the manifolded assembly with the pump and pressurized reservoir. In addition, shelf life characteristics are improved by the self-pressurizing "boot strap" type reservoir.

Research programs are continuing the search for lighter and smaller components without the sacrifice of performance and reliability. Higher temperature applications at higher speeds are being tested and promise to permit early revision of specifications that impose more stringent requirements.

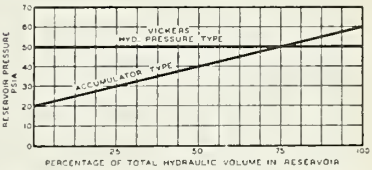
And the components utilized in



Comparison of pressurized reservoir and bleed-air type reservoir assuming no controls on bleed pressure.



Ambient temperature characteristics of hydraulic reservoirs.



Performance of pressurized reservoir and accumulator type reservoir for various oil capacities.

How Vickers self-pressurizing reservoir compares with other types. Note "flat" pressure characteristics for all altitudes, temperatures and reservoir levels.

the example power source package do not constitute the limit of those available for missile application. Another useful accessory is the hydraulic-powered electrical power package.

This unit is a further application of the package concept. It is a constant-speed hydraulic motor-driven alternator assembly. It is designed to supplant a conventional, bulkier inverter in providing a-c power. Speed control is within ± 2½ percent regardless of load. Special configurations will maintain 400 cps frequency within ± 0.1 percent, regardless of load.

These new units are available in six sizes for 0.5 to 3.0 kva output. Weight of the individual units is from 7 lb. for the smallest package to 19 lb. for the 3.0 kva output size. Special larger sizes up to 9 kva are being tested.

A subsystem such as this, complete within itself, makes the job of the missile project engineer easier and fixes firmly the responsibility for both performance and reliability with a single subcontractor.

Aerophysics

By Seabrook Hull

Operational intercontinental ballistics and glide missiles already may be in prototype stage. Effort is toward optimum, not desperation designs. Intensive physics research of high temperature gas dynamics and critical thermal properties is beginning to yield definitive knowhow.

Take a 2,500-mile ICBM initiating re-entry at Mach 18 with 10,000 lbs/ft^2 nose pressure; 12,000°F boundary layer temperature; and a 1,000 BTU/ft^2/sec average heating rate for 20 seconds. A warhead skin of thick copper for fast heat conductivity and primary heat sink capacity, plus a thin platinum alloy coating for chemical stability and over 95% reflectivity might make addition of deadweight coolant, such as water, unnecessary. Holding maximum skin temperature to 1,500°F design target indicates need for high drag-to-weight ratio nose cone (hemisphere) to slow re-entry speed early and average out heating rate. Future high-temperature materials to cope with 10,000 BTU/ft^2/sec heating rate just before impact will facilitate cutting heat-sink weight and enable switch to faster-falling, low drag-to-weight ratio tapered nose cone.

Glide bomber technology centers on thermal equilibrium of mission flight conditions—2,500-mile range, Mach 12, 150,000 ft and ram air pressure of 300 lbs/ft^2. Resulting 9,000°F boundary layer temperature over sharply swept delta gives a 5 BTU/ft^2/sec average heating rate for 20 minutes in the laminar flow forward wing area. Radiation away equal to heat input occurs at skin temperature of 1,600°F. Equilibrium in the turbulant boundary layer across the aft wing occurs at 2,500°F. Proposed wing cross-section shows red hot inconel outer skin separated from inner steel structural skin by a layer of thick insulation.

Steam from supplementary cooling in leading edges, where heating rates hit 50 BTU/ft^2/sec and equilibrium temperatures exceed materials limits, could power control/guidance gear. These two concepts are heavy and primitive but would work, though the cost in massive firing stages would be vast. Materials to stand 3,000°-to-5,000°F are badly needed in order to reduce final missile weight.

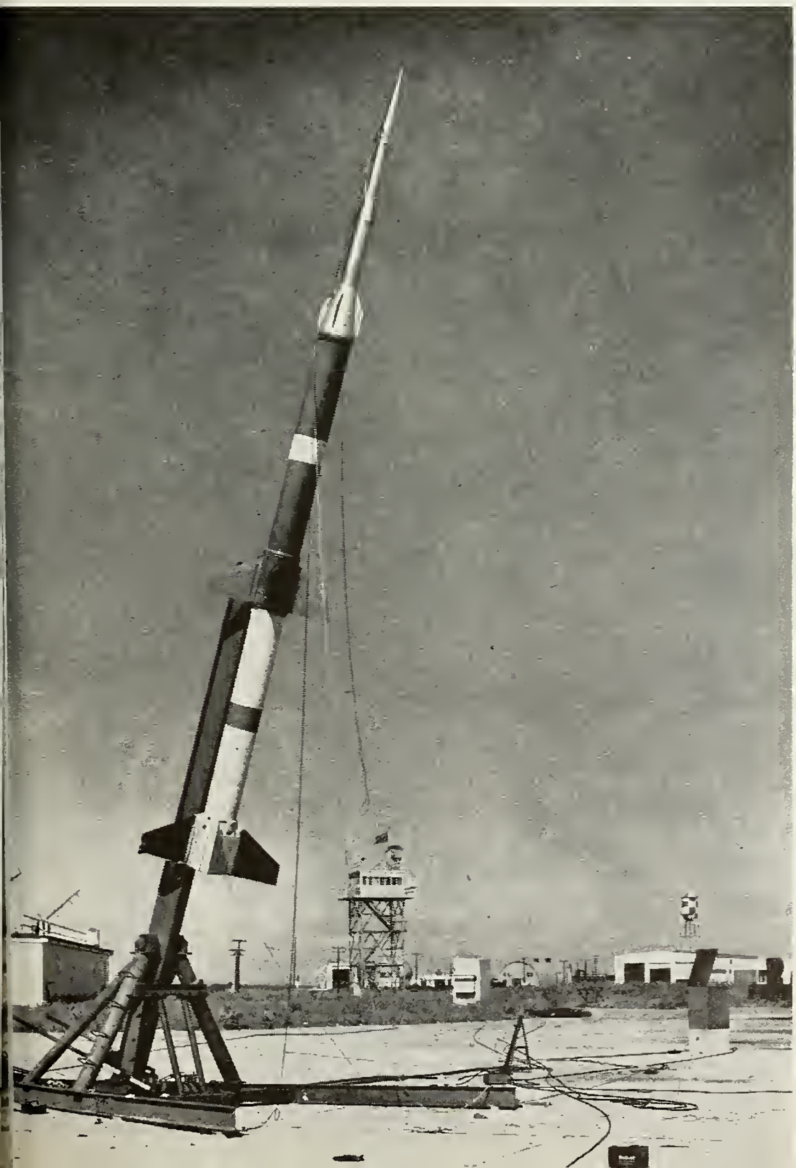
NACA is developing rate controlled stability and guidance system to make up for lack of oscillation damping in the space and near-space flight of manned vehicles . . . For some hypersonic devices (order of Mach 10) flared tail cones provide higher stability and less aerodynamic heating than conventional swept cruciform fins . . . NACA is flight testing materials to temperatures up to 7,000°F . . . Air Research and Development Command's latest "Tables and Graphs of the ARDC Model Atmosphere, 1956" (replaces NACA Tech-Note 1200) gives atmosphere data to an altitude of 330 miles; is being printed by Cambridge Laboratory.

NACA boosts rocket research

200-mile altitudes 7,000 mph speeds

A four-stage research rocket assembled by the National Advisory Committee for Aeronautics has attained a velocity of Mach 10.4 (6864 mph), an altitude of approximately 200 miles and an estimated range of about 500 miles.

This was disclosed by NACA last month during the Triennial Inspection of its Langley Aeronautical Laboratory. The record flight took place about two years ago at NACA's Pilotless Aircraft Research Station at Wallops Island, Va. Its disclosure at this time suggests that far greater achievements have taken place during the interim period which the government is not willing to discuss yet. At least one is the recent firing of a *Redstone* assembly for a record 3000 miles. (See page 33)



The four-stage NACA rocket measured 35 feet, 8 inches in length and weighed a total of 2800 pounds. First two stages were finned Nike boosters, each 11 feet long. Third stage was a finned Thiokol T-40 rocket 4 feet, 6 inches in length; the fourth was a flare-stabilized Thiokol T-55 which measured 6 feet in length with instrumentation.

The assembly was launched over the Atlantic from Wallops Island after the area had been cleared by a Navy air search. The stages were fuzed to permit a brief time lag between the burning of one stage and the firing of the next. This was done to avoid excessive heating in the lower atmosphere.

Maximum speed was attained at an altitude of 84,000 feet, when the last of the four stages was exhausted. The fourth stage, together with its cargo of thermocouples, accelerometers and telemetering equipment, coasted from that point to an altitude of more than one million feet. Although its fall into the Atlantic was not observed, its velocity and trajectory indicated a range of approximately 500 miles.

Extreme range is definitely not one of NACA's objectives in conducting the aerodynamic heating research program. To minimize this feature of its high-speed rockets, it has developed an "over-the-top" trajectory in more recent firings. This involves burning the first two stages

NACA 4-stage research rocket ready for launching.

on the upward portion of the trip and delaying ignition of the remaining two stages until they reach their peak altitude and begin to descend.

Even with this technique, however, horizontal ranges of 60 to 100 miles are regularly achieved, according to Robert L. Krieger, Engineer-in-Charge of Wallops Island.

NACA is presently using a souped-up four-stage rocket vehicle at Wallops Island which employs an *Honest John* as the first stage. The other three stages are identical to those of the earlier models. It is 41 feet in length and weighs 5700 pounds when loaded. Use of the bigger first stage unit provides the valuable addition of two seconds of firing time and thus permits the entire assembly to reach an appreciably higher altitude.

This, in turn, means that substantially greater velocities—possibly bordering on those faced by re-entering ballistic missile warheads—can be achieved for the final stage of the assembly upon its plunge into the denser layers of the atmosphere.

NACA's high speed vehicles are providing considerable data on nose cone re-entry problems for ballistic missiles, but an equally important project is the accumulation of information on the behavior of small aircraft models at super-speeds. This is of particular significance to the hypersonic rocket glider which would obtain its initial impetus from rocket boost to great altitude and then rely on the aerodynamic lift of its wings to coast to its destination.

"This type of vehicle appears to be the one most suited for man-carrying wherein we may set as our goal the effective shrinking of the size of the earth so that any two points on it are only a short day's journey apart," said F. L. Thompson, Assistant Director of Langley.

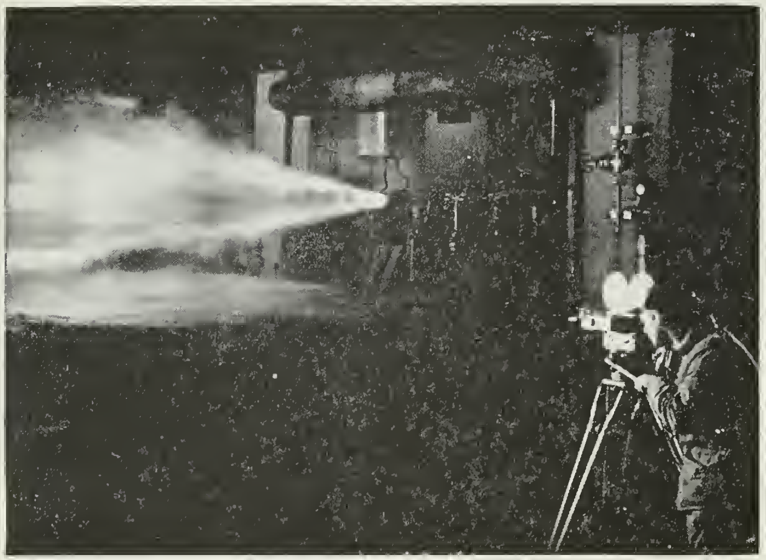
Chief advantage of solid-propellant research vehicles is their low cost and ease of handling compared with liquid-propellant rockets, according to NACA technicians. "We can set up one of these solid rocket assemblies, check out all the equipment and be ready to go in three hours," one official noted. The cost advantage is also substantial. NACA paid a total of about $7500 for its earlier four-stage rockets, exclusive of modification and instrumentation. Liquid-propelled rockets carry a

NACA shoots stage-rockets using current hardware in different combinations.

price tag of $35,000 and up.

NACA also described some of the work by Lewis Flight Laboratory near Cleveland on the problems of "chugging" and "screeching" in rocket combustion chambers. These are low and high frequency oscillations in the flame front inside the chamber. Even a mild oscillation can produce pulses with a force of five tons against the sides of the rocket chamber, while more rapid vibrations accelerate the heat transfer rate by as much as four times, with the result that the engine is quickly and spectacularly destroyed.

Chugging can probably be eliminated through improved design of the propellant system, but no general solution may be found for screeching, which takes a variety of forms. Motion pictures of the screeching phenomenon, taken at the rate of 47,000 frames a second, disclose three separate movements within transparent lucite combustion chambers: transverse oscillations from one side of the chamber to the other, longitudinal oscillations from one end of the chamber to the other, and rotary oscillations around the longitudinal axis of the chamber.



NACA rocket engine under static test.

Simple NACA model to check operation of a new multi-rocket booster.

Research vehicle to obtain data on jet vane in booster exhaust.

In addition to photographing the shock fronts which occur during screeching, NACA uses pressure-sensing devices to measure their force and an ingenious method to record temperature variations. Sodium, which ionizes at a known rate in terms of temperature, is added to the propellant. A micro-wave signal transmitted through the rocket chamber is altered by the variations of sodium ionization so that an accurate record of the temperature of the shock fronts during screeching can be obtained.

NACA employs a variety of other test facilities in its attack on the problem of aerodynamic heating. Among them are:

• A light gas gun at Ames Aeronautical Laboratory south of San Francisco which is capable of firing small models at velocities up to Mach 20. A small magnesium model fired in this tunnel reached a speed of 11,000 mph and ignited as a result of the tremendous heat.

• Combustion products tunnels at Langley, one utilizing a 2.5-inch rocket engine capable of velocities of 4750 mph and temperatures of 4100 degrees F., and the other using high pressure air heated to 3500 degrees F. in a combustion chamber and capable of 1300 mph.

• Quartz tube heat lamps capable of producing rapid, extreme and unsymmetrical temperature variations on wing and tail structures and other components to simulate the effects of uneven heating encountered in high-speed flight.

• Carbon rod radiator which can generate up to 4700 degrees at the rate of 100 Btu per square foot per second—equal to Mach 5.

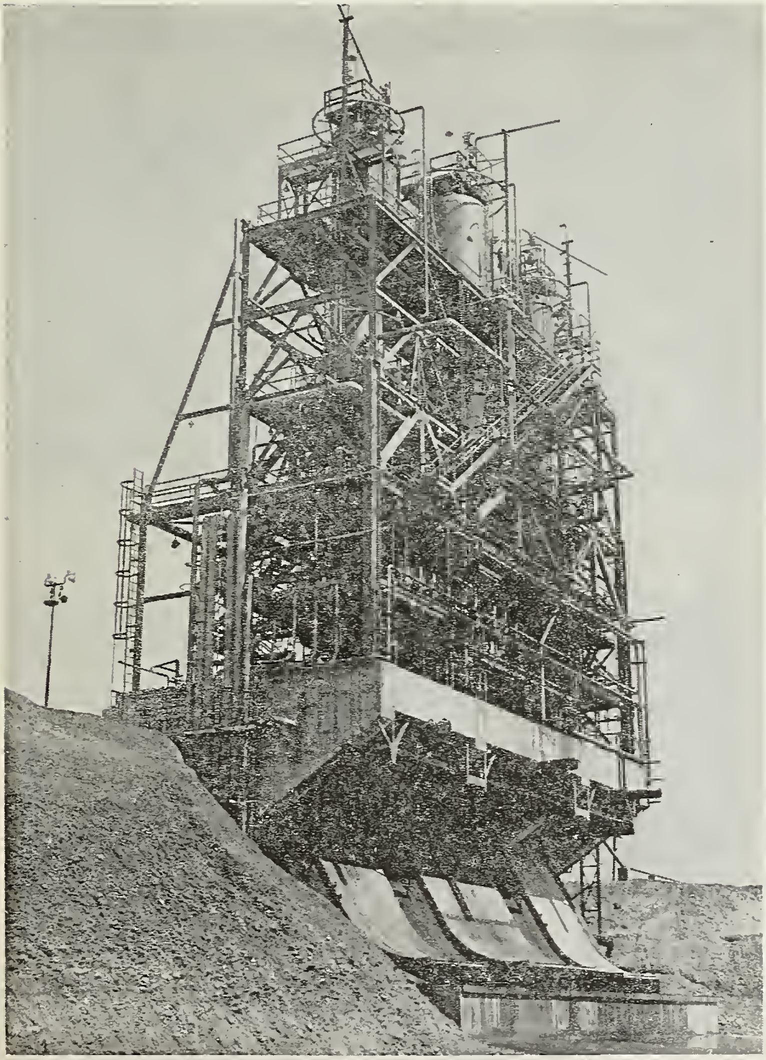
• Blowdown tunnel incorporating a ceramic heat exchanger capable of producing a jet blast of Mach 5 velocity and 4000 degrees F.

• A system of windtunnels built under the Unitary Plan which can simulate air velocities ranging from Mach 0.7 to Mach 5. A new tunnel with a larger test section capable of subjecting full-scale components to velocities up to Mach 3 is expected to go into operation next year.

• Flight testing of rocket-powered research aircraft like the ill-fated Bell X-2. Work will continue with the Bell X-1-B and X-1-E at NACA's High Speed Flight Station at Edwards AFB, Calif.

ICBM Engines — *Ahead of Schedule?*

By Fred Hunter



This is a high-thrust test stand at Aerojet-General Corp.'s Sacramento facility, which is capable of testing rocket engines up to 1,000,000 pounds thrust. It is 84 feet wide, 65 feet deep and 100 feet high, including superstructure.

BULLDOZERS already had swung into action clearing the site when Dan Kimball, president of Aerojet-General Corp.—aboard a bright new tractor—officially broke ground for the new $13,000,000 Production Plant, which will be the latest addition to the company's rocket engine facility. The plant will be located on a 20,000-acre site near Sacramento, Cal.

To be devoted to the manufacture of big rocket engines for the Air Force's ballistic missiles program, the new Aerojet plant will be the twin to another $13,000,000 facility now nearing completion at Neosho, Mo. for operation by North American Aviation.

The Air Force originally intended to have Aerojet operate the Missouri plant. Subsequently, it was decided efficiency would be served by turning Neosho over to North American.

Flanked on one side by the $9,000,000 Solid Rocket Plant, which has been producing between 500,000 and 900,000 pounds of propellant per month since it began production in 1952, and on the other by the Liquid Rocket Plant, a research and development facility started early in 1955 to work on the ICBM program, the Production Plant embodies a manufacturing building 550 feet wide and 560 feet long. It will employ approximately 1200 workers in administration, inspection, machining, sheet metal work, welding, assembling, heat-treating, hydraulics, tooling and maintenance. Machine tools of approximately $5,000,000 value will be installed.

Maj. Gen. Bernard Schriever, commander of the Air Research and Development Command's Western Development Division, said construction on the Aerojet Production Plant would be expedited to bring it into manufacture at the earliest possible date. The company has a production contract for rocket engines under the Air Force's program for long range ballistic missiles, which includes the intercontinental *Atlas* and *Titan* and the intermediate *Thor*.

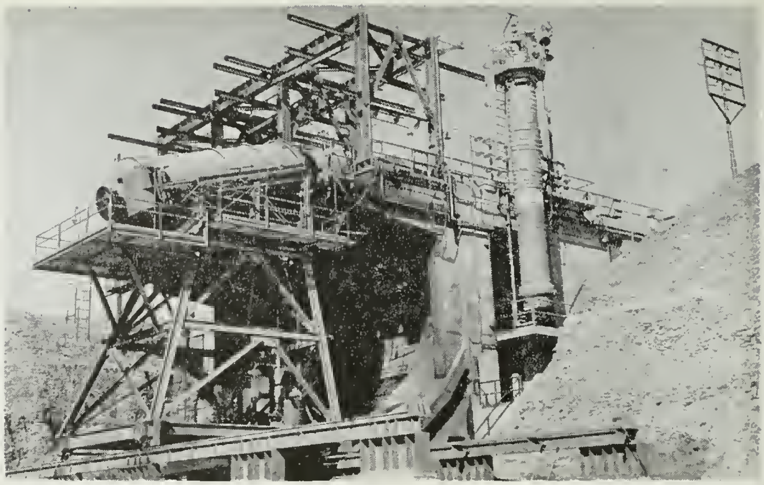
Aerojet has just marked up a record for itself in the speed in which it accomplished the installation of the test facility for its liquid rocket developments. The four complexes of two test stands each were completed in 18 months, or about half the time it ordinarily would take to complete an installation of this character.

Although only 15 miles from Sacramento, the area is isolated. The gold dredges which once mined the area have made thousands of acres useless for agricultural purposes, but an ideal location for the development and testing of large rocket engines. The test area has a buffer zone one mile wide around it.

The test stands range from 50 feet wide, 50 feet high and 67 feet deep to 87 feet wide, 100 feet high and 82 feet deep. They are located along a 40-foot deep ravine left by past dredging operations and their construction required the use of 11,807 yards of concrete. The largest stands are capable of taking up to 1,500,000 pounds thrust. All of the high thrust stands have three firing positions and employ large steel deflection plates which are cooled by spraying water at a rate of 5,000 to 10,000 gallons per minute in order to prevent erosion.

In addition to rocket engines for the big ballistic-type missiles, Aerojet uses its test facility to test rocket engines for other uses, such as for the *Bomarc* and second-stage *Vanguard*. Two high thrust stands for these purposes incorporate a superstructure design permitting a complete missile to be rolled up to the stand and titled into place for vertical firings.

Liquid oxygen is supplied by a mobile plant in the test area and a liquified gas plant under construction west of the Solid Rocket Plant. This facility is being constructed by the Air Products Co. under contract to the Air Force.



This photo of a test stand at Aerojet-General Corp.'s Sacramento facility shows how the concrete apron is protected by water-film-cooled steel plate which deflects the rocket exhaust during vertical test firings, protecting the concrete structure from blast erosion.

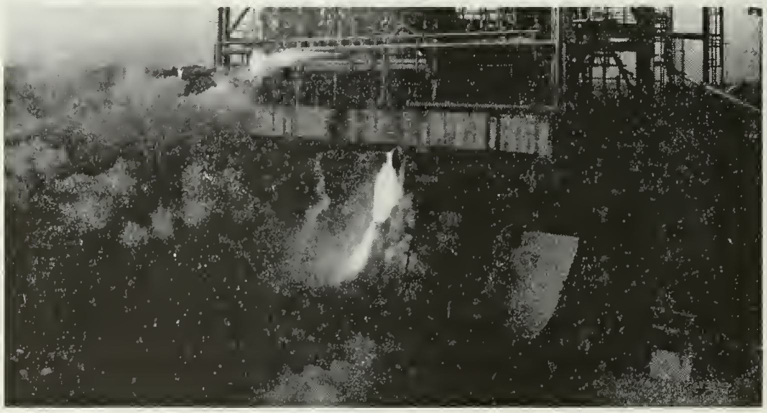


Photo shows test firing of liquid rocket engine in one of the high-thrust test stands installed this year at Aerojet-General Corp.'s facility at Sacramento.

This three-position, C-clamp type test stand at Aerojet-General Corp.'s Sacramento plant is used in development test firings of thrust chambers and ejectors. Each firing position has a 300,000-pound thrust rating.

INDUSTRY SPOTLIGHT

By Joseph S. Murphy

Noble Metals for Guided Missiles

Already there is talk of using *platinum alloy-clad copper* to enable the ICBM warhead to cope with the intense heating of re-entry. Some of the pointed nose cones of the satellite launching vehicles may be platinum at the very tip.

Platinum is an important contender, too, as one of several simultaneous cladding materials needed to make molybdenum oxygen resistant for high temperature operations.

These uses are being compounded on top of the sharp increase in demand that has resulted in the last few years from rising consumption by the electronics industry, where it is used to build greater reliability and accuracy into electrical contacts, etc.

The platinum group consists of platinum, palladium, iridium, rhodium, ruthenium and osmium. As they are members of the same family in the periodic table they are quite similar in many ways. Their differences, however, serve the very useful purpose of supplying the qualities of one to another through alloying.

Their basic advantages are: chemical stability; a very shiny natural state, thus high reflectivity (95-98%); high melting points; relatively low vapor pressures; high strength and ductility; relatively low coefficients of thermal expansion.

At normal high temperatures, the platinum group metals do not oxidize. Platinum, for example, is used with induction heating elements at temperatures over 2,000°F.

At higher temperatures, oxidization is liable to occur, but it is at a very small rate and usually the oxide is stable only over a small temperature band, decomposing or vaporizing away once that band is left. It always leaves a shiny highly reflective surface.

Between the members of the group, hardness, strength, ductility, etc., vary. But when used in small amounts, one with another, properties can be altered pretty much to suit the metallurgist's wishes.

This is fortunate because only platinum and palladium occur in any appreciable quantities.

What isn't known too well about the platinum metals is how they perform under critical, ultra-high-temperature conditions. There is some possibility that one or more of these materials may suddenly become highly unstable if submitted to too high a heating rate or simply to too high temperatures and pressures in an oxygen-nitrogen atmosphere.

Critical properties of this nature are the subject of intense research by those now concerned with very fast, very high aerodynamic heating such as that encountered at hypersonic speeds in the denser atmosphere.

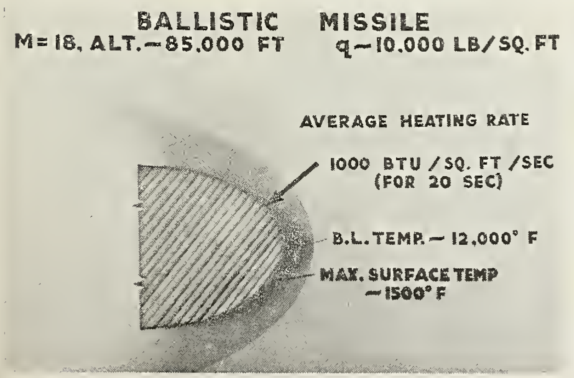
In a way this is unfortunate, for they are both expensive and rare. Production and sales are figured in ounces instead of pounds or tons.

Up-to-date figures on total world production are not yet available. It takes Washington about two years to catch up on mineral output and trade on a global basis.

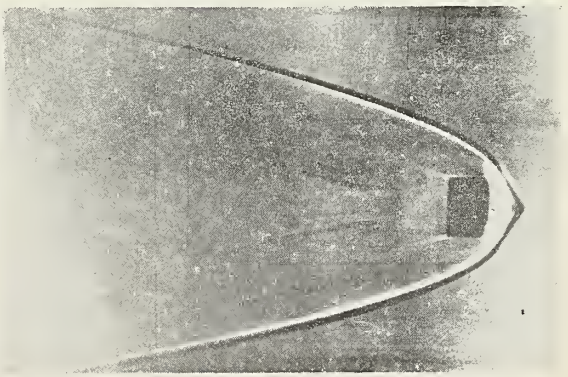
However, output—and U.S. imports—has been rising for some years, and probably hit 1-million fine troy ounces in 1955. The total for 1952 was 675,000 ozs. and in 1953, 750,000.

In 1955 the U.S. imported 1,009,819 ozs., up sharply from 601,612 ozs. in 1954. Part of this undoubtedly came from stocks on hand, part from new production. You get a good idea of how un-strategic the U.S. position is in these metals when you realize that domestic output in these two years was 61,481 and 56,766 ozs. respectively.

For platinum, palladium, osmium, ruthenium, iridium and rho-



NACA demonstrates thermal design limits of typical high drag-to-weight ratio ICBM warhead.



Heating problems of ICBM reentry is demonstrated by luminosity of gas around nose.

dium supplies, we are 90% dependent on foreign sources. Fortunately, neighbor Canada is one of the world's largest producers with a total of nearly 296,000 ozs. in 1953.

The Union of South Africa is the world's other largest producer with 296,000 ozs. Between the two, they account for over 90% of the total free world output.

Since the war, information on Soviet production has been non-existent. They have been estimated at 100,000 ozs. a year, but may have been much larger. Red natural resources are thought to be the largest in the world.

And lately, Russia has been offering metals of the group for export in trade agreements with free-world countries—about 13,000 ounces per year per agreement. Some have bought more, however, and Britain, for example, purchased 30,012 ozs. in 1955. Fortunately, much of this is re-exported to the U.S. for stockpiling and use by industry.

Though Western estimates put Soviet reserves at only 4-million ozs., Russia still claims 80% of known world reserves, and the odds are these claims are probably valid.

Free world reserves of platinum metals break down something like this: Canada, 6.5 million ozs.; South Africa, 10 million; and 5.5 million scattered widely among a number of countries.

Including the 4 million estimate for Russia, the 25 million of ounces still estimated to exist in recoverable form in the ground, 15 million are platinum; 7.5 million, palladium; and 2.5 million iridium, osmium, rhodium and ruthenium together.

One catch in this picture is the fact that most production now is as a by-product of mining nickel and copper (Canada) and of gold and silver (South Africa). Only Russia is known to have substantial, economic deposits of placer deposits. And any major increase in free-world output solely for the purpose of extracting platinum would result in a material increase in the cost.

And they are already expensive with platinum running some $80-to-$120 an ounce depending on market conditions; palladium, $19-to-$24; iridium, $90-to-$135; osmium, $80-to-$140; rhodium, $118-to-$125; and ruthenium, $45-to-$65.

An important and saving feature of this picture from a strategic point of view is the fact that these metals don't disappear. They are stable chemically and in the majority of uses they are put to, they are 100% recoverable.

Such stocks, excluding the stockpile (platinum and iridium are being strategically stored by the government), must now total several million ounces. In wartime, these could be requisitioned if needed.

But it's still not a lot in the face of sharply rising demand. Ten million ounces, for example, sounds like a lot, but a slide rule will quickly tell you it adds up to only about 350 tons.

Bell Executive Forecasts Increased Rocket Spending

U.S. spending for rocket procurement and development will probably reach $1.25 billions over the next five years, Leston P. Faneuf, Bell Aircraft Corp. president, predicts.

Addressing the recent Buffalo, N. Y. meeting of the American Rocket Society, the Bell executive made it clear that rocket propulsion is now a full-scale industry—no longer just a sideline.

Faneuf said investments in rocket facilities over the past five years have run well into nine figures. Bell Aircraft alone has spent $12 million on rocket instrumentation and production/testing facilities.

Bell's work now extends all the way from early development to high production, he concluded.

GE Establishes West Coast Propulsion Systems Unit

General Electric Co.'s Aircraft Gas Turbine Division has set up a California Advanced Propulsion Systems Operation in temporary headquarters at Danville, Calif. near San Francisco.

The new organization will take on the task of designing propulsion systems "both within and beyond the earth's atmosphere," GE officials say. And it will be free to employ any source or kind of energy engineers and scientists find adaptable to the system they design.

The company has optioned a 12-acre plot near Danville. If exercised, GE will begin as early as December with construction of a 7,000 sq. ft. facility to house some 75 engineers.

Overall direction of the propulsion group will stem from GE's flight propulsion laboratory department in

Cincinnati. However, the new west coast activity will not result in any curtailment of advanced propulsion research work at Cincinnati.

New Missile Facilities At Douglas, Northrop

Douglas Aircraft Co. and Northrop Aircraft, Inc. early this month added to their respective missile plant facilities some 133,000 sq. ft. combined.

Douglas took a 10-year lease on a 61,000 sq. ft. building at 11500 Tennessee St., West Los Angeles. It will be used for missiles engineering and missiles service and training.

Northrop leased an additional 72,000 sq. ft. at its Torrance, Calif. plant to provide more space at Hawthorne for *Snark* missile activities. Some 700 office and technical workers were due to occupy the new facilities early this month.

Regulus Powerplant Reordered

Allison Division, General Motors Corp. has received a contract totaling $1,503,200 for production of J33 jet engines to be used for Navy's Chance Vought *Regulus* I surface-to-surface missile.

Whittaker-Gyro Expansion Underway

History of the electrically driven gyroscope for airborne applications began in 1937 in a garage in Los Angeles owned by Leo Nevin Shivien.

Prior to that time airborne gyros were air driven devices. Large gyros for ground use were made by the Sperry Gyroscope Co. But Schivien's work is generally acknowledged to have been the beginning of practical application of the electrical driven principle to aircraft gyros.

During World War II the Schivien Engineering Co. produced gyroscopes for two glide bombs —*Azon* and *Razon*. Both were radio controlled and stabilized by Schivien's electrically driven gyros.

When the *Nike* missile was developed some of its gyros were made by the company Schivien founded and are still being made today by that company's successor.

The Whittaker Gyro division of Telecomputing Corp. in Van Nuys, Calif. carries on the work begun by Schivien. Schivien's interests were bought by the William R. Whittaker Co., Ltd. in 1954.

Whittaker Gyro is part of a growing organization that has been building up facilities for R&D and production in the missile and aircraft control mechanism, data processing, and electronic instrument fields.

Early in 1956 Whittaker and the Telecomputing Corp. merged. In August 1956, Telecomputing Corp. acquired Brubaker Electronics Inc. Brubaker became the fifth operating unit of Telecomputing Corp. Others are the Engineering Services division, and the Enterprise Development and Mfg. Co.

Telecomputing Corp. of North Hollywood, Calif. manufactures and develops semi-automatic data reduction equipment and business data handling systems. Brubaker produces precision electronic products such as delay lines, antenna filters, pulse transformers and laboratory test equipment. It is located in Culver City, Calif.

Engineering Services at Holloman Air Development Center in New Mexico operates the data reduction facilities there for handling optical tracking and telemetry data.

Enterprise Development and Manufacturing in Burbank, Calif. develops and produces special testing systems used by the Atomic Energy Commission for automatic control and data recording. The corporation received AEC telemetry contracts $1.5 million over the past 12 months.

AF Checks on Surplus

Air Force Air Materiel Command is screening about $5 million worth of heavy duty electronics and communication equipment stored at depots throughout the country to segregate current from surplus stock.

One phase of the inspection program is to determine the best approach to marketing highly specialized surplus electronic gear.

Program is under the direction of AMC's Materiel Redistribution and Marketing Division. Sales that may develop from the depot survey will be announced.

AEDC To Circulate Unclassified Reports

Air Force Arnold Engineering Development Center has launched a program to attain the widest possible industry circulation of reports on testing and test equipment.

First two of a series so far published are AEDC Reports TR-56-1 and TR-56-4. Subjects are "Online Automatic Data Reduction for Tunnel E-1 Gas Dynamics Facility" and "Investigation of a Multiple-Source Schlieren System for Application to a Perforated Wall Windtunnel."

Requests for these and future reports should be addressed to Commander, AEDC at Tullahoma, Tenn.

$26 Million For *Snarks*

NORTHROP AIRCRAFT, Inc. was assured continued developmental production of its SM-62 *Snark* intercontinental missile recently by a $26-million follow-on Air Force contract. *Snark* is powered by a Pratt & Whitney J57 jet and has a range of about 5,000 miles.

AMC Production Official Cites Rising Materials Costs

At the present rate of critical materials consumption in the U.S. for newer aircraft and missiles, conservation of certain of these materials has become essential, according to Air Materiel Command's deputy director of production, Brig. Gen. C. H. Mitchell.

And what is more, he told the recent National Industrial Conference in Phoenix, the situation promises to get progressively worse with attendant increases in cost of materials.

The next generation of aircraft, he said, will be composites of steel, titanium, aluminum, ceramics and high-temperature non-metallics—all needing development of methods for producing, forming, joining, contouring and assembly.

The AMC official cites these comparative costs per pound:

Aluminum	$ 0.35
Stainless sheet	$0.73 to $ 0.87
Titanium alloy	$20.00

For newer engines such as nuclear powered types prices run higher:

Lithium	$11.50
Reactor grade zirconium	$23.00
Beryllium (unfabricated)	$71.50

Materials costs are rising for two reasons, he added, scarcity and difficulties of fabrication. For example, he points out that it takes 3,000 lbs. of metal to produce 650 lbs. of finished discs for one jet engine. Such low utilization rates increase material costs alone to $60.00 per lb., Gen. Mitchell said.

Bendix Acquires Interest In Canadian Electronics Firm

Bendix Aviation Corp. has acquired a 40% interest in Computing Devices of Canada, Ltd. of Ottawa, an electronics firm which will market Bendix electronic and missile components.

Deal was arranged through its Canadian subsidiary, Bendix-Eclipse of Canada, Ltd. It calls for a sales and licensing arrangement whereby the Canadian firm will handle Bendix products.

Earlier, Bendix bought a 70% interest in another Canadian firm, Aviation Electric Ltd. of Montreal. It serves as an outlet for the company's electrical and mechanical aircraft components.

IAM Approves Raytheon Contract

International Assn. of Machinists has ratified a three-year contract with Raytheon Mfg. Co. at Waltham, Mass. calling for total wage increases of 41¢ an hour. Other benefits provide an eighth paid holiday, 10 and 15% shift differentials and an emergency wage reopener clause.

An immediate raise, retroactive to June 1, involves increases from 14¢ to 25¢ an hour. Others become effective June 1, 1957 and 1958.

Company now holds contracts to build Navy *Sparrow* III and Army *Hawk* I missiles.

Northrop to Build Missile Test Cell

Northrop Aircraft, Inc. has awarded contracts for design of an enclosed check-out building and test cell that will house an entire tactical missile and its operational launcher.

New facility, to be built at its Hawthorne, Calif. plant, is intended to make possible a full missile check-out and test yet protect nearby personnel and facilities from the extreme noise levels these operations produce.

Contract for design and fabrication of noise control equipment went to Industrial Acoustics Co., Inc. of New York through its west coast representative Midair. Architectural and engineering contracts were awarded to Pereira & Luckman.

Project is headed by Z. E. Sheffner of Northrop's plant engineering staff.

Another Northrop facility nearing completion is a missile engine test cell that will accommodate a missile the size of its SM-62 *Snark* with wings removed. It is essentially a "double building" with one concrete structure built within another.

Northrop engineers say its mass is so great that other plant workers will hear no noise whatever when an engine is being run in the cell.

Sperry Rand Names Arizona Division

Sperry Rand Corp. has chosen Sperry Phoenix Co. as the official name of its new electronics production facility to be built in Phoenix, Ariz.

Actual plant construction, initially involving between 75,000 and 100,000 sq. ft. and costing more than $2 million, will begin soon on a 480-acre site north of Phoenix.

Pending completion of the new plant, Sperry will start preliminary manufacturing operations in January using 10,000 sq. ft. of leased space at the Arizona State Fair Grounds in Phoenix. The company is not planning regular employee recruiting programs until later next year.

Lockheed Contracts For Nuclear Facility

Lockheed Georgia Division has let a $1,151,000 contract for construction of a nuclear support laboratory building as part of its A-plane research center at Dawsonville.

Laboratory will house engineers and scientists from Lockheed's Georgia Division and will include a two-story office building plus two one-story wings. It will be situated on a 10,000-acre tract set aside for the multi-million dollar Air Force center.

Missile Gyro Firm Votes 200% Stock Dividend

Directors of G. M. Giannini & Co., producers of missile gyros and control components, have voted a 200% stock dividend subject to approval of California Commissioner of Corporations.

Dividend is payable December 1 to holders of record November 15 and will increase company's common share holdings to 300,000. Giannini's present backlog of $5.6 million is highest in its history. It compares with $3 million in unfilled orders a year ago.

Convair Top Employer At Palmdale

Convair Division of General Dynamics Corp., builder of the *Terrier* and *Atlas* missiles, is now the largest contractor from the standpoint of employment at Palmdale, Calif., jet flight test center.

Convair payroll numbers more than 1,300; Northrop Aircraft is second with about 1,100. However, Convair is reported to be hiring at the rate of 50 each week and expects to employ approximately 1,800 by the year-end.

Litton Division Moves

U.S. Engineering Co., Inc., a division of Litton Industries, has occupied larger facilities located at 5873 Rodeo Blvd., Los Angeles 16.

Cooper Changes Name, Plans New Facilities

Cooper Development Corp., formerly Cooper, Inc., plans to construct a two-story office building and other production facilities at its Monrovia, Calif., location.

The company manufactures rocket and missile systems and holds a contract with Grand Central Rocket Co. for a rocket-motor unit for the *Vanguard* third stage.

Greer Forms R&D Group

Greer Hydraulics, Inc. of Jamaica, N.Y. has set up a new research and development division under v.p. Jules Kendall to develop and build prototype missile test systems.

New division has undertaken projects with Navy Bureau of Aeronautics, The Martin Co. and Farnsworth Electronics Co. on missile test systems and is also assisting in evaluation work on advanced rocket fire control systems.

Greer's work with Farnsworth was not disclosed, but presumably involves the Air Force's Boeing *Bomarc* supersonic surface-to-air missile. The Ft. Wayne, Ind. division of International Telephone and Telegraph Corp. is known to be developing a "push-button" go or no-go type test system for the ramjet and rocket-powered *Bomarc*.

AMF To Build New Lab

American Machine & Foundry Co. is planning construction of a $4-million central engineering laboratory on a 38½-acre tract at Stamford, Conn.

New unit will consolidate operations now situated at four locations in Greenwich, Conn., and one already in Stamford. No manufacturing is planned in the new facility.

New *Talos* Facility Gets Defense Nod

Navy has received approval of Defense Secretary Charles E. Wilson for a $4,440,000 expansion of facilities at the Naval Industrial Reserve Ordnance Plant, Mishawaka, Ind., for production of the *Talos* surface-to-air missile.

Plant is operated by Bendix Aviation Corp., prime contractor on the ramjet-powered *Talos*.

Norden-Ketay Plans Move

Norden-Ketay Corp. has begun construction of an executive office building on a 450,000 sq. ft. plot in Stamford, Conn. as part of a program to shift its offices from 99 Park Ave., New York City.

A second building, already in the planning stage, will house a central research laboratory for the company's missile activity. Contracts it holds in this field now exceed $5 million.

Pending completion of the new facility, the company has leased a building on Commerce Rd., Stamford.

Talco Commissions New Catapult Test Facility

A rocket-catapult for ejection of fighter pilots from high-speed aircraft has entered the test phase at Talco Engineering Co. of Hamden, Conn. Evaluation is being conducted at the company's new testing facility on a 23-acre plot at No. Branford, Conn.

Facilities at the new site include a 200-ft. horizontal track to handle large cartridge-activated devices and a 25-ft. track to test small units.

North American Gets $65-million Contract

North American Aviation, Inc. has received a $65,507,103 Air Force contract for continuation of research and development of undisclosed weapons systems.

NAA is known to have at least three major missile or rocket engine programs now underway. In addition to its own Navaho missile, the company is building liquid propellant engines for the Army's Chrysler Redstone missile and Convair's *Atlas* intercontinental ballistic missile.

Beckman Sales, Earning Up

Beckman Instruments, Inc., producers of missile test instrumentation, reported a 38% increase in sales and similar jump in earnings over 1955 for its fiscal year ended June 30.

Company's net after taxes was $1,744,856 compared with $1,322,050 last fiscal year. Sales were $29,362,131 against $21,330,598 for the year ending June 30, 1955.

Lockheed Again Expands Missile Division

Mushrooming activity at Lockheed Aircraft Corp.'s Missile Systems Division has resulted in a 1,000% expansion of space planned less than a year ago for its new facilities in Stanford University's Palo Alto, Calif. industrial park.

Lockheed now plans to start construction of a 51,000 sq. ft. laboratory, bringing to seven the number of buildings either completed or underway. It will also raise the Division's facilities to about 1,000,000 sq. ft. compared to some 96,000 sq. ft. it projected less than a year ago.

The new laboratory will supplement two similar research buildings occupied in September and a 14,000 sq. ft. experimental building soon due for completion.

Missile Systems Division payroll now numbers about 5,000 and Lockheed anticipates that sales in 1956 will more than double the $25 million recorded last year.

Ouest-Aviation Reveals Missile Projects

First details of guided missile activity by Ouest-Aviation (formerly SNCASE), including a series of strategic missiles with a completely new navigation system, have been disclosed by the nationalized French aircraft firm.

The company has developed another missile for armament on its Vautour bomber and is working on a long-range ground-to-air missile for which its *Trident* will serve as a manned prototype.

First pilotless *Trident* is expected to begin flight tests soon.

GE Sets Up New Missile, Ordnance Departments

General Electric Co.'s Defense Electronics Division has set up a Missile and Ordnance Systems Department under general manager George F. Metcalf with key elements to be situated in Pittsfield, Mass. and Philadelphia.

New department will take on systems responsibility for surface-basic weapon systems and associated equipment to be used on land and sea, according to Division manager, Dr. G. L. Haller.

Nucleus for the new organization will be GE's former Naval Ordnance Dept. in Pittsfield and its Special Defense Projects Dept. in Philadelphia. However, the company does not anticipate any substantial shift of personnel or facilities from present locations.

Five Firms Named In *Sidewinder* Program

Navy's announcement that *Sidewinder* air-to-air missile has entered operational status (see page 27) also made it official that five major firms are involved in its development and production.

In addition to prime production by Philco Government Industrial Division, Navy recently awarded a $1-million second source contract to General Electric Co. at Utica, N.Y.

Avion Division of American Car & Foundry at Paramus, N.J., built experimental missiles during the *Sidewinder's* research and development stage at Naval Ordnance Test Station, China Lake, Calif.

Two other firms named were Bulova Research and Development Laboratories, Woodside, N.Y., and Eastman Kodak Co., Rochester, N.Y. Participation by the latter confirms use of infra-red or heat-seeker type of guidance system. The company is also developing the Navy's *Dove* air-to-underwater missile believed to employ these guidance techniques.

Bell Sued on Computer Deal

Missouri Research Laboratories, Inc. has filed suit against Bell Aircraft Corp. for $12,267 in alleged unpaid overhead costs arising out of secret radar work it subcontracted from Bell in 1948 and 1949.

The St. Louis firm charged in Federal District Court, Buffalo, N.Y., that it incurred the expenses in modifying a radar computer under a $51,350 government sub-contract with Bell.

Marquardt Employment Up 65% Since January 1

Employment at Marquardt Aircraft Co., producer of the ramjet engines for the Boeing *Bomarc* missile, reached 2,000 on October 1—a 65% increase since the beginning of the year. Company expects it to reach 3,000 by mid-1957.

Distinction of being the 2,000th

employee went to George C. Johnson who joined Marquardt's test engineering division as an engineer.

Industry Briefs

SERVOMECHANISMS, Inc., specialists in aircraft and missile control systems, has opened new corporate offices at 445 Park Ave., New York City. Company also operates two divisions at Westbury, L.I., two in California at Hawthorne and El Segundo, a research laboratory near Santa Barbara, Calif., and has two Canadian subsidiaries at Toronto.

THE GARRETT CORP.'S AiResearch Manufacturing Division has begun construction of two new laboratory buildings in Los Angeles. New facilities will be used to broaden the company's electronic and instrument operations.

RAYTHEON Mfg. Co. of Waltham, Mass., has received a $60-million Navy contract to produce *Sparrow* III air-to-air missiles of undisclosed configuration.

HUGHES AIRCRAFT Co., Culver City, Calif., builder of the *Falcon* air-to-air missile, has received a $5,420,700 Air Force contract for fighter missile systems and support equipment.

FLIGHT RESEARCH, INC. of Richmond, Va., and Traid Corp. of Sherman Oaks, Calif., manufacturers of photographic recording instruments, have signed a joint sales representation agreement.

CONVAIR has awarded a $1-million contract to Berkeley Div. of Beckman Instruments, Inc. to develop and build an electronic synchronizing system to cross-correlate operational flight test data. It will be used in Convair's missile program presumably the *Atlas* ICBM.

NORTH AMERICAN AVIATION, Inc. will develop new titanium alloys of 170,000 psi tensile strength —40% higher than that of present alloys—under a $2.2-million Air Force contract.

OFFICE OF DEFENSE MOBILIZATION has awarded a rapid tax writeoff of $44,624 at 70% to Industrial Tool & Machine Co. of Smithfield, R.I., for manufacture of missile components.

Industry Highlights

By Fred S. Hunter

Few people realize the progress Lockheed's Missile Systems division has made in the last six or eight months. Truth is it has been little less than phenomenal. A year ago Lockheed's missile division had some good business, but it also could have done with some additional projects which could have produced a profit, not merely big, thick reports. Today, its contracts total 28 in number. Some of these, of course, are on the modest side in dollar-volume and future prospects. But others are highly stimulating contracts, leading all the way up to weapons system management.

•

Because of the magnitude of three or four of these projects, Lockheed has already outgrown its expansion plans, which were pretty optimistic in the first place. Lockheed had every intention of being out of its Van Nuys missile facility by the end of this year. But it simply could not build its new plant at Sunnyvale fast enough. This left it no recourse, but to revise its plans so as to retain the Van Nuys facility, much to the disappointment of the California division, covetously eyeing the space. Here, incidentally, appears an ironic implication for the future. One of these days, when the manned aircraft passes out of the picture, it undoubtedly will be Lockheed's still growing missile division doing the coveting of the California division's Burbank space.

•

Lockheed expects that one year from now it will have more than 10,000 employees on the missile division payroll. This not only assures the permanent continuation of the Van Nuys facility, but means more construction than originally planned probably will have to be added for the new facilities in the San Francisco Bay area, and with no waste of time.

•

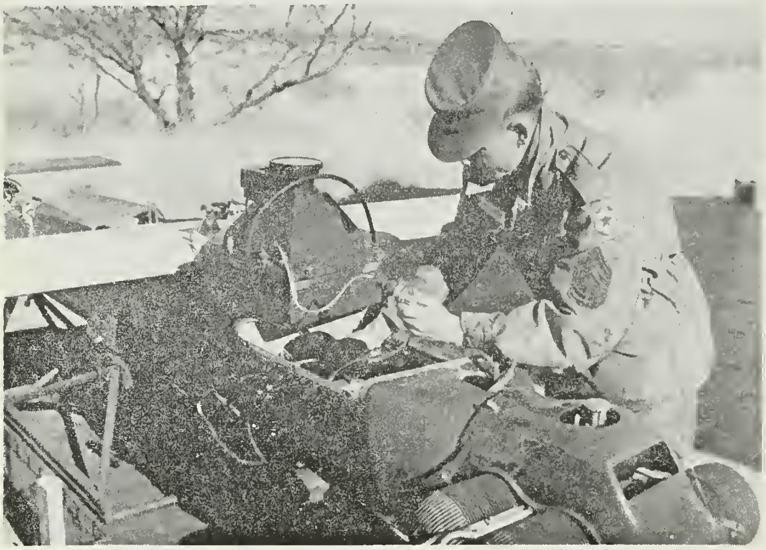
North American Aviation hasn't as yet appointed a chief engineer to succeed Ray Rice, who recently became general manager of the Los Angeles division. Most likely candidate probably is L. L. Waite, who now heads up the so-called MACE (Missile & Control Equipment) group at Downey. Waite was in engineering before he was upped to vice president at Downey, and it would be a logical promotion. MACE, as such, probably will be broken up after North American moves its corporate offices into the new general office building now under construction in El Segundo. This will leave the two divisional setups, Autonetics and Missile Development, at Downey.

•

Convair is working hard to make Florida life more pleasant for its transplanted Californians. It has started construction on a $2,000,000 housing project at Cocoa Beach, Fla., where it will build 130 houses on a 45-acre site to lease to Astronautics employees working at the Air Force missile test center. J. R. Dempsey, program director for Convair's ATLAS intercontinental ballistic missile, said the employees will have the privilege of buying the homes through private financing.

NEW MISSILE PRODUCTS

MISSILE CAMERA



New 20-pound aerial reconnaissance camera designed by Hycon Mfg. Co. for use in missiles and high-speed drones features built-in image motion compensation for forward speed at the time an exposure is made.

The Hycon K-20 uses 9 x 9 film and a 6-in metrogen lens to provide maximum area of coverage. Initially, it was developed for the Radioplane RP-71 drone under direction of the Army Signal Corps Engineering Lab.

Write: **Hycon Mfg. Co., Dept. M/R, 2961 E. Colorado, Pasadena, Calif.**

MINIATURE GYRO

Aeronautical Div. of Minneapolis-Honeywell Regulator Co. has developed a ½-pound, miniature integrating gyro company engineers feel may prove the answer to short-term inertial needs for a mass-production, low-drift-rate, floated gyro.

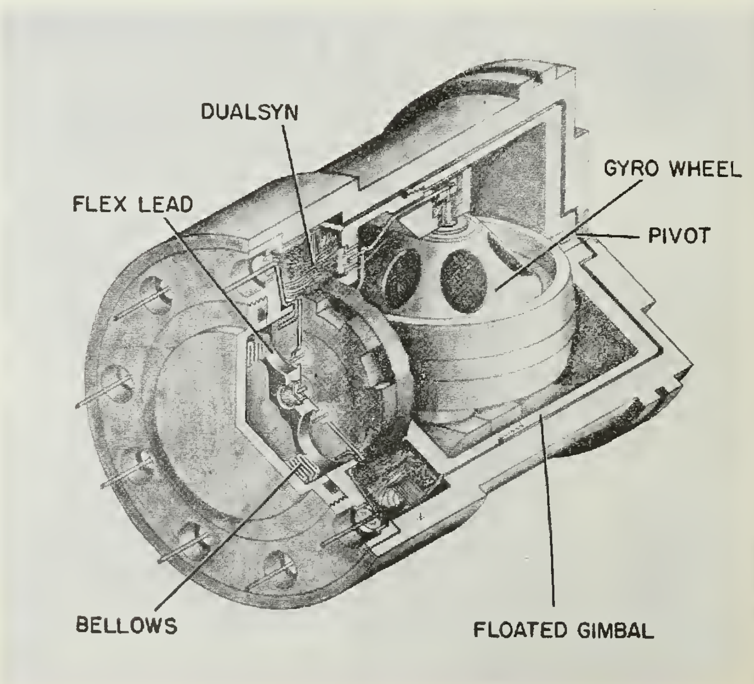
Called the MIG (miniature integrated gyro), it has entered production this month and low-quantity output is expected early in 1957.

M-H officials say the new unit has the same angular momentum as its HIG-5 gyro with performance comparable to the larger HIGs under rugged environmental conditions. The unit was developed for Douglas Aircraft Co. in its Navy instrument program, but its role was expanded for Jet Propulsion Laboratory's major missile program.

The MIG measures 1.75" in diameter and 2.5" long compared to 2.75" and 6" respectively for the HIG. One example of the extent of its miniaturization is a 7-watt internal heater element that is about the size of a dime.

M-H pilot production tests show a drift rate of less than .5 degrees/hour. Under trim with each warm-up, random drift rate will be in the order of .15 deg./hr., the company states.

Write: **Minneapolis-Honeywell Regulator Co., Aeronautical Div., Dept. M/R, 2600 Ridgway Rd., Minneapolis 13, Minn.**



STRUCTURAL ALLOY

A new magnesium-thorium alloy, designated HM21XA-T8, has been announced by The Dow Chemical Co for supersonic aircraft and missile applications. Quantities are on hand for immediate evaluation, the company states.

The new material is said to offer improved properties over its Dow predecessor, HK31A, in the 300 to 600°F range. It now extends that range to at least 700°, Dow officials say, and some tests have been conducted up to 900°. At 700°, the new alloy reportedly withstands prolonged exposure—in the order of 100 hrs.—with little effect on its properties.

Evaluation of HM21XA-T8 is being sponsored by USAF's Wright Air Development Center materials lab.

Write: **The Dow Chemical Co., Dept. M/R, Midland, Mich.**

FLURAN SEALANTS

Complete chemical resistance to highly oxidizing acids and alkalies, including red and white fuming nitric acid, is reported by Chemical Process Equipment Division of U.S. Stoneware Co. for its new fluorocarbon sealants.

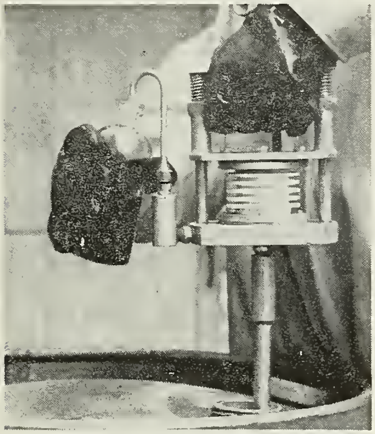
Fluran J-20 and J-30 are designed for sealing stainless steel and aluminum joints in high-speed aircraft and missiles. Fluran J-20 is rated as moderately soft and J-30 as soft, and both may be applied from the container as received, or with a caulking gun having a 150 to 175°F heating chamber.

Fluran is a grey-white putty-like material and is said to have an indefinite shelf life. Because of its high initial cost (now $55 per pound) manufacturer suggests its use only in highly critical applications. Write: **U. S. Stoneware Co., Dept. M/R, Akron 9, Ohio.**

ACID SAMPLER

A lightweight, hand-operated sampler developed for use by rocket and guided missile contractors in testing fuming nitric acid has been announced.

The unit is designed to permit rapid removal of acid samples from containers without the hazard of tilting or dipping. It is intended for use in field work or factory operations where nitric acid samples must be secured for laboratory analysis.



Operation of the unit involves placing the pick-up tube in a container and pumping a hand lever. The acid is transferred into a jar or receptacle near the handle. The device minimizes danger to the operator during the process, yet permits him to vary the position of the pick-up tube to insure that a representative sample is secured.

Unit weighs three pounds and is said to be priced at $274 each. Write: **Texas Metal and Manufacturing Co., Dept. M/R, 6114 Forest Park Rd., Dallas, Tex.**

VACUUM PRESSURE SWITCH

A Gorn GAB 1000 series of vacuum pressure switches respond to pressure as low as 2 inches of mercury absolute, and are said to retain their accuracy to ± 1 inch of mercury pressure under conditions encountered in missiles.

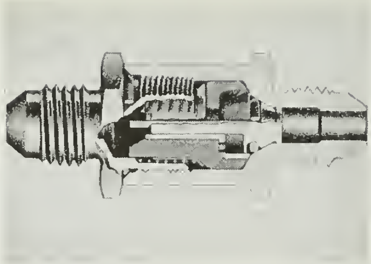
Operating element as a bellows that resists self-actuation under severe vibration to 2000 cps at 10 g. The switch was designed for use in inert gas vacuums. Write: **Gorn Aircraft Controls Co., division of Gorn Electric Co., Dept. M/R, 845 Main St., Stamford, Conn.**

CHECK VALVES

Protected type 3,000-psi stainless steel check valves for missile pneumatic systems guard the "O" ring seal on the valve poppet from damage due to flow turbulence or erosion.

This feature, the manufacturer says, allows a broad choice of synthetic materials for the seal since the tensile strength of the synthetic does not effect reliability of operation.

For example, a low tensile strength silicone can be supplied for



temperatures up to 450°F and special seals can be furnished for red fuming nitric acid.

The protected feature of the valve takes the shape of a cage with a cup-shaped end. When the valve opens, both poppet and seal move into the sheltered end and out of the flow stream around the cage. Literature available.

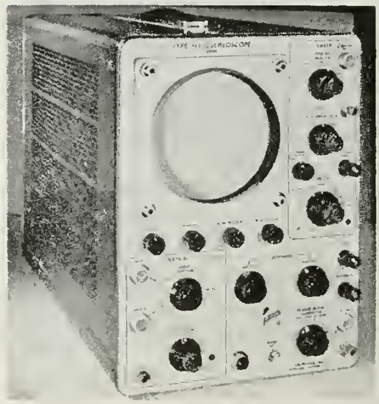
Write: **Mansfield & Green, Dept. M/R, 1051 Power Ave., Cleveland 14, Ohio.**

OSCILLOSCOPE

Tektronix has announced a Type 515 oscilloscope with a 5" cathode ray tube said to occupy less space and to have wider application than many larger instruments.

Size is 9¾" x 13½" x 21½". Bandpass is dc to 15 mc. with 0.023 μ/sec rise time. Calibrated sweeps from 0.2 μsec/cm to 2 sec/cm are said to be accurate within 3%.

The square wave calibrator has 11 steps from 0.05 v to 100 v said to be accurate within 3%. with a frequency of about 1 kc. Wgt. is 40 lbs.



Write: **Tektronix, Inc., Dept. M/R, P. O. Box 831, Portland, Ore.**

LOADING EQUIPMENT

Load-O-Matic, a new completely automatic loading platform for dock-to-truck materials handling operations has been introduced by Industrial Products Engineering Co. Hydraulically operated, it handles loads up to 20,000 pounds.

Up and down movement of Load-O-Matic is started by an automatic switch bar in the loading platform, or by an overhead pull switch if preferred. Platform is automatically stopped at the exact level of the truck floor by a leveling ramp which "bridges the gap" between platform and truck.

Load-O-Matic platform measures 8 ft. 6 in. by 4 ft. and is raised and lowered by a 8⅝-in. diameter piston. Lift speed is four seconds per foot.

Write: **Industrial Products Engineering Co., Dept. M/R, 26-40 Jackson Ave., Long Island City, N. Y.**

PROPELLANT VALVE

Hydromatics, Inc. has introduced a line of pressure-operated, multi-line propellant valves rated for use with a variety of fuels and oxidizers.

Valve design and materials are said to be suitable for controlling flow of liquid oxygen, JP-4, JP-5, air, helium, RFNA, WFNA, hydrazine, nitrogen, aniline, ethylene oxide, propyl nitrate, hydrogen peroxide, anhy-

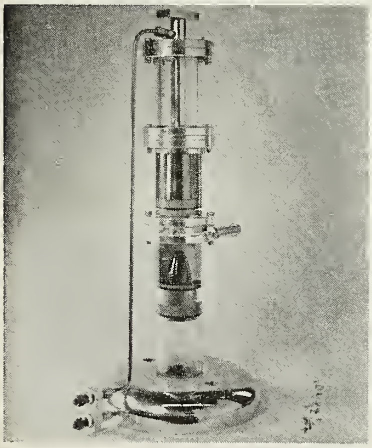
drous ammonia and water.

Light weight of the series is demonstrated by ½" — ⅝" 2-line model that weighs 2.5 lbs. Other types are available for 2-line or 3-line control functions for line sizes from ½ in. to 4 in.

The valves feature a floating ball-seat arrangement said to provide absolute zero leakage at extreme temperatures and pressures. Units are pressure actuated with inputs from 200 to 3,000 psi.

Line operating pressures handled by the valves range from zero to 1,500 psi. Write: **Hydromatics, Inc., Dept. M/R, Cedar Grove, N. J.**

SHOCK TESTER



A dynamic shock testing device, which measures only 26 in. high and 3 in. in diameter, yet produces a 12,000-pound thrust, is being marketed by Consolidated Electrodynamics Corp. under license with Convair.

The instrument is designed for shock testing of components for jet engines, aircraft, missiles and rockets.

The Hyge unit consists basically of a cylinder enclosed piston that is subjected to differential pressures on its two faces. There are only two moving parts—piston and a floating seal—with no complicated controls.

Design of the actuator is modular in concept to provide a variety of forms to meet specific applications. For testing large objects, a group of instruments can be connected and fired simultaneously to provide additional power and range. Literature available. Write: **Consolidated Electrodynamics Corp., Rochester Div., Dept. M/R, 1775 Mt. Read Blvd., Rochester 3, N. Y.**

FREE GYRO

G. M. Giannini & Co. has developed a new free gyro, the Model 3416, with a drift rate said to be less than 18 minutes of arc per minute. It features a cast steel frame mounted solidly inside a structural outer shell having an integral cg mounting flange.

Shock specification for the Model 3416 is 50 g's in all axes. Potentiometers which supply outputs up to 70 volts for telemetering and control operations have a linearity of ±0.5% and resolution of 0.09°.

Motor is powered by 115, 200 or 26 volt three-phase 400 cps voltage.

Write: **G. M. Giannini & Co., Dept. M/R, 918 E. Green St., Pasadena 1, Calif.**

INTERNAL DIMENSION GAUGE

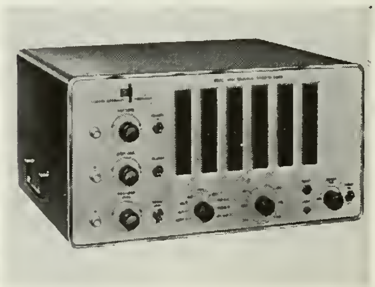
Internal dimensions from 5 to 36 inches may be measured to an accuracy within several millionths of an inch by the Internal Calibrating Master. In kit form, the gauge has a plastic handle with a gauge cartridge mounted in one end and an adjustable screw assembly on the other.

A series of ⅝ inch diameter bars of different lengths thread into the gauge handle to provide a wide range of adjustment. Connected to an electronic amplifier, various amplifications of the cartridge signal are available in different switching ranges.

Amplifications from 10 to 20,000 are available through switching. The gauge operates on 110 volt 60 cycle power. Write: **The Sheffield Corp., Dept. M/R, Dayton 1, Ohio.**

COUNTER TIMER

Model 226A universal counter timer has been designed for precise measurement of frequency, frequency ratio, period (1/frequency) and time interval. Featured are direct readout in kilocycles, megacycles, seconds or milliseconds with automatic decimal point indication.



There is provision for oscilloscope marker signals for trigger level adjustment of start and stop points. Three independent continuously adjustable trigger level controls permit full rated sensitivity at any voltage level between —300 and + 300 volts. Write: **Computer-Measurements Corp., Dept. M R, 5528 Vineland Ave., North Hollywood, Calif.**

TEFLON HOSE & FITTINGS

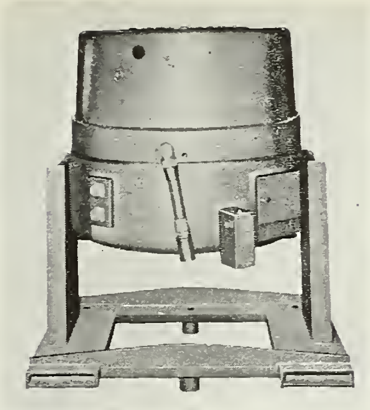
Aeroquip Corp. has introduced a new combination of Teflon hose and "super gem" fittings for use in aircraft and missile fluid systems including red and white fuming nitric acid.

Aeroquip's Type 666 hose is rated for operation in temperatures from —100 to 500°F. The new 666000 fittings features an arrangement wherein compression during assembly is applied to the wire braid only to grip the hose in the fitting. Fluid sealing and fitting retention become separate functions within the same fitting.

Reinforcement for the Teflon inner tube in the 666 hose is provided by stainless steel wire braid, making the assembly non-oxidizing inside and out. Fittings are reusable. Write: **Aeroquip Corp., Dept. M/R, Jackson, Mich.**

VIBRATION EXCITER

An oil-cooled, electrodynamic vibration exciter produced by MB Manufacturing Co. is rated to produce a continuous force output of 3,500 to 5,000 lbs. and equivalent acceleration in a frequency range from five to 2,000 cycles.



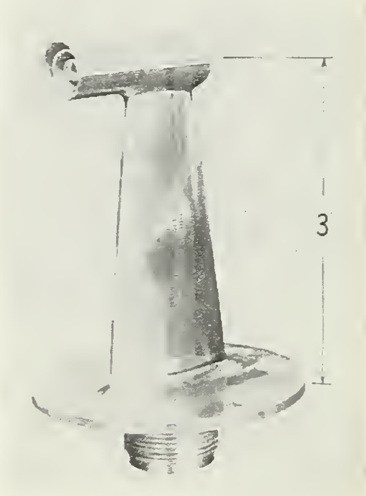
The Model C25HB meets these performance ratings at environmental chamber altitudes from 0 to 125,000 ft., relative humidities from 0 to 95% and temperatures between —100° and +300°F.

Exciter may be rotated 90° and operated in any position from vertical to horizontal. It is used with electronic or rotary power supply and either automatic or manual control system. Literature available.

Write: **MB Manufacturing Co., Dept. M/R, 1060 State St., New Haven, Conn.**

TEMPERATURE PROBE

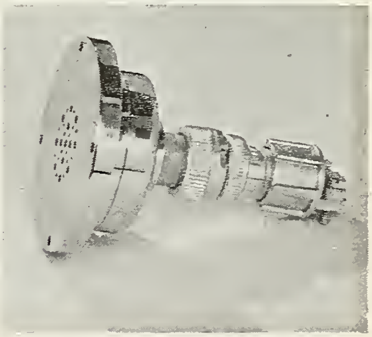
Rosemont Engineering Co. has introduced a total temperature probe designed to meet critical accuracy requirements of Air Force specifications for air measurement at speeds up to Mach 3 and higher.



Model 101U probe features a 50-ohm platinum resistance thermometer element that is said to be hermetically sealed without sacrificing the very low time constant.

Available literature describes probes that are useful to temperatures of 1500°C.

Write: **Rosemont Engineering Co., Dept. M/R, Rosemont, Calif.**



DYNAMIC PRESSURE PICKUP

A dynamic pressure pickup will measure pressures that may consist of complex waves from sonic vibrations, blast pressures and water hammer in liquid-filled lines.

The Type 4-430 pickup features low internal impedance of 100,000 ohms, calibration retention, high output and lack of phase lag or overshoot between 3 and 2500 cps.

The pickup will operate at a pressure range of 10-4 to 100 psig and temperature range of —10 F to + 140 F. Size of the unit is 1⅞ in. diameter, and thickness of about 1 in. Write: **Consolidated Electrodynamics Corp., Dept. M/R, 300 North Sierra Madre Villa, Pasadena, Calif.**

ELECTRON MICROSCOPE

An electron microscope with better than 20 Angstrom resolving power operates at 100 kv and has a hinged objective lens for quick change or cleaning of pole inserts.

Also featured are a magnetic compensator, objective diaphragm with multiple apertures, and insert screen with binoculars for ultra-thin specimens. Pole pieces permit magnification to be continuously variable through a range of 5,000 to 100,000 diameters.

With diffraction pole pieces, the magnification ranges from 1,750 to 35,000 diameters. Camera equipment extends the range to 200,000.

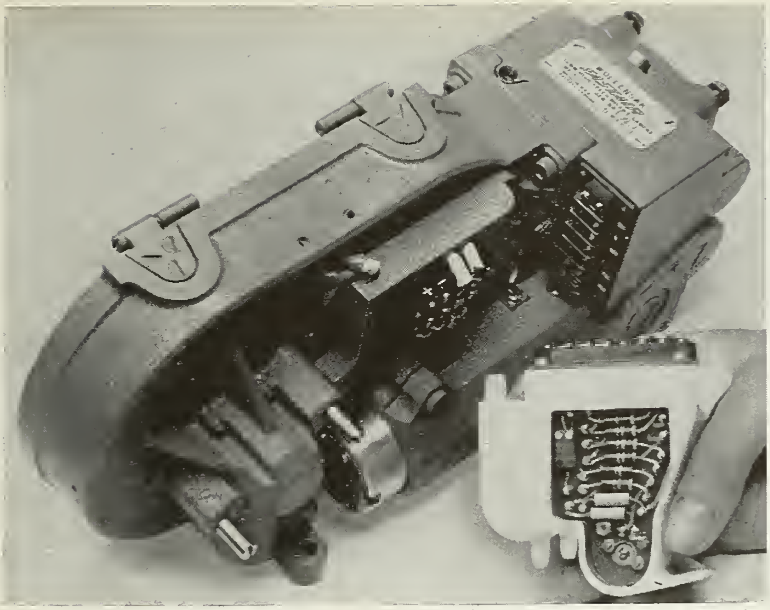
Weight of the unit is 1251 lbs. and it operates from 110 to 440 volt supplies. Cooling water of 2-3 quarts per minute at 30 psi or over is needed. Write: **North American Philips Co., Inc., Dept. M/R, 750 South Fulton Ave., Mount Vernon, N. Y.**

GUIDANCE MOUNTING

All external plumbing is eliminated in a new compact manifolded mounting base developed by Pacific Division, Bendix Aviation Corp. for a hydraulic missile guidance system.

The device was developed for Convair's Terrier missile. The package contains 18 components, all mounted on the manifold and interconnected with 15 ft. of integral plumbing. As a result, components can be removed readily for servicing and the entire system can be tested as a unit and installed in a minimum of time.

The Terrier's hydraulic system uses compressed air to deliver electrical power for the missile wing actuation through integral servo valves and cylinders, and hydraulic power for a remotely located roll actuator. Write: **Bendix Pacific Division, Dept. M/R, 11600 Sherman Way, No. Hollywood, Calif.**



TIMING GENERATOR

A new 2¼-ounce timing generator developed by Lockheed Aircraft Corp.'s Missile Systems Div. is designed to pulse at any rate from once to 3,000 times per second.

Intended to supply a time base on the film of airborne data recording cameras, the Lockheed-developed unit is said to be virtually G-immune. It is being produced under license by Electromation Co.

Initial application will be in GSAP cameras modified for data recording and in the newly developed Wollensak Fastair high-speed missile camera.

The new unit occupies 4 cu. in. of space. Write: **Electromation Co., Dept. M/R, 116 So. Hollywood Way, Burbank, Calif.**

FLOATED RATE GYRO

A floated rate gyro manufactured from Monel, Inconel and stainless steels has been developed that eliminates the need for heaters to counteract differential expansion effects on accuracy over a temperature range of —65°F to +165°F.

Type R-170 gyro is of the hysteresis synchronous type for operation from 26 or 115 volts at 400 cycles single phase or three phase. Input to the pickoff is 26 volts ac and output is 5 volts with a 10k ohm load. Gimbal restraint is achieved by means of a torsion bar. The rate ranges from 15° per sec. to 1000° per sec. with natural frequencies from 15 cps for low range units to 100 cps for high range. Accuracy is said to be better than 0.5% and sensitivity better than 0.1%.

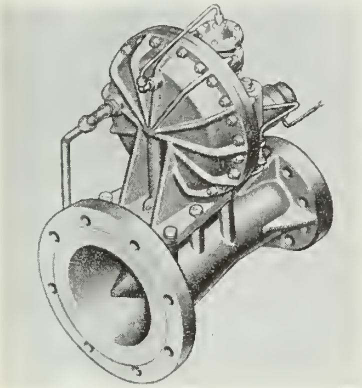
Write: **Whittaker Gyro, division of Telecomputing Corp., Dept. M/R, 16217 Lindberg St., Van Nuys, Calif.**

TELEMETRY TRANSMITTER

A VHF-FM telemetry transmitter is available that supplies 15 watts minimum rf power into a 50 ohm load over the frequency range of 215-235 mc. Type 1461-B is designed for PDM/FM modulation. The 1461-D is for FM/FM modulation. Either produces ±125 kc maximum deviation at the output frequency.

The transmitter is designed for bulkhead mounting. It uses an FM modulated crystal oscillator operating at 1/6 output frequency. Sine wave response from 100 cps to 80 kc is ± 2.5 db. Square wave response has a rise and fall time of not more than 5 microseconds. Weight is about 34 ounces. Size of the unit is 5 19/32 x 3 13/16 x 4 inches.

Write: **Telechrome Mfg. Corp., Dept. M/R, 28 Ranick Drive, Amityville, N.Y.**



PNEUMATIC VALVE

A pneumatic pressure regulator and shut-off valve, developed by The Garrett Corp.'s AiResearch Industrial Division, is designed specifically for rocket, ramjet and jet engine facilities where source gases are stored under high pressure.

The new valve operates with a closing time of 1/10th of a second and provides a zero leakage shutoff control. Its regulating function is to reduce high pressure gas at 3,000 psi inlet pressure to a pre-determined lower outlet pressure.

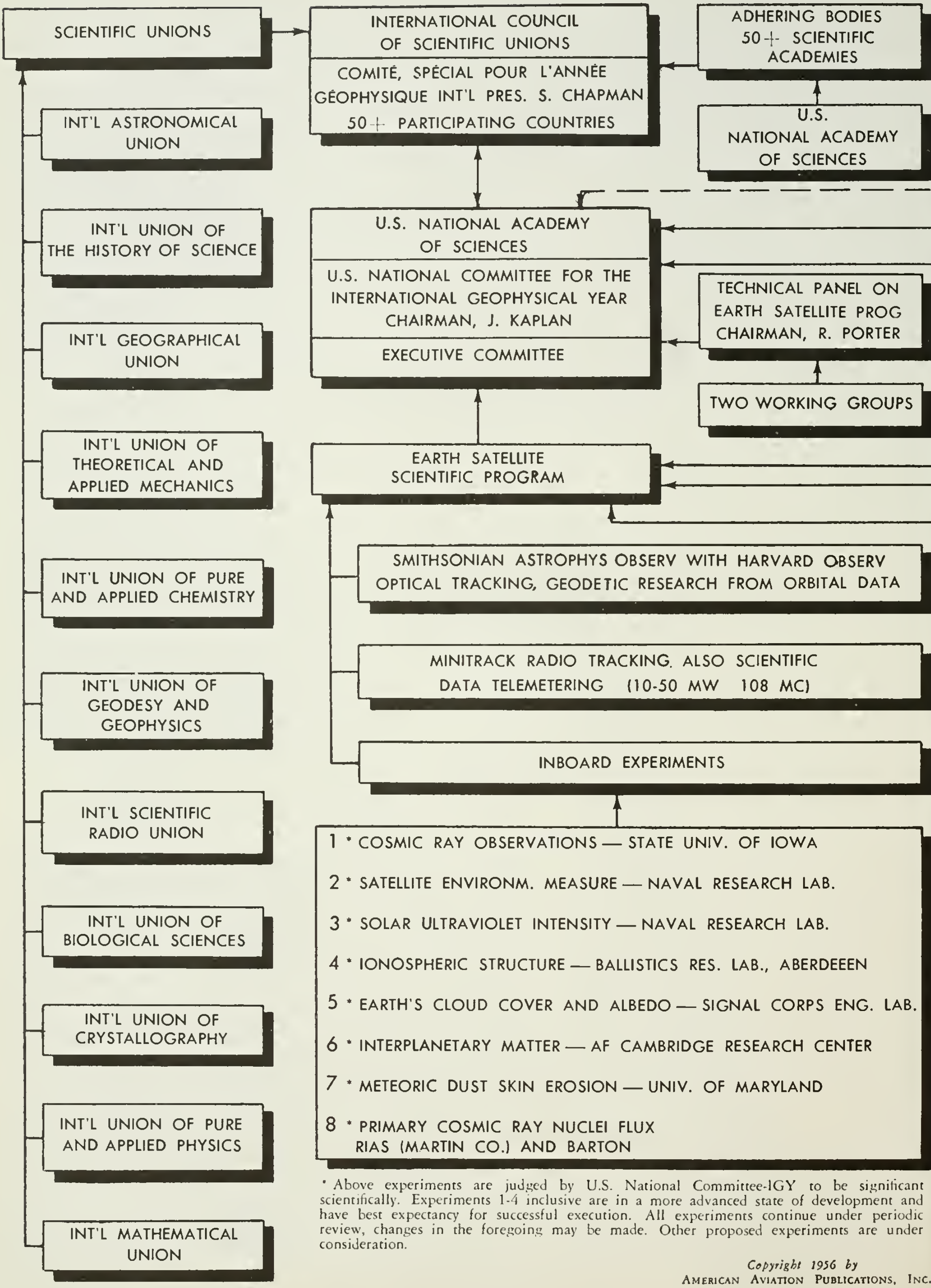
In addition, the basic valve can be used as a reducing and shut-off valve for other high-pressure industrial gas systems such as flowing nitrogen or natural gas. Write: **The Garrett Corp., AiResearch Industrial Div., Dept. M/R, 9851 Sepulveda Blvd., Los Angeles.**

Missile Literature

SCIENTIFIC SERVICES. New brochure outlines engineering facilities and services, including aeroelasticity and structural dynamics, aerodynamic research, aircraft operations, missile design, thermoelastic research, vibration analysis and testing. Write: **Allied Research Associates, Inc., Dept. M/R, 43 Leon St., Boston.**

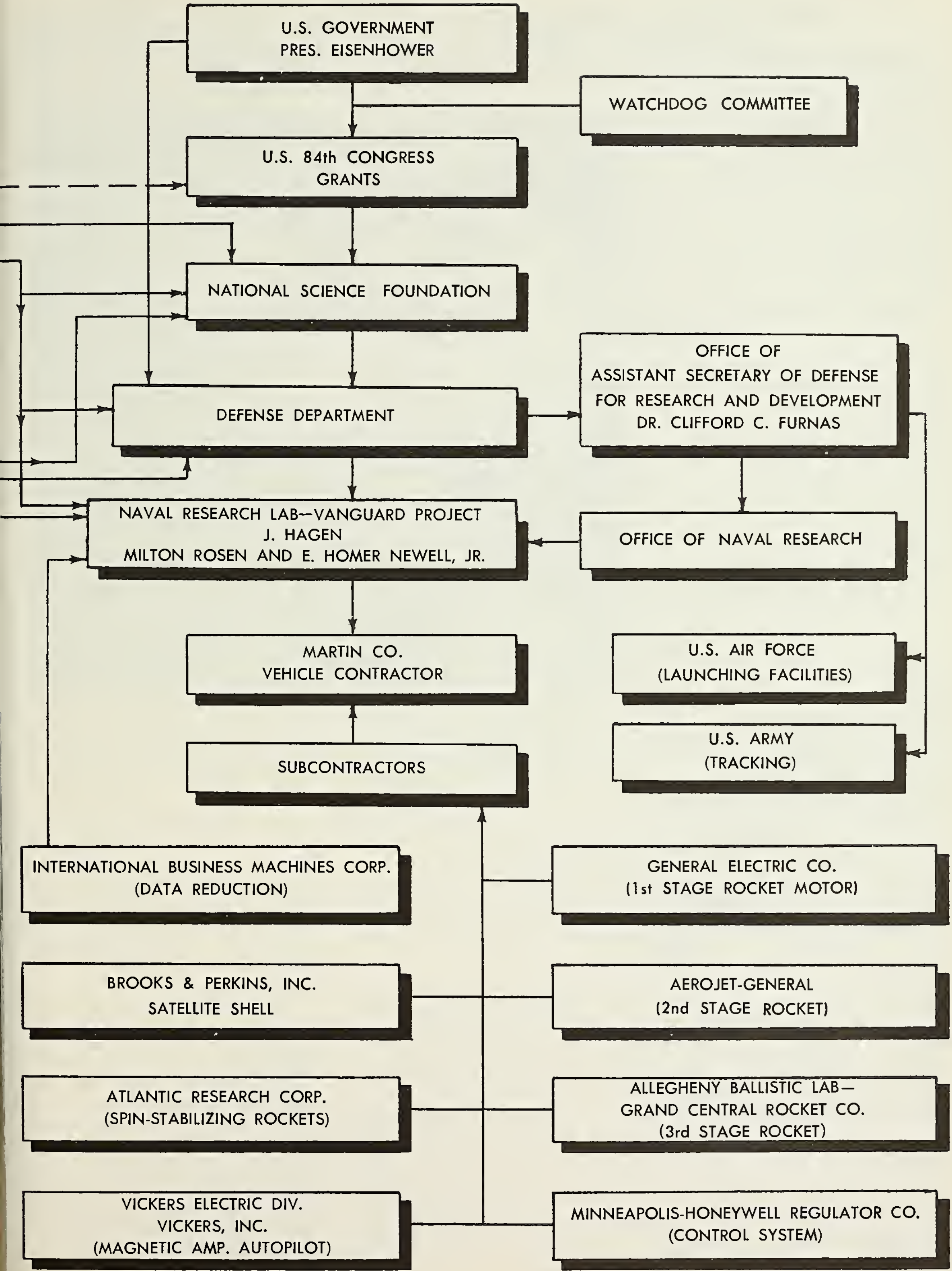
MISSILE FORUMS. Two new bulletins, GEZ-1741 and GEZ-1742, present extensive treatment of technical forums on guided missiles conducted by General Electric's special defense products department. Topics include systems engineering, aerophysics problems of hypersonic flight and hypersonic experimentation. Write: **General Electric Co., Apparatus Sales Div., Dept. M/R, Schenectady 5, N.Y.**

HYDRAULIC VALVES. Data sheets describe new 3-way selector and lightweight restrictor valves for 3,000 psi hydraulic service. Write: **Aircraft Products Co., Dept. M/R, 300 Church Rd., Bridgeport, Pa.**



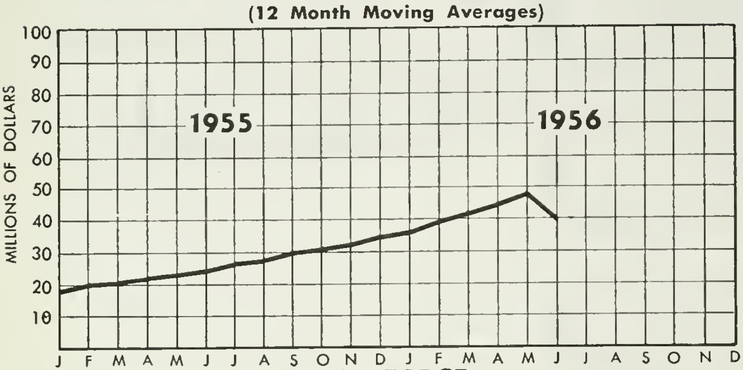
* Above experiments are judged by U.S. National Committee-IGY to be significant scientifically. Experiments 1-4 inclusive are in a more advanced state of development and have best expectancy for successful execution. All experiments continue under periodic review, changes in the foregoing may be made. Other proposed experiments are under consideration.

EARTH SATELLITE VEHICLE PROGRAM

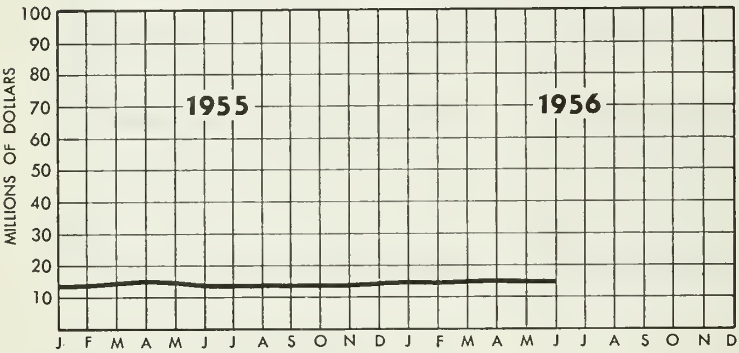


INDUSTRY BAROMETER

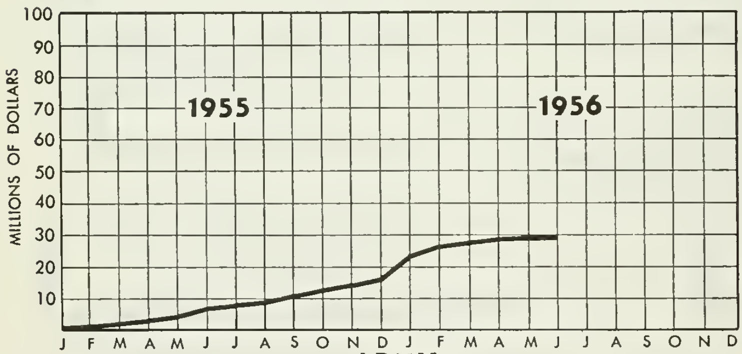
GUIDED MISSILE EXPENDITURES
(12 Month Moving Averages)



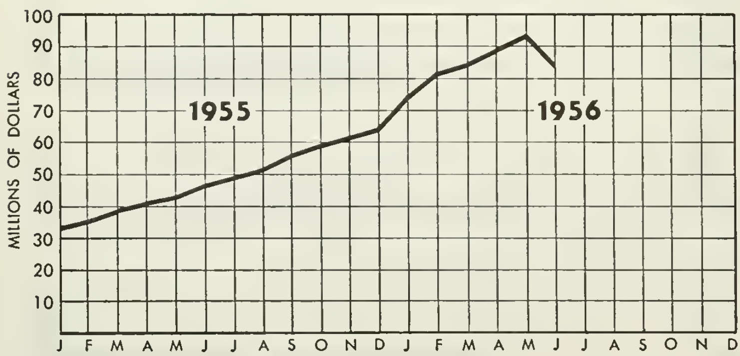
AIR FORCE



NAVY



ARMY



THREE SERVICES TOTAL

As missile expenditures by the three services change from month to month, these variations tend to observe some rather obvious trends. To eliminate the extreme peaks and valleys of the monthly data (see Industry Barometer-October 1956), we have employed a twelve month moving average. A twelve month moving average is a yearly average adjusted one month at a time.

For example, the expenditure figure shown for the Air Force for the month of January 1955 was obtained by adding the monthly figures of February through December 1954 and January 1955, then dividing by 12 to get the monthly average for this period.

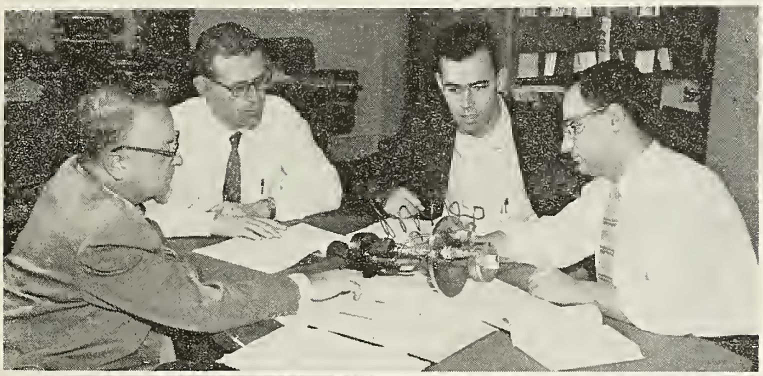
The accompanying graphs demonstrate rather forcibly the rapidity in which missiles have been integrated into the services as major offensive and defensive weapons. For the twelve month period ending January 1955, the average monthly guided missile expenditures by the Army was $302,000. Exactly one year later the average monthly expenditures was $24,151,000, an increase of $23,849,000, an increase of 7897%!

Navy's average monthly expenditures for missiles has been rather consistent. Low for the period January 1955-June 1956, was August 1955 ($13,886,000). High month was May 1956, $15,731,000, a difference of $1,845,000.

Air Force is currently spending some $45,000,000 per month on missiles and related equipment. This is an increase of approximately $25,000,000 over January 1955. As Air Force is obligating money for this account at the average rate of $60-65 millions per month, 1957 expenditures should reach the $60,000,000 per month level.

Missile expenditures by the Department of Defense have risen rapidly from $34 millions (January 1955) to the current level of $95,000,000 (May 1956). The services are now obligating money which will, in turn, show up as future expenditures. By the end of 1956 or early 1957, these obligations incurred will become expenditures boosting missile procurement well above the $100,000,000 per month level.

RIAS RESEARCH for Tomorrow



RIAS "gravity" researchers plan an experiment to aid in verification of some of the concepts of general relativity theory. Left to right are: Dr. Gerhart Groetzinger, Dr. Phillip Schwed, Dr. Albert Krall, and Dr. Louis Witten. Bottom: Dr. David Kahn, RIAS staff scientist, studies the change in surface resistivity of strained wires.

STAFFED by a select group of scientists who are encouraged to create their own programs of theoretical and experimental study, the areas under study at Martin's RIAS Baltimore laboratory are in no way tied to product development or production line problems of the parent company at Middle River, Md. Research contracts from outside agencies are acceptable, provided that they deal with basic research consistent with current interests of the RIAS.

Very few of the technological problems in any given field of endeavor can be solved—whether concerning missiles, rockets, spaceships, or any other scientific area. RIAS is not preoccupied with this consideration. Nevertheless, "the right piece of mosaic" turned up in a program of basic research may offer the essential clue to a whole chain of important technological developments.

Just as plants, with the assistance of moisture and fertilizer, can convert light and inorganic elements into food and fuel, so the reprocessing of material, plus the addition of energy which can be converted for human use, may hold a clue to the solution of resupplying energy for crew members for long expeditions on a satellite.

Although the practical design concepts for such a mechanism may still be far in the future, it is already too late to begin expanding our understanding of the fundamental energy transfers that take place in plants. Scientists at RIAS, therefore, are looking into the physical, chemical, and biological aspects of photosynthesis. These studies may turn up knowledge useful only in areas far removed from space flight. But that is the chance taken by any explorer who seeks new fields of discovery.

Another problem close to the missile and rocket designer is that of material. But while the difficult material environmental aspects of this problem are, and must continue to be the object of applied research, scientists also may find it profitable to devote attention to such phases as surface resistivity, lattice dislocations in both crystal and structure, or the effects of impurities on brittle fracture of tomorrow's materials.

These latter approaches are typical of the multitudinous problems being tackled by solid state physicists and metallurgical scientists at RIAS who seek new effects, or a better understanding of previously known phenomena, in order to be able to add to the store of knowledge of the properties of materials. Studies such as these may turn up clues to the eventual attainment of materials with strength properties on the order of magnitudes better than those which are presently available.

Welfare of Mankind

RIAS was chartered in 1955 to seek underlying knowledge of the phenomena of nature and to "evolve new technical concepts for the improvement and welfare of mankind." The function of the scientist at RIAS is to cultivate sufficient seeds of new knowledge, leaving to the practicing technician the function of harvesting the right crops.

A break-through in nuclear physics, for example, might, to the propulsion engineer, ultimately revolutionize his concepts of space travel, while to the medical researcher the same discovery might mean a new weapon in the war against cancer.

The process of transforming new discoveries into useful products, meanwhile, will be quickened by the relationship which RIAS enjoys with industry.

Through lectures and reports, members of the engineering profession, as well as representative groups of scientific colleagues from universities, government, and industry, are already being apprised of the developments in basic research occurring at the RIAS research center.

At present occupying temporary quarters at 2120 North Charles Street, RIAS will eventually move to a larger laboratory to be constructed in the suburban Baltimore area. END

CALENDAR

OCTOBER

29-31—Air Industries and Transport Assn. (Canada), annual general meeting, Chateau Frontenac, Quebec.

NOVEMBER

1-3—National Aviation Trades Association annual convention, St. Louis.

8-9—SAE national fuels and lubricants meeting, Mayo Hotel, Tulsa, Okla

13—Fourth Massachusetts Aviation Conference, Hotel Statler, Boston.

14-15—Aircraft Industries Association export conference, Miami Beach, Fla.

15-16—New England Radio-Electronics Meeting, sponsored by Boston and Connecticut section of IRE, Hotel Bradford, Boston.

25-30—American Rocket Society annual meeting, Henry Hudson Hotel, New York City.

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

DECEMBER

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

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

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

JANUARY

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

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

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

FEBRUARY

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

MARCH

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

People

Alexander Kartveli, vp and chief engineer of Republic Aviation Corp., under a change of duties program will devote full time to heading company-wide research

Alexander Kartveli

and development activities in aircraft, guided missiles, and programs in such fields as weapons systems, atomics, nucleonics, and electronics; **Richard G. Bowman** advances to chief engineer in charge of production and experimental en-

Dr. William O'Donnell

gineering; and **Dr. William O'Donnell** has been promoted to chief engineer in charge of aircraft and missile development.

Col. L. Zoeckler is the new chief of the aircraft and missiles division of Air Materiel Command. He will be responsible for procurement and production of all aircraft and guided missiles for the Air Force.

Dr. Herbert C. Corben is now a member of the staff of the Electronic Research Laboratory, The Ramo-Wooldridge Corp.

Dr. Bruno H. Wojcik has been appointed manager of research and development for the industrial chemicals division of the Olin Mathieson Chemical Corp.

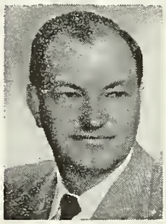
Dr. Raymond H. McFee, until recently director of research of the Electronics Corp. of America, has been appointed director of research for Aero-Jet General Corp's electronics and guidance division.

K. F. Umpleby was promoted from chief engineer to asst. Gen. Mgr. of the York division, Bendix Aviation Corp. **W. H. Sims, Jr.,** has been named chief engineer.

Dr. Frank C. Hoyt has joined Lockheed's missile systems division as asst. director of research and head of the general and nuclear physics div. of the research labs.

Samuel Storchheim has been promoted to chief of manufacturing engineering & research in the Martin Co.'s nuclear division.

Charles D. W. Thornton was appointed director of research at Farnsworth Electronics Co.


Ballhaus


Thornton

Dr. William F. Ballhaus, chief engineer for Northrop Aircraft, Inc., Hawthorne, Calif., has been elected chairman of the Aircraft Industries Association's Guided Missile Committee for the coming year. He succeeds **Edwin A. Speakman,** vice pres. and gen. mgr. of Fairchild Guided Missiles Div.

Members of the AIA Guided Missile Committee, made up of representatives of the leading missile manufacturers in the country, have just returned from Norfolk, Va., where they were briefed on the operations and capabilities of the USS Boston, one of the Navy's new missile ships.

RAdm. William Henry Ashford. Jr. (USN, ret.) has been made manager of the newly formed missile applications division in the Electric Storage Battery Co.'s Exide industrial division.

Dr. Marshall N. Rosenbluth has joined the general atomic division of General Dynamics Corp.

F. E. Huggin, formerly of Lockheed missile system, has been appointed design specialist at the San Diego advanced electronic research and development center of Marvelco Electronics division, National Aircraft Corp.

Gerhard Reethof has been named chief of research under the director of research and development for Vickers Inc.; **LeRoy D. Taylor** is asst. chief engineer for development.

George I. Willis, asst. to the gen. mgr. of Hamilton Standard, division of United Aircraft Corp., will head the company's new electronics department.

Peter J. Schenk has been named manager of the projects section for the new Technical Military Planning Operation in the General Electric defense electronics division.

William A. Rockwood has been made asst. gen. mgr. of the telecommunication division of Stromberg-Carlson, a division of General Dynamics Corp.; **Robert E. Dobbin** has been named chief engineer.

Kirke W. Marsh has been appointed general project manager on a major guided missile project of Bendix Aviation Corp., North Hollywood, Calif. Prior to joining Bendix in February of this year, he was senior project engineer for Fairchild Guided Missiles on a project for the Navy Bureau of Ordnance in cooperation with the National Bureau of Standards.

William Q. Nicholson, director of engineering for Hycon Manufacturing Co.'s instrument division, has been appointed chief staff engineer for the company. He will direct the development, introduction and promotion of new products. Before joining Hycon in 1951 Mr. Nicholson was a research engineer for Hughes Aircraft Co., and an electrical engineer at Gilfillan Brothers, Inc.

Arthur Sommer has been named mgr. of engineering for the American Bosch Arma Corp.'s Arma Division.

Donald R. Church has been named chief engineer of Acoustica Associates, Inc., a firm which designs and manufactures ultrasonic cleaning, processing and measuring systems. **Morris Kenny** has been appointed project engineer of the company's long-range Air Force missile systems development program; **Martin A. Damast**, senior electronic engineer.

J. Donald Haas, formerly a project engineer and then asst. Dayton representative of Reaction Motors, Inc., has been appointed asst. Washington representative.

Samuel Storcheim promoted to chief of mfg. engineering and research in The Martin Co.'s nuclear division.

RAdm. William Henry Ashford, Jr. (USN ret.), appointed mgr. of Electric Storage Battery Co.'s new missile applications division.

Marcus C. Eliason appointed gen. sales mgr. of Air Associates, Inc.

Charles D. W. Thornton appointed director of research at Farnsworth Electronics Co.

Donald M. Hazard has been promoted from assistant to the engineering mgr. of Pratt & Whitney Aircraft to chief of engineering operations at the company's Florida branch.

Karl D. Swartzel, former head of the physics dept. of the Cornell Aeronautical Laboratory, has been named chief research and development engineer of the Guided Missiles Div. of Republic Aviation Corp. He will be in charge of operations research as well as development of new missiles systems.

J. S. Morison has been appointed chief of Douglas Aircraft Co.'s missiles computing section and **O. E. Nemitz** chief of the Co.'s missiles data reduction section.

Baboo Ram Teree

Baboo Ram ("Bob") Teree, recently chief engineer of Weatherhead Co.'s Aircraft Division and Special Products Division, has been appointed chief engineer of Greer Hydraulics, Inc., Jamaica, N. Y.

Eugene E. Crowther has been named base mgr. of Lockheed Missile Systems Division's flight test base at Holloman AFB, Alamagordo, N. M., succeeding **Everett E. Christensen**, transferred to Van Nuys as asst. flight test division engineer. **Dr. Alan Andrews** has been appointed to the staff of the nuclear physics and engineering dept. and **Dr. William E. Frye** to the staff of the division's research laboratories at Palo Alto, Calif.

E. C. Cornford has been named head of the Guided Weapons Department of the British Supply Ministry.

The new Missile and Ordnance Systems Dept. of General Electric Co.'s Defense Electronics Division, with headquarters at Philadelphia, will be headed by **George F. Metcalf**, formerly gen. mgr. of the Special Defense Projects Dept.

John E. Lowe appointed director of personnel and pub. rel. of American Machine & Foundry Co.'s new guided missile launching system plant.

New Propellant Firm

Propellex Chemical Corp., a new firm specializing in development and production of propellants and explosives, has been formed by Dr. Robert A. Cooley, formerly of Olin Mathieson Chemical Corp.

Company has set up headquarters at 227 Oakley Place, East Alton, Ill. and has arranged for sufficient land, buildings and production facilities in that area. Plan is to place major emphasis in the aviation field on gas generating devices such as jet engine starters, aircraft and missile power units and non-electric safety devices.

In launching PCC, Dr. Cooley said company officials are convinced there is a whole new world of propellant and explosive actuated tools not only for the military but for industry.

As examples he cited guided transport missiles, auxiliary gas generators for emergency power, ejection devices and jet starters.

Dr. Cooley indicated that the library of propellants now known to industry permits the safe, reliable and economical use of propellant power to take the place of bulky air compressors or electric power sources. He noted, too, that more versatile and less expensive propellants based on fertilizer grade ammonium nitrate are rapidly being developed.

British Propellant Firm Formed

British Oxygen Research and Development Co., Ltd., a new firm, was formed early this month to take over the Research and Development Station of the British Oxygen Co. Group.

Firm has undertaken a two-fold investigation of the basic problems of liquid oxygen, as a rocket propellant and for crew breathing needs.

Thompson to Build Fuel Test Facility

Thompson Products, Inc., Accessory Division has set 1957 as target for start of operation in a new $10-million facility to be built near Roanoke, Va. to test rocket and missile fuel and auxiliary power systems.

Propulsion Notes

By Alfred J. Zaehringer

Drastic reductions in solid propellant costs are in evidence with new Phillips Petroleum Co. propellant plant 66 at McGregor, Texas. The ammonium nitrate-carbon black-synthetic rubber propellant runs about ten cents per lb. sec. impulse which includes motor and propellant. Unit is the M15 RATO which has an operating temperature range of —75° to 170° F. One shot takeoff system for B-47 now costs about $160 a unit as compared to about double cost of old unit.

•

New process developed by Olin Mathieson is aimed at dropping costs of double-base solid propellants. Propellant cost for some newly developed units has dived below $1/lb. Previous double-base costs averaged $5-10/lb, especially for development units.

•

Scientists at Standard Oil Co. (Ind.), developers of new smokeless cartridge starter for B-57, believe solids will prove useful in space operations. Reason: about 30% greater performance than advanced liquid fuel motors and long-term storage under space conditions.

•

Rocket lab at Purdue is studying film cooling of rocket motors. Engineers at the lab conclude that experimental data are needed on friction co-efficients, flow of films, and turbulence of flows before film cooling can be put on a sound engineering basis. With WFNA and JP rocket motors using film cooling, loss in specific impulse varied linearly with film coolant flow. Loss of 1-4% in I_{sp} results with 2-9% coolant flow.

•

Is first firing of an atomic rocket motor near? AEC labs at Los Alamos and Livermore have openly announced research and development on nuclear rocket propulsion. Sandia Corp. also has been hinting at the same thing. General Electric has generally been pessimistic about an atomic rocket motor. However, it is significant to note that two of today's big guns in conventional rocket propulsion—North American and Aerojet—have entered the atomic side door in the reactor field.

•

Combustion work done at Royal Aircraft Establishment indicates that chlorine introduction may lower flame temperatures in hydrocarbon combustion. Carbon formation results in large heat absorption. Result: ramjets and turbojets that run cooler but emit black smoke exhaust. Bromine was also studied but it has a definite inhibiting effect on limits of flammability. British missile industry has put substantial emphasis on ramjets lately, although liquid rocket development is progressing satisfactorily.

THEORETICAL PERFORMANCE OF SEVERAL ROCKET PROPELLANT COMBINATIONS

Prepared by ROCKETDYNE *a Division of North American Aviation, Inc.*

SYMBOLS

- (white bar) Theoretical specific impulse (I_{sp}), sec
- (shaded bar) Theoretical specific impulse x bulk density ($I_{sp}d$), (sec) ($\frac{g}{cc}$)
- r Mixture ratio, lb oxidizer/lb fuel
- T_c Theoretical combustion temperature, F
- γ Ratio of specific heats, C_p/C_v
- M_c Average molecular weight of combustion products
- d Bulk density, g/cc, at 80F* of propellant combination at given mixture ratio.

$$d = \frac{r+1}{\frac{r}{d_{oxidizer}} + \frac{1}{d_{fuel}}}$$

*The density at the boiling point was used for those oxidizers or fuels which boil below 80F at one atmosphere pressure

CONDITIONS

Combustion chamber pressure = 500 psia

Nozzle exit pressure = 14.7 psia

Optimum nozzle expansion ratio ($\frac{\text{exit area}}{\text{throat area}}$)

Contraction ratio ($\frac{\text{chamber area}}{\text{throat area}}$), assumed to be infinite

Adiabatic combustion

Isentropic expansion of ideal gas

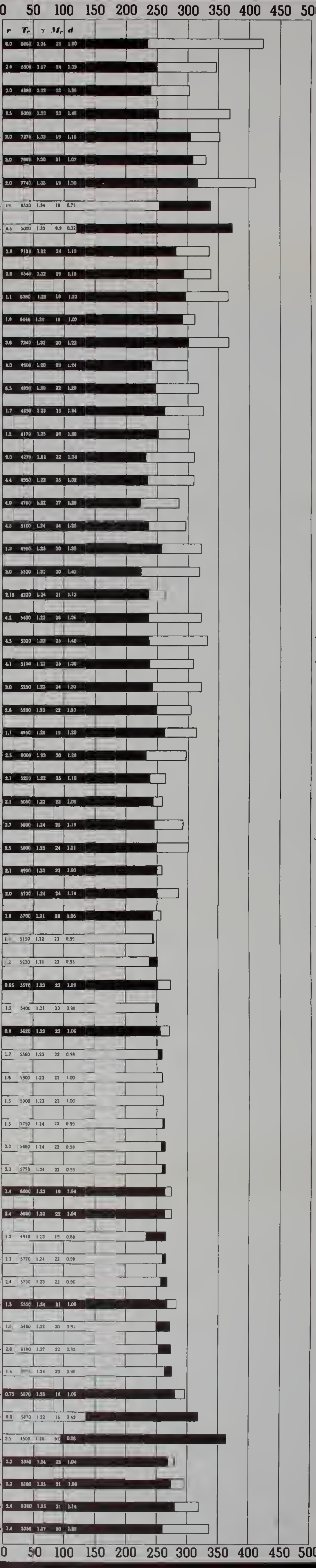
Compositions expressed in weight percent

The composition of the combustion products was assumed to be frozen at chamber conditions. If shifting equilibrium were assumed during expansion, the theoretical specific impulse would be 3 to 10 percent higher. The most important parameter determining this increase is the combustion temperature, the increase being greater at higher temperatures.

TO CONVERT I_{sp} AND $I_{sp}d$ TO OTHER CHAMBER PRESSURES

PRESSURE	MULTIPLY BY
200	0.89
300	0.94
400	0.98
500	1.00
600	1.02
700	1.03
800	1.05
900	1.06
1000	1.07
1100	1.09
1200	1.10

oxidizer	fuel	r	T_c	γ	M_c	d
BROMINE PENTAFLUORIDE	AMMONIA	6.0	6660	1.34	29	1.80
85% CHLORINE HEPTOXIDE + 15% NITROGEN TETROXIDE	TURPENTINE	2.8	5900	1.27	24	1.39
CHLORINE TRIFLUORIDE	AMMONIA	3.0	4980	1.32	22	1.36
	HYDRAZINE	2.5	6000	1.33	23	1.48
FLUORINE	AMMONIA	2.0	7270	1.33	19	1.16
	DIBORANE	3.0	7880	1.30	21	1.07
	HYDRAZINE	2.0	7740	1.33	19	1.30
	HYDROGEN (MAX. $I_{sp}d$)	19.	8530	1.34	18	0.75
	HYDROGEN (MAX. I_{sp})	4.5	5000	1.33	8.9	0.32
	JP-4	2.8	7100	1.22	24	1.19
50% FLUORINE + 50% NITROGEN TRIFLUORIDE	AMMONIA	3.8	6540	1.32	19	1.15
OXYGEN DIFLUORIDE	HYDRAZINE	1.1	6380	1.28	18	1.23
	AMMONIA	1.8	6040	1.28	18	1.07
	n-OCTANE	3.8	7240	1.33	20	1.22
99.6% HYDROGEN PEROXIDE	92.5% ETHYL ALCOHOL	4.0	4800	1.20	23	1.24
	JP-4	6.5	4830	1.20	22	1.28
	HYDRAZINE	1.7	4690	1.22	19	1.24
90% HYDROGEN PEROXIDE	HYDRAZINE	1.3	4170	1.25	18	1.30
54% HYDROGEN PEROXIDE + 40% AMMONIUM NITRATE + 6% WATER	KEROSENE	9.0	4270	1.21	22	1.34
100% NITRIC ACID	TURPENTINE	4.4	4950	1.22	25	1.32
95% NITRIC ACID	BUTYL MERCAPTAN	4.0	4780	1.22	27	1.28
RFNA (6.5% NO_2)	n-OCTANE	4.5	5100	1.24	24	1.26
RFNA (15% NO_2)	HYDRAZINE	1.3	4980	1.25	20	1.38
RFNA (22% NO_2)	TRIETHYL-TRITHIOPHOSPHITE	3.0	5520	1.21	30	1.42
	AMMONIA	2.15	4220	1.24	21	1.12
	TURPENTINE	4.2	5400	1.22	26	1.36
	POLYETHYLENE	4.5	5320	1.22	25	1.40
	JP-4	4.1	5150	1.23	25	1.30
	80% DIETHYLENETRIAMINE + 20% METHYLAMINE	3.0	5250	1.23	24	1.33
	UNSYMMETRICAL DIMETHYL HYDRAZINE	2.6	5200	1.23	22	1.23
NITROGEN TETROXIDE	HYDRAZINE	1.1	4950	1.26	19	1.20
ON 7030 (70% NITROGEN TETROXIDE + 30% NITRIC OXIDE)	TRIETHYL-TRITHIOPHOSPHITE	2.5	6000	1.23	30	1.28
	METHYL ALCOHOL	2.1	5210	1.22	25	1.10
	50% AMMONIA + 50% METHYL ALCOHOL	2.1	5050	1.23	23	1.06
	63% TRIETHYLAMINE + 37% ORTHOTOLUIDINE	3.7	5600	1.24	25	1.19
	TURPENTINE	2.5	5800	1.25	24	1.21
	AMMONIA	2.1	4900	1.23	21	1.03
	ETHYLENE OXIDE	2.0	5730	1.24	24	1.14
OXYGEN	ETHYL SILICATE	1.6	5700	1.21	26	1.05
	75% ETHYL ALCOHOL	[illegible]	5150	1.22	23	0.99
	METHYL ALCOHOL	[illegible]	5230	1.21	22	0.95
	NITROETHANE	0.85	5570	1.23	23	1.09
	92.5% ETHYL ALCOHOL	1.5	5400	1.21	23	0.98
	NITROPROPANE	0.9	5620	1.23	23	1.06
	ISOPROPYL ALCOHOL	1.7	5560	1.22	22	0.98
	PROPYLENE OXIDE	1.6	5900	1.23	23	1.00
	62.5% PROPYLENE OXIDE + 30.5% ETHYLENE OXIDE	1.5	5900	1.23	23	1.00
	ETHYLENE OXIDE	1.5	5750	1.24	22	0.99
	JP-4 ($C/_H$ = 6.85)	2.2	5880	1.24	22	0.98
	JP-4 ($C/_H$ = 6.00)	2.3	5770	1.24	22	0.98
	88% ETHYLENE DIAMINE	1.4	6000	1.23	19	1.04
	TURPENTINE	2.4	5880	1.23	22	1.04
	AMMONIA	1.3	4940	1.23	19	0.88
	METHYL CYCLOPENTANE	2.3	5770	1.24	22	0.98
	n-OCTANE	2.4	5730	1.23	22	0.96
	DIETHYLENETRIAMINE	1.5	5550	1.24	21	1.06
	METHYLAMINE	1.6	5460	1.22	20	0.91
	METHYL ACETYLENE	2.0	6180	1.27	22	0.93
	UNSYMMETRICAL DIMETHYL HYDRAZINE	1.4	[illegible]	1.24	20	0.96
	HYDRAZINE	0.75	5370	1.25	18	1.06
	HYDROGEN (MAX. $I_{sp}d$)	8.0	5870	1.22	16	0.43
	HYDROGEN (MAX. I_{sp})	3.5	4500	1.26	9.0	0.28
70% OXYGEN + 30% OZONE	JP-4	2.3	5950	1.24	22	1.04
30% OXYGEN + 70% OZONE	JP-4	2.3	6180	1.25	21	1.08
100% OZONE	JP-4	2.4	6380	1.25	21	1.14
TETRANITROMETHANE	HYDRAZINE	1.4	5250	1.27	20	1.28



Book Reviews

AERODYNAMICS, PROPULSION, STRUCTURES. *By E. A. Bonney, M. J. Zucrow and C. W. Besser. Edited by Capt. Grayson Merrill, U.S. Navy. Published by D. Van Nostrand Co., Inc., 120 Alexander St., Princeton, N. J. 595 pp. $10.00.*

This second volume in a series on the principles of guided missile design contains a wealth of fundamental data for practicing missile engineers and students. Ten chapters are devoted to all aspects of missile aerodynamics from preliminary design to flight test, eight to missile propulsion including ramjet, turbojet and rocket power, and five to structures and design practice. J. S. M.

A SPACE TRAVELER'S GUIDE TO MARS. *By Dr. I. M. Levitt, 175 pp. $3.50, Henry Holt and Company, New York.*

The title of this book is rather misleading. The theme indicates the book is written for science fiction fans and that it departs from known facts. But Dr. Levitt actually presents a highly respectful and skillfully authored introduction to tomorrow's Mars trip.

First of all, however, as only the expert astronomer could do it, Dr. Levitt has introduced a guide to planet Mars and to some extent to other planets and the universe. One can rightfully say that the author has "distilled all that is known about Mars into a highly readable book of interest to everyone with a normal curiosity about the world around us."

Furthermore, this is the kind of book that may merit consideration for vocational purposes. But this is not just another school book; this book belongs in the adult's library. Of particular interest is Dr. Levitt's concise and colorful description of the face of Mars and of atmospheric and climatic conditions on the neighbor planet.

In two appendices the author has included an absorbing section on the evolution of the solar system, its origin and the beginning of life. Illustrations are few but very good indeed.

E. B.

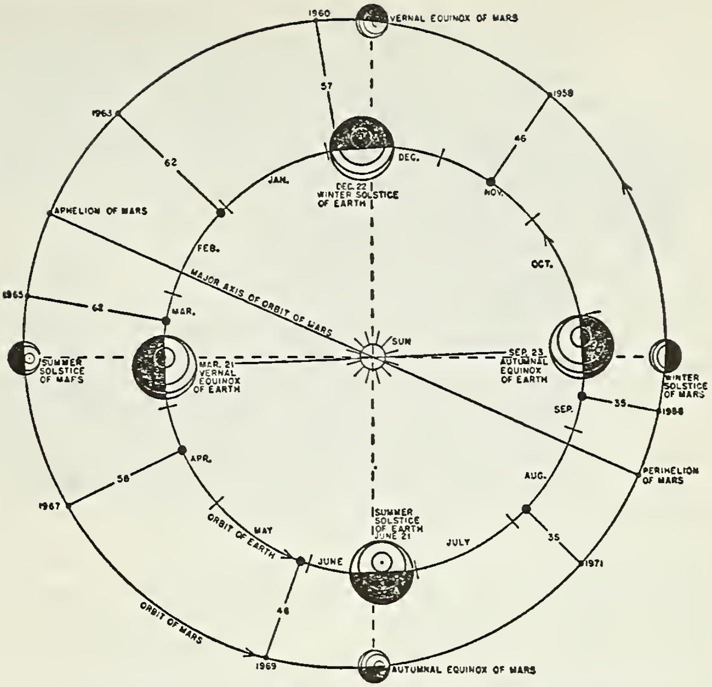
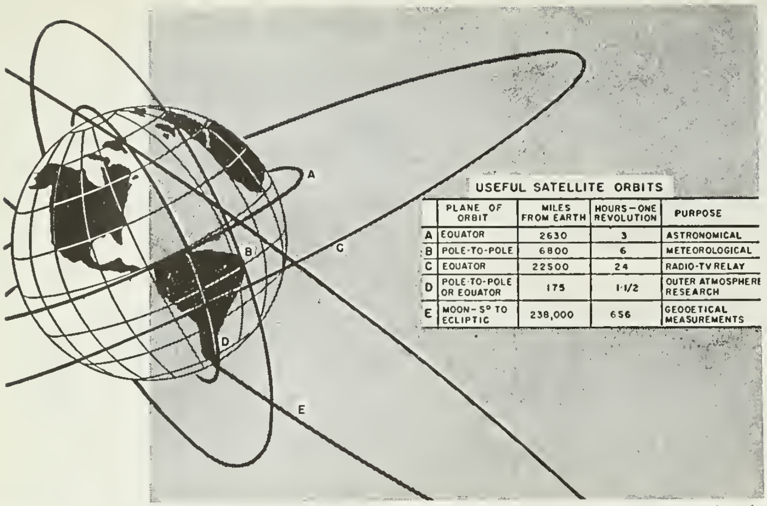


Illustration from GUIDE TO MARS. The orbits of the earth and Mars, as seen from the north pole of the sky, showing the near approach of the two planets. Notice that only those oppositions which occur in the fall are the close ones, when Mars is at perihelion.

VISION, A Saga of the Sky, *By Harold Mansfield, 389 pp., $5.00. Duell, Sloan and Pierce, New York.*

In this book author Mansfield has presented the spirited history of Boeing Aircraft Company as it evolved from a spark of enthusiasm caught by William E. Boeing while witnessing America's first international aeronautical tournament at old Domiguez Ranch, a few miles south of Los Angeles, in January, 1910. The story of the early flying machines which inspired Boeing, the Curtiss, Bleriot, and Farman, is familiar to all whose life work is firmly entrenched in man's dreams of conquering the heavens. Though the



	PLANE OF ORBIT	MILES FROM EARTH	HOURS—ONE REVOLUTION	PURPOSE
A	EOUATOR	2630	3	ASTRONOMICAL
B	POLE-TO-POLE	6800	6	METEOROLOGICAL
C	EOUATOR	22500	24	RADIO-TV RELAY
D	POLE-TO-POLE OR EOUATOR	175	1-1/2	OUTER ATMOSPHERE RESEARCH
E	MOON—5° TO ECLIPTIC	238,000	656	GEODETICAL MEASUREMENTS

Illustration from SATELLITE! shows useful orbits for different kinds of satellites contemplated during the next few years.

names and events belong to the history of Boeing Aircraft Company, the story is that of all aviation industry and mankind with the dreams, ambitions, set backs, and goals which have characterized the development of present day aviation. It is a book which, if begun, must be read; it is a book truly dedicated to, and inspiring, vision.

W.R.

SATELLITE! *By Erik Bergaust and William Beller, 287 pp. $3.95, Hanover House, New York.*

Erik Bergaust and William Beller have accomplished a difficult feat. They have written a book which is technically accurate and at the same time immensely fascinating. There are not many popular books which contain as an appendix a list of technical references and very few scientific books which are so absorbingly written you hate to put them down.

The authors have taken full advantage of their close contacts with the planners of the U.S. satellite program. They have dwelt on the background and the early history of the project and have presented the latest up-to-date technical information on the first satellites, their scientific applications, as well as on the technical problems of rockets, control and telemetering.

But there are other topics besides instrumented artificial satellites. Starting with a discussion of present rocket research planes, such as the X-1 and X-2, the book leads to their logical extension, the piloted satelloid vehicle which circles the earth in a satellite orbit partially supported by aerodynamic lift.

Beyond this the authors approach more cautiously such controversial topics as the giant space stations and exotic schemes of propulsion, such as photon rockets and gravity control; but all of it makes fascinating reading. The book ends with a discussion of a crucial problem, educating and training personnel for the age of space.

S. Fred Singer

How About a *DEGREE* In Missile Engineering?

By Captain Grayson Merrill, USN

NO first-line university, to the writer's best knowledge, offers open courses leading to a degree in Guided Missile Engineering.

Policy-making executives of leading United States institutions of learning should establish courses of instruction in Guided Missile Engineering, ultimately to achieve the present stature of Aeronautical Engineering. Available textbooks, students and teachers make this practical. Great public interest and essentiality to our national defense make it desirable.

The greatest proportion of U.S. engineers are working on research and development financed by the Department of Defense and, if the Fiscal Year 1957 budget is a guide, over one-half of these will be working on guided missiles.

It is paradoxical, therefore, that these engineers must train themselves "on-the-job" rather than in the nation's universities.

One probable reason for the tardiness of universities to set up guided missile instruction is the important factor of what unclassified literature they can utilize in teaching the subject. The Department of Defense has assumed no responsibility for creating such a body of literature and that which exists is principally in the form of uncorrelated technical papers sponsored by the technical journals.

Technologies employed in Guided Missile Engineering are probably more diverse than in any other field of application. There should be a broad undergraduate base, including mathematics through the calculus, physics, chemistry, electronics, mechanical engineering, and sufficient of the humanities to ensure social responsibility and administrative, as well as technical capacity.

Proper instruction using appropriate textbooks could lead to a BS or MS degree. A doctorate probably would involve specialization in one of the missile components, such as guidance, propulsion, aerodynamics, and would, of course, require original work of significance.

Effective guided missile instruction could be given by instructors presently working in allied fields, such as aeronautical, mechanical, and ordnance engineering. However, it obviously would be advantageous to recruit engineers, scientists, and technical officers of the Armed Services who can provide the desirable ingredient of practical experience.

In view of the great demand for such persons in the industry and the latter's salary advantage over institutions of learning, it is expected that retired persons will be a best source of experienced teachers, at least for some time.

Public opinion, in the form of literature and entertainment, indicates there is a deep-seated interest in guided missiles for young people. They see in it a fascinating challenge and a lucrative career which operates now to preserve national security and in the future to enable the exploration of space. A survey of any undergraduate technical body probably would show a strong predilection to guided missile careers.

Government will be forced to establish a positive program to solve the problem, possibly in the form of subsidy or other incentive for students of technologies important to national defense.

Patently, any university which already has established courses in Guided Missile Engineering will be in a position to benefit from such a program and serve its country at the same time.

Spare Time Rocketeers

A new section has been established by the Rocket Research Institute in Sacramento, California, to make a contribution to the International Geophysical Year: The designing, construction, and launching of an Intermediate Altitude Sounding Rocket to be known as *Spark* I.

Spark I system actually consists of two rockets, a 350-lb thrust, 85-second duration, liquid oxygen-alcohol sustainer rocket and a 5,000-lb thrust, one-second duration, solid-propellant booster rocket. Calculations indicate that the liquid sustainer will be able to carry instruments to altitudes in excess of 100,000 feet.

The Institute's project is being carried out by five development groups, Airframe, Facilities, Liquid Propulsion System, Projects, and Solid Propulsion System. The activities of each group are directed by professionals in the field. Consequently, even though the educational program is a non-military, unclassified endeavor, its value is increased because participants are guided by personnel with substantial industrial rocket experience.

The Rocket Research Institute, a non-professional organization with headquarters in Glendale, California, was established in 1943. All work is of a basic unclassified nature and members gain experience through "spare-time" training programs in which actual solid and liquid propellant rockets are designed, constructed, and tested.

Participation in the *Spark* I training program is open to all and a desire to learn more about rocket propulsion is the only prerequisite. Dues are $10 per year. For additional information, contact RBI Membership Committee, 2901 Rubicon Way, Sacramento 21, California.

18 Million Manhours Without Accident

A safety milestone unprecedented in the aircraft industry is claimed by Convair. Announcement that 88 consecutive days worked without a lost-time accident recently was given at Convairs' San Diego plant as a reminder to its 35,000 employees of their own unparalleled safety achievement. The 18,000,000 accident-free manhour mark reached was double the record-setting 9,000,000 manhours worked at Convair-San Diego last year without a lost-time accident.

For the 1955 achievement, the National Safety Council recognized Convair-San Diego as having established a world record for safety in the aircraft industry. Meanwhile, an inter-plant safety rivalry was developing rapidly as Convair-Pomona, the guided missile production facility Convair operates for the U. S. Bureau of Ordnance at Pomona, Calif., approached a full year worked without a lost-time accident.

Approximate man-hours worked without a disabling injury at Convair-Pomona recently was 9,821,224 established over a 359-day work period. Convair-Pomona attained the one-year no-acciden mark Oct. 25, with a manhour total of nearly 10,-000,000. Pomona's lower manhour record is attributable to its smaller payroll—less than one seventh the number at Convair-San Diego.

Redstone's Housing Crisis Being Eased

Critical housing shortages at the Army Ballistic Missile Agency and the Redstone Arsenal near Huntsville, Ala., are being relieved with award of a contract for immediate construction of 270 Capehart-type apartment dwelling units. These are the first of 670 such units already authorized.

Bush Construction Co. of Norfolk, Va., was awarded a $3,789,000 contract for the first 270 units. A contract of $98,502 for off-site utilities to serve the units was awarded to Nichols Plumbing & Heating Co. of Birmingham, Ala. Work has begun after ceremonies in which a charge of missile explosive replaced the traditional spade to break ground.

Contract specifications for the additional 400 units are being drawn for circulation to prospective contractors. Redstone already has 125 Wherry-type units. More than 9,000 civilians and 2,000 military personnel are employed at the missile and rocket center.

In another step to ease the housing shortage, special certificates of eligibility for housing benefits under Title 809 of the National Housing Act have been authorized for 500 essential civilian workers. Almost 300 of the certificates had been issued within the first week of the authorization which enables the Federal Housing Administration to guarantee more mortgages in given areas and to provide for lower down payments than on normal FHA-guaranteed mortgages.