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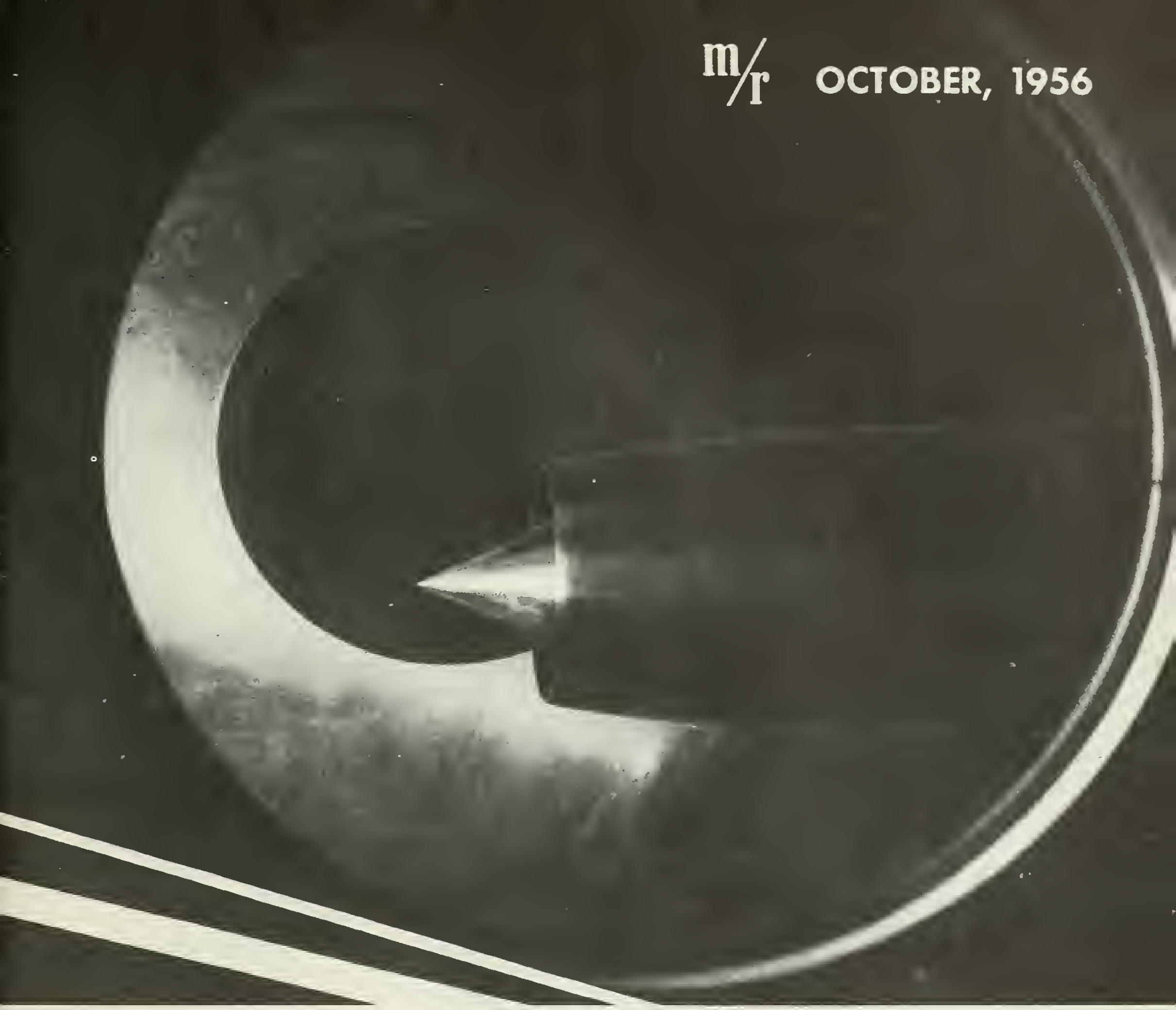

missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS

AN AMERICAN AVIATION PUBLICATION

IN THIS ISSUE: DR. WERNHER VON BRAUN • DR. HUGH L. DRYDEN • KURT R. STEHLING • LOVELL LAWRENCE JR. • VANGUARD SATELLITE IN PICTURES •

missiles and rockets

Magazine of World Astronautics

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A New Age Unfolds

THIS IS THE AGE OF ASTRONAUTICS. This is the beginning of the unfolding of the era of space flight. This is to be the most revealing and the most fascinating age since man first inhabited the earth.

Shortly the first satellite vehicles will be hurtled aloft by powerful rockets to bring back the known from the unknown. Out of the coming conquest of space will come scientific data that will benefit the whole world. There will be advances in the fields of meteorology, flight safety, medicine, physics and many others. The possibilities are without limit.

The visionaries who long ago dreamed of the conquest of space have been succeeded by scientists and industrialists who have transformed a fantasy into a vast and important industry combining the needs of defense with a search for peaceful uses of space vehicles.

Rocketry has come a long way since the time less than twenty years ago when Adolf Hitler and his close associate Heinrich Himmler were skeptical of the efforts being exerted by German scientists to build huge and costly rockets for upper air research. But the impact of the first V-1s and V-2s which fell on London was not lost on the scientists of the world. Today the rocket—or a rocket weapon—is being openly discussed as perhaps the ultimate weapon for the prevention of war. Perhaps it will be the last weapon of war.

The age of astronautics, as has been true with so many scientific advances, leans heavily upon the military in these early stages. But a great amount of research and development must come from scientific institutions and industry. A prime example of the frontal approach now being made is the Vanguard Satellite Program utilizing an amazing combination of talent from both military and scientific organizations.

A measure of the rapid expansion in the entire missiles field is the increase in expenditures by the Department of Defense alone from $21 million in fiscal 1951 to $1.3 billion in the current fiscal year. But this is only a part of the over-all total.

It is our purpose to serve this new and growing field of missiles, rockets, satellites and astronautics to the best of our ability and within the limitations of national security. Rigid though certain security restrictions may be, there is a vast amount of unclassified material available.

The official journal of the American Rocket Society, *Jet Propulsion,* is performing an excellent technical service. It is our purpose to supplement its valuable work with a news and feature periodical geared to the growing industrial, government and scientific requirements of what is today a complete new industry.

To ensure political quality, we have support without peer. Mr. Robert H. Wood, for eighteen years a top aviation editor, will supervise this magazine as editorial director for the company. Mr. Erik Bergaust, a recognized authority in the field of astronautics, is managing editor. In the background is an editorial board of world renowned scientists. We shall spare no effort to make MISSILES & ROCKETS a magazine that fulfills the interests and needs of all who believe that they are, indeed, embarking on another great adventure in the history of mankind.

WAYNE W. PARRISH
President and Publisher

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the Cover Picture

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Army to Launch 'Satellite' Before Vanguard?

Defense Research Officials Disturbed

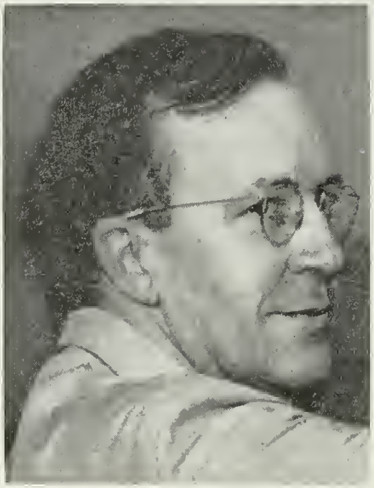
Army Ordnance rocket experts are quietly planning to launch what may become an Earth-circling "satellite" of their own—long before the Navy Vanguard is ready to go, MISSILES & ROCKETS has learned.

But the Army's plans for an "accidental" satellite aren't secret from high officials of the Office of Research and Development in the Defense Department. What's more, these officials make it clear they don't like the Army plan and that the soldiers have no authorization to launch a satellite.

Be that as it may, no one disputes that the Army possesses the raw capability of boosting a small rocket up to orbital velocity. This could be achieved with a *Redstone* rocket as the first stage, a *Sergeant* or some other ballistic rocket as a second stage and a small solid-propellant rocket as the third stage which would become an orbiter.

Thus, the potential does exist, and the current series of *Redstone* tests at Patrick AFB, Fla. may see the feat performed. Whether it works or not, however, it should be observed that a satellite would be merely incidental to the Army's basic desire to learn more about the staging techniques of tomorrow's ballistic missiles.

● **The three-step principle** is familiar to Redstone rocket scientists, but previously it has only been applied to small missiles. In order to learn more about the separation of stages for larger ballistic missiles the Army can well justify the "satellite experiment." In other words, the fact that a small uninstrumented body might be placed in an orbit around the earth is quite incidental and not so much of importance to the Army as is the valuable information it could obtain on separation of one missile from another.



VANGUARD'S JOHN P. HAGEN
Army coming from behind.

Although the Army "satellite" will be sort of appropos, if successfully launched, such experiments certainly will yield terrific prestige; after all, the Army was called upon originally to handle the hardware stage of the first Office of Naval Research satellite project, Project Orbiter, which was blended into the later Project Vanguard.

When asked whether Army Ordnance is planning to put up a "satellite," an Army spokesman told MISSILES & ROCKETS: "No comment"—but he said it with a smile.

An independent rocket propulsion expert was more definite: "Certainly, the Army has got hardware powerful enough to send a substantial payload to the moon!"

Meanwhile, the Naval Research Laboratory is struggling with the world's first instrumented satellite (first—provided the Russians don't beat us to it).

● **Vanguard project director** Dr. John P. Hagen claims his venture is moving along according to schedule. Because it is basically a crash program, many NRL scientists and technicians work overtime to meet the deadline. The magnitude of Project Vanguard is very great indeed; obviously the Vanguard engineers do not have much time to worry about possible "competition" from the Army.

Incidentally, the Army's interest in actual satellites as such is not a new thing. It will be recalled that astronomer Clyde Tombaugh was granted an Army Ordnance contract some time ago to find out whether the earth already has a tiny, natural satellite. Tombaugh has not yet found any satellite, but if he does, Army thinking is that such a small celestial body (or bodies, possibly) might be useful for tracking purposes.

As a matter of fact, Tombaugh is currently planning to set up an observation post in Peru close to the equator, whereupon possibilities for finding the natural satellite, if any, will be substantially increased.

180-Mile Altitude Seen For Rocket Aircraft

North American is developing a manned rocket aircraft which will be capable of reaching an altitude of 180 miles, according to NAA test pilot George Smith.

He did not identify the aircraft, but it was believed he was referring to North American's X-15 experimental rocket aircraft. This machine has been said to have a preliminary capability of 50 miles and eventually 150 miles.

Smith is the first man known to have survived a supersonic bailout. He spent six months in the hospital after ejecting from an F-100 just off the coast of California.

Army Policy Statement Reveals Aim To Acquire Control of IRBM

In a forthright bid to gain control of the intermediate-range ballistic missile, the Army has issued a formal policy statement declaring flatly that its tactical requirements include long-range surface-to-surface weapons "capable of supporting deep penetrations or airheads from protected and widely dispersed rear areas; and of delivering accurate fire on distant targets."

Stated purpose of the new Army Regulation, No. 525-30, is to lay down the ground rules for the integration of guided and free missiles into the Army weapons system. But most observers regarded it as another move in the soldiers' campaign to win jurisdiction over the IRBM from the Air Force.

● **Both the Army** and the Air Force are developing 1,500-mile IRBM weapons. Douglas Aircraft Co., Inc., is working on the Thor for the USAF, while the Army's Redstone Arsenal is tackling the Jupiter IRBM. Defense Secretary Charles Wilson has approved the two separate development programs, but he has withheld a decision as to whether both services will be allowed to use the weapon once it is completed.

In discussing the role of artillery and antiaircraft missiles within the Army, the regulation stated: "Such missiles are not merely specialized items of equipment; they have broad and general application to land warfare. All surface-launched missiles which meet Army operational requirements will be developed and integrated into Army forces, as a natural transition from present types of conventional artillery."

The Army described its short-range requirements as including "assault or demolition guided missiles to be used against armor and fortifications," and its medium-range needs as including "missiles to supplement and extend the range or firepower of artillery cannon, to provide close or interdictory fire support for ground combat forces, and to compensate for the expanding dimensions of the battle area."

● **In the crucial area** of long-range surface-to-surface weapons, the Army said it needs "missiles capable of supporting deep penetrations or airheads, from protected and widely dispersed rear areas; and of delivering accurate fire on distant targets which are capable of affecting the execution of the Army's combat mission."

The missile policy regulation said the Army's requirements for surface-to-air missiles "include land-based antiair missiles for defense against high, medium or low altitude aircraft, drones or artillery missiles." It added that such weapons "should also have a surface-to-surface role when feasible" and suggested no limitations on their range.

Missiles Bring Boom To Central Florida

Guided missiles and the forthcoming earth satellite vehicles have brought a boom to Florida's Brevard County and its three towns Cocoa, Cocoa Beach and Rockledge. The area's population has increased from 10,000 to 38,000 in three years and continues to grow.

Air Force estimates 2,000 families will arrive at Patrick AFB during the next 16 months. Currently Air Force has a $4.5-million per month payroll there.

S. GARY BENNETT, Jr.
Real estate up $1 million

Cocoa Mayor S. Gary Bennett, Jr. told MISSILES & ROCKETS the Patrick missile and satellite activity boosted real estate evaluation more than $1 million last year. Real estate people see no reason why this trend will not continue. Cocoa building permits increased more than 100% from 1954 to 1955.

● **But housing** still is the big problem. Furthermore, the water supply to Patrick and the nearby towns is at a critical point. The city of Cocoa is building a $7-million water supply system to meet current and future requirements. A 42-mile long pipeline will transfer water from a well-field west of Cocoa. The system is expected to be completed within the next 16 months

● **In Washington**, a spokesman for the Air Force Family Housing Office said the Patrick housing problem is being studied intensively at the present time. The Air Force plans to start a major housing development on the base for the R&D personnel connected with the Patrick missile and satellite activities.

Big Construction Planned

Major construction programs for missile facilities also are being planned for both the Patrick and Cape Canaveral areas and the Grand Bahamas Missile range to meet the increased requirements of the three services. The Corps of Army Engineers is building the launching site for the Vanguard earth satellite vehicle. This site will include the launching pad with exhaust tunnels, a block-house control station and other facilities.

On the GBI range itself, Pan American World Airways Guided Missile Division continues to expand. On Grand Bahamas, the tracking station employs more than 200 people today, but it is anticipated that more than 1,000 technicians and engineers will be busy there before the first satellite vehicles are ready for launching. In all, the GBI range, which is being expanded to include Ascension Island, requires literally thousands of personnel.

U.S. Sees Possibilities In French Missiles

Agencies of the Department of Defense have been studying French coleopter missiles and have concluded that such missiles may have merit. There is still a question whether they will prove practical in actual operation, which will be difficult to establish without full-size test vehicles.

The French firm Institut Technique Zborowski now has a French government contract to build some full-size test vehicles, and U.S. agencies are watching closely.

Of particular interest is Zborowski's 412-01 *Ogre* photo-reconnaissance vehicle, a long-range missile fitted with an annular wing around the fuselage and a jet powerplant. A 10,000-pound turbine will give the *Ogre* a velocity of close to 600 miles per hour.

Sweden Building Ramjet Missiles

STOCKHOLM—A spokesman for the Swedish Robotvapenbyran, Sweden's guided missile establishment, has confirmed that great emphasis is placed on ramjet missiles in this country.

While Sweden has built *Nike*-type missiles, future surface-to-air missiles will also be ramjet-powered and have greater range. All work on Swedish ramjets is classified. Among leading Swedish missile firms are Svenska Aeroplan Aktiebolaget (SAAB), Svensk Flygmotor A/B, Svenska, Turbinaktiebolaget Ljungstrom (STAL) and Bofors.

SWEDEN'S AIR MATERIEL COMMAND has asked $28 million to procure guided missiles for aircraft and $1,600,000 for continued development of an interceptor missile during 1957-58. Latter item has been in Air Force budgets for several years and is expected to cost about $6 million.

* * *

ACF INDUSTRIES, INC. has set up a Missiles Group to integrate the skills of its Erco, Avion and American Car & Foundry Divisions and apply them to overall weapons systems. Chairman of the new group is Richard F. Wehrling, president of Avion Division.

Super-Propellants Needed, Says Murphree

The most critical job confronting chemists in the rocket-powered guided missile field is the development of super-propellants capable of higher energy release per pound than present fuel-oxidizer combinations, according to Eger V. Murphree, Special Assistant for Guided Missiles to Defense Secretary Charles Wilson.

In a recent talk before the American Chemical Society in Atlantic City, N. J., he declared: "Higher energy production per pound of reactance is of utmost importance from the standpoint of range that can be obtained with missiles."

"Cost of propellants within limits is not nearly so important as the energy that can be obtained per unit weight," he added. He said substantial advances in energy yields will permit corresponding weight reductions and increased mobility in rocket missiles since the bulk of their weight consists of propellant.

● **In the field** of liquid propellants, Murphree noted that the combination of liquid hydrogen and oxygen, or liquid fluorine and ammonia, would produce "considerably greater energy release" per unit weight than the standard combinations of liquid oxygen or fuming nitric acid and jet fuel, alcohol or other hydrocarbons. At the same time, he pointed out, the more powerful propellant combinations involve considerably more complex handling problems.

On the solid-propellant side of the picture, he said, "There are very real possibilities of getting combinations of oxidizers and organic materials which give higher energy than present propellants," plus the possibility of "new types of energy producing reactions using quite different types of materials."

Solid propellants fall into two broad classes—double-base propellants and composite propellants. The double base variety consists of mixtures of nitrocellulose and nitroglycerin with suitable plasticizers and stabilizers, he said, while the composite type presently consist of some organic material mixed with an oxidizer.

Navy's Truax Guides AF Satellite Work

One of the Navy's most outstanding missile and rocket authorities, Commander Robert C. Truax, currently assigned to the Air Force

COMMANDER ROBERT C. TRUAX

. . . USAF picks the best

Western Development Division, is likely to be in the spotlight next month. He's a nominee for the American Rocket Society's presidency. The annual meeting and election of the ARS will be held in New York November 25-30.

Commander Truax was an ensign when he first started to work on liquid rockets in 1941. Since July 1953 he has been assigned to the Bureau of Aeronautics as head of the Ship-Launched Branch, Guided Missiles Division.

Among his contributions to the advancement of rocketry has been his work on liquid rocket-assist for naval flying boats. His missile and rocket experience has been a great asset to the whole missile business and especially to the Navy, although many naval officials may not have been aware of it.

Informed sources believe Commander Truax is guiding WDD's satellite work.

New Problem at Missile Ranges: Overcrowded Telemetering Frequencies

Crowding of the telemetering frequency bands used in missile research and development is posing increasingly severe problems between users at launching sites and between test ranges.

Meeting during the National Telemetering Conference held recently in Los Angeles, a panel of experts from key installations reviewed the needs for better-use coordination and for improved equipment. They also weighed the possibilities of using the newly assigned 2,000-megacycle channel to ease the crowding problem.

W. E. Miller, from Army's White Sands Proving Ground, called attention to the need for improved liaison between contractors using the sites. Day-to-day plans must be made, he said, so that best use could be made of time and frequencies available.

● **An example** of interference was given by R. S. Reynolds, Sandia Corp. Stressing a need for improved automatic tracking antennas, Reynolds cited a case where an antenna picked up a signal from another missile center 500 miles away and then lost track of the missile it was supposed to track. Better equipment with crystal control was needed, he said, for long-range tracking. This would also aid frequency assignment coordination.

Miller said steps toward improving planning and utilization had been taken at White Sands. A document known as Frequency Utilization Parameters and Criteria, No. 102-56, had been produced by a group at White Sands known as the Interange Instrumentation Group. It is expected the document will aid development of equipment and coordination methods in telemetering work.

Interference problems should be attacked on three fronts, Miller thinks. These should be: (1) control of frequency usage through careful screening of all requests, (2) better control of equipment frequency stabilization to prevent waste of band space and (3) better control of radiation from closed-loop test facilities where checkouts take place inside of buildings.

● **In the** serious need for better equipment, Nems-Clarke, Inc. was singled out as having made a significant contribution to frequency-saving by production of its new narrow-band receiver. The receiver permits spacing of standard FM/FM channels only one megacycle apart.

Recently the Department of Defense provided a new telemetering channel in the 2,200-2,300 mc range which was expected to lessen interference problems. However, consensus of the NTC Panel was that the new assignment offered little aid at this time. R. T. Merriam, Naval Ordnance Test Center, China Lake, Calif., said the new frequency was impractical for small missiles. To produce and handle such short wavelengths, microwave "plumbing" such as waveguides are necessary.

● **Such** hardware takes up much more space in a missile than the 200-megacycle equipment now being used. According to panel chairman George S. Shaw, Radiation, Inc., this amounts to a few hundred cubic inches for the 2,000-megacycle equipment in a missile. He predicts it will be five years before the new band can be utilized for telemetering, except in very large missiles at short ranges not over 100 miles.

Newest 'Demon' Bolsters Navy Missile Power

McDonnell Aircraft's F3H-2M, missile-carrying version of its Demon all-weather fighter, has passed all Navy trial and evaluation programs required for fleet release and joined operating squadrons. New Demon carries four Sperry Sparrow air-to-air missiles plus rapid-firing, high-velocity 20mm cannon. Powerplant is Allison J71 jet. Both F3H-2M and F3H-2N all-weather fighters are slated for production through March 1958.

Nike B Has Longer Range, Greater Speed

Army's *Nike B* missile, now under test and due to be available within two years, will have a longer range than present *Nike's* 25 miles and speed in excess of its 1,500 mph, according to Don Belding, civilian aide to Army Secretary Wilber N. Brucker.

Belding told a recent Los Angeles Town Hall meeting of reports that a *Nike B* with an atomic warhead could destroy a whole fleet of aircraft in one hit if the planes were bunched for attack. He stressed that the new *Nike* can be launched from existing installations with minimum modifications—a factor being questioned by the Air Force in the current *Talos/Nike* dispute.

In disclosing first details of Los Angeles' *Nike* defenses, he noted that each of its 12 batteries has eight officers and 100 enlisted men —two-thirds of them specialists. It cost $20,000 to train each man, $2,300,000 for a battery, and the payroll for each installation runs $25,000 monthly.

Research Rocket Zooms To 5,000 MPH in 2 Seconds

Development of a needle-nosed research rocket that can accelerate to speeds approaching 5,000 mph within two seconds has been disclosed by the Air Force Air Research and Development Command. The rocket, called the Hypersonic Test Vehicle (HTV), was evolved by the ARDC and Aerophysics Development Corp. of Santa Barbara, Calif., a new subsidiary of Curtiss-Wright Corp.

Basing figures on the variation of the speed of sound at different altitudes, engineers calculate that the 12-foot long HTV can reach nearly Mach 7 just about two seconds after launching. ARDC revealed that a score of the test rockets have been fired and tested at Holloman Air Development Center, Alamagordo, N.M.

● The HTV is a two-stage solid-propellant rocket vehicle fired from a portable launcher. Seven rockets igniting simultaneously kick off the first stage—five feet long with a diameter of nine inches. When this battery of rockets burns, the first stage drops off and four second-stage rockets boost the remaining section to its top velocity. The second stage is the same length with a six-inch diameter.

The unprecedented acceleration is the rocket's major feature. It develops a velocity rate equal to 100 gravities, at least ten times that of most rockets and missiles.

● Six seconds after the second-stage burnout, a small explosive charge blows off the fins, destroying the rocket's stability and it spins to earth at about 100 mph. Hypersonic data on aerodynamic shapes, aerodynamic heating, rocket stability and air pressure distribution may then be retrieved from the 10-pound nose cone assembly.

The HTV is the first of a group of such high-acceleration rockets, ARDC said. Wright Air Development Center expects to move on to newer research rockets of improved velocity and performance. The first test flight was made in November, 1954, a year or so after work was started in 1953 under a $1,000,000 contract.

Pentagon Planning IRBM and ICBM Launching Sites

Eger V. Murphree's billion dollar responsibility embraces many new and sophisticated missile development concepts. The enormous task that he faced at the time he took on the missile czar job has become even more enormous—not moneywise, but in scope.

First, ICBM development has progressed more rapidly than first anticipated. As a matter of fact, the ICBM program already has reached the stage where one is discussing selection of launching sites. Obviously, hydrogen-warhead ICBMs cannot be launched from air bases or localities near built-up areas and cities. This is one of the new missile system concepts Murphree and the Defense Department must tackle successfully. Planning for IRBM and ICBM launching sites is done now.

Recently, Secretary of the Air Force, Donald A. Quarles, confirmed that work will be pushed to completion on four main air bases in Spain. One of these bases was called a "double base" that might be counted as two. Originally the Air Force counted on nine bases in Spain, but Quarles said it was not quite clear whether all of these would be completed. There has been some talk about the possibility of using overseas bases for launching sites for both IRBMs and ICBMs, but—as can be expected—no official statement has been issued in that respect.

It is not known whether Quarles discussed the missile launching site problem with Spanish authorities during his recent trip to that country, but it is quite probable that he did.

Quarles told a press conference that "there is no question that we will complete those Spanish bases we have started and on which we place great value."

Other U.S. overseas bases feasible for intermediate-range missile operation include those in Morocco.

In all probability, the American bases in Saudi Arabia and Iceland will not be considered for long-range or intermediate-range missile launching. Saudi Arabian King Ibn Saud has granted the United States only temporary permission to continue the USAF operations in that country.

Although the United States Government intends to negotiate with the Saudi Arabian Government for the purpose of obtaining permission to stay on, it is not likely that IRBM launching site negotiations will be attempted. The same applies to Iceland, where the United States position is rather weak.

Nose Cone Re-entry Problem Solved?

Dr. F. Vandrey of the Martin Co.'s aeronautics department stated in a paper on "Upper Bounds and Conservative Estimates for Aerodynamic Heating at Great Altitudes," read before the American Rocket Society's Annual Fall Meeting in Buffalo recently that materials are already available which can stand the intense aerodynamic heating at the nose and leading edges of an artificial satellite.

Using calculations for a missile similar to the *Vanguard* as his example, Dr. Vandrey presented simplified methods for calculating aerodynamic heating at extreme altitudes, pointing out that the 1490°F. skin temperature is still within the short-term stability limits of stainless steel and that the 2740°F. peak nose cone temperature compares with a platinum melting point of 3223°F. Vandrey emphasized that there are a number of other metals, oxides and ceramic materials with still higher melting points.

On the problem of re-entry Vandrey claims "a certain vehicle with low re-entry velocity would not burn up." Which may mean that modification of the true free-fall ballistic nature of the ICBM by equipping it with forward firing rockets to slow its re-entry velocity (now estimated at over 20,-

Furnas Predicts Rocket That Will Circle Moon

A rocket vehicle capable of circumnavigating the moon will probably be the next step after Project Vanguard in the conquest of space, according to Dr. Clifford C. Furnas, Assistant Secretary of Defense for Research and Development.

The Pentagon research chief also predicted that a nuclear powerplant for a rocket "may eventually come into its own," but he said such an engine would be large, heavy and expensive. Such an engine would require only a small amount of fuel, but it would still require a "very substantial" amount of material to eject from the exhaust to develop the necessary drive impulse.

Atomic Oxygen In Atmosphere As Fuel Source?

At the International Astronautical Federation Congress last month Jerome Pressman of U.S. Air Force's Air Research and Development Command, Geophysics Research Directorate at Cambridge Research Center, told of recent experiments which point to possible use of atmospheric atomic oxygen as an energy source to power satelloid vehicles for reasonably long times at altitudes of about 65 miles.

Pressman said that tests at Holloman AFB last March using an *Aerobee* X-1A rocket produced direct evidence of the presence of atomic oxygen at these altitudes as well as its concentrations. Experiment involved release of 18½ pounds of nitric oxide gas to free atmosphere with the *Aerobee* X-1A at an altitude of 66 miles.

● **Most significant result** of the experiment, he pointed out, is the fact that a large amount of energy of the upper atmosphere was released. The energy coming into the earth in the ultraviolet region of the solar spectrum disassociates molecular oxygen into atomic oxygen, and because of the relatively slow rate of three-body recombination, a reservoir of atomic oxygen exists in the upper atmosphere. These atoms, when they recombine, give off 5.08 electron-volts.

The AF physicist referred to previous research which indicated the number of photons emitted by a sodium cloud of -2 magnitude a value of 6.7×10^{21} photons/second. Assuming the energy contained in the sodium D-line as average for the photons released by the nitric oxide cloud, the total flux of photons emitted per second amount to about 3 hp with an additional 3 hp dissipated in other modes of energy.

The problem, Pressman said, lies in making use of this energy.

Speculating on just how to do this, he indicated the design of a propulsion system suggests itself as a continuous flow type. Use of a gaseous-type catalyst appears difficult to achieve, he noted, since it would be swept out with the exiting gas.

● **Pressman** discussed two main types of possible systems—one involving a heterogenous type of recombination, the other a homogeneous reaction.

In the former, a direct recombination could occur on the entrance throat of a cylinder, or on a catalytic surface contained within the cylinder. The heated gas would subsequently expand and accelerate outward.

In the homogeneous case, the system would be so designed so as to give a large increase of pressure locally within the cylinder, a feature that might be achieved by a pulse-jet, ramjet, or by shaping the inner walls in the fashion of effusors or diffusors.

The pressure increase, he added, would have to be very large since the partial pressure of atomic oxygen is of the order of a micron and the pressure at which the pertinent reactions of a series of recombinations outlined by Pressman was placed at one millimeter.

● **As an example** of the energy involved, purely for purposes of calculation, he used a hollow cylinder model with an entering throat cross section of 10 square meters and a length of 10 meters. By moving it horizontally at Mach 1 (approximately 300 meters per second) at an altitude of 100 km, with a concentration of 10^{13} atoms of oxygen per cubic centimeter, there is swept out 3×10^{22} atoms per second. Assuming 100% efficiency in extracting the energy of recombination from these atoms, this amounts to 15 hp. At Mach 10, it would amount to 150 hp and at Mach 20, 300 hp.

Without calculating drag and lift, he noted that the thrust available at relatively low speeds would be adequate to overcome reasonable estimates of the drag, but not enough to give sufficient lift to maintain a true satellite type of vehicle. He concluded, however, that it would appear adequate as an auxiliary, or possibly prime, power source for maintaining a satelloid vehicle for reasonably long periods in the 65-mile high region.

Satellites Offer Unique Platform to Study Earth's Atmosphere

The lower hemisphere of an earth satellite, bathed in the far-infrared thermal radiation emitted both by the earth and its atmosphere, will provide a unique platform for an astronomical study of the earth in the light of its own emission spectrum, Jean I. F. King of USAF's Cambridge Research Center Geophysics Research Directorate told the IAF Congress in Rome.

No other physical parameter accessible to the satellite contains the wealth of data concerning the thermal state of the atmosphere than that inherent in the far-infrared emission of the earth, King said.

The Air Force physicist pointed out that a far-infrared, thermal-sensing device situated on the satellite would have an obvious use in determining the constituents of the upper atmosphere by a frequency scan of the spectrum.

● **A less obvious**, but potentially fruitful possibility, said King, arises from the variation of the terrestrial emission as the satellite field of view sweeps across the earth's apparent disk. He then proceeded to present the mathematics whereby this variation of emission, (or limb-darkening effect) which is a measure of the departure of the atmosphere from an isothermal state, would produce data on the vertical thermal structure of the atmosphere.

King expressed the opinion that power and weight considerations of the satellite seem to rule out a scanning, gear-driven, infrared spectrometer of conventional design. He noted, however, that a rugged, semi-passive, lightweight filter photometer has recently been developed under Air Force contract by John Strong of Johns Hopkins University for balloon probing of the atmosphere. Its only power requirements are for a chopper blade and an a-c signal amplification.

Such an instrument, King said, could be built with interference filters tuned strategically at 6, 9.6, 11 and 15 microns. The 6-micron filter would receive water vapor radiation, the 9.6 micron the ozone and the 15-micron carbon diozide emission window would see direct to the earth's surface.

King concluded that this would provide a spectral scan of sorts, while a limb-darkening scan would be obtained by a proper distribution of sensing elements on the satellite surface.

Molybdenum May Solve Hi-Temp Problems

Molybdenum, in relatively good supply in the U.S., may prove to be the "answer" metal to ultra-high-temperature flight. Alloys of molybdenum (with less than 1% amounts of calumbium, cobalt and vanadium) are now being researched by both airframe (Convair) and jet engine makers (General Electric).

On 100 and 1,000-hour temperature rupture strengths molybdenum comes out on top of the nickel-cobalt alloys, falling well in the range of the cermets. Unlike the cermets, molybdenum is ductile. In order to overcome the oxidation problem, research is being carried out with a number of coating materials, including those of the platinum group of metals.

The best idea of molybdenum's strength-temperature potential is gained by knowing its melting point (4760°F) and modulus of elasticity ($E=50,000,000$).

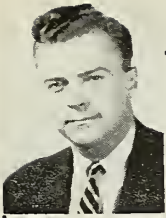
Other efforts now under way to solve the high temperature materials problem includes basic research into ways of making ceramics ductile.

Air Products to Build LOX Generating Plant

A convenient source of liquid oxygen for rocket engine tests will be available for The Martin Co.'s Denver Division when it begins to roll out *Titan* intercontinental ballistic missiles.

Air Products, Inc., Allentown, Pa., announced it will start construction of a $2,810,000 liquid oxygen generating plant as soon as possible on a three-acre, government-owned site adjacent to Martin's new *Titan* plant southwest of Denver. It will go into operation in the first half of next year with a daily capacity of 150 tons of liquid oxygen.

Leonard Pool, Air Products president, said the facility will be sold to the Air Force when it is completed, then leased back to Air Products for operation. Only 20 to 25 skilled engineers will be needed to keep the plant in operation because it features "practically complete" automation, he added.



Rocket Trends

By Erik Bergaust

The American Rocket Society probably is the fastest growing professional society in the United States. Five thousand membership mark may be reached by the end of the year. Nineteen fifty-six has been the society's most "prosperous" year with an average gain of 100 new members per month. Newest section is Philadelphia, mostly made up of General Electric SDPD personnel.

First of its kind? Reaction Motors, Inc., Denville, N. J., is launching a rocket museum. With several hundred items, such as combustion chambers, propellant pump systems, valves, fittings and control system components, the new museum houses many historic gadgets, including early German and American rocket engines.

Hellmuth Walter, famous German rocket engineer, now Research Director for Worthington Pump Corporation in New Jersey, has indicated he is interested in forming a new German rocket company in Kiel. Informed sources seem to think the new Walter rocket company will be registered in his wife's name. A glass factory is currently operated in Mrs. Walter's name, and the rocket company might become its subsidiary.

German missile and rocket comeback is indicated by the fact that BMW (Bayerische Motoren Werke) in Munich has established a rocket propulsion study group. BMW built several liquid rockets during the last war, but none of the wartime rocket engineers are currently employed by BMW.

Future design and construction of atomic-powered rockets and space satellites may be determined by a study of radiation damage to electronic components, according to Admiral Corporation. Company is doing study for Air Force.

Slow-burning solid-propellant research rockets built in Great Britain are designed to fly to 120 miles altitude. Built by R.A.E., the rockets are 25 feet long and 17 inches in diameter. A test program for the new rockets is currently in the works at the Woomera range.

Water-rocket devices for catapulting carrier-based fighters is being studied intensively by the Office of Naval Research. If successfully developed, the water rockets probably will replace the more complex steam catapults now used by the Navy.

A large rocket and space satellite exhibit, to be held in conjunction with the American Rocket Society's semi-annual meeting next spring, is being planned by ARS' National Capital Section.

The German underground factory in the Kohnstein Hills, near Nordhausen (Thuringia), where V-1s and V-2s were made during the war, is reported to be a busy key facility in Russian rocket motor development.

Chrysler Corporation, in its Redstone rocket development, has been praised for outstanding component and system production reliability.

Canada Spent $24 Million On *Velvet Glove* Missile

Total spending in Canada on the recently concluded *Velvet Glove* air-to-air missile project came to just under $24 million, according to Canadian Defense Minister R. O. Campney.

The *Velvet Glove* project was conducted in conjunction with U.S. and British research teams and brought practical experience to some 400 Canadian scientists and specialists in the air-to-air missile field.

As a result, Canadian industry has been geared to produce such weapons and contracts could be awarded to build a Sperry *Sparrow* type air-to-air missile.

* * *

THE AIR MATERIEL COMMAND at Dayton has announced the following contracts: Avco Manufacturing Co., Cincinnati, O., $25,150,558, fire control systems, spare parts, components and data; Minneapolis-Honeywell Regulator Co., Minneapolis, Minn., $600,000, for facilities in support of guided missile programs.

C-W New Factor in Missiles Field

Outright purchase of Aerophysics Development Corp., formerly a wholly-owned Studebaker-Packard subsidiary, has installed Curtiss-Wright Corp. as a first-line missile-builder.

Only days after the ADC purchase, C-W won a $16,565,000 contract from the Army for the *Dart* anti-tank missile. It will be built by Utica-Bend Corp., another C-W subsidiary formed as an outgrowth of the S-P deal, in a plant at Utica, Mich.

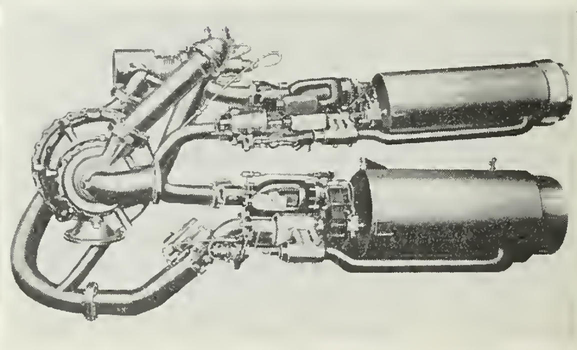
The *Dart* was developed at Aerophysics before the Santa Barbara, Calif. firm joined Studebaker-Packard. Powered by a solid-propellant rocket, the new Army missile is based on an earlier development by France's SNCA du Nord. It is wire-guided and has a range of 1,000 to 2,000 yards.

● **According to** some industry reports, the *Dart* is the "last word" in missile design for simplicity, low unit cost and producibility. For example, it is said to employ a non-electrical gyro system to obviate the need for complex electronics devices and power supplies in its stabilization.

As part of the Studebaker-Packard deal, Curtiss-Wright has taken a 12-year lease on S-P plants at Utica, Mich. and South Bend, Ind. and will pay for all work in process at a cost of $25 million. It has also arranged to supply S-P with $15 million more, by underwriting an extension of its credit.

Other elements of the transaction give C-W a three-year contract to provide the auto firm with management advice, as well as an option to buy 5,000,000 shares of S-P stock. Latter is subject to approval of Studebaker-Packard stockholders and their agreement to reduce par value of the stock from $10 to $1 a share.

Last phase of the deal involves an agreement with West German firm of Daimler-Benz A.G. which will give S-P rights to important German developments in the diesel and gasoline engine field.



Curtiss-Wright's XLR-25-CW-1, liquid-propellant rocket engine is rated at 15,000 lbs. thrust, uses two thrust chambers (top). Bottom photo shows engine operating on test stand.

Washington Spotlight

By Henry T. Simmons

Pentagon insiders regard the *Talos* surface-to-air missile as a "minimum" area defense weapon and take a skeptical view of the Air Force's argument that it will be valuable preparation for the *Bomarc.* Real reason the airmen want it is to head off Army missile ambitions—specifically, the 50-mile *Nike B.*

A committee headed by Pentagon Missile Czar Eger V. Murphree is looking into the technical merits of the competing *Talos* and *Nike B* systems, but no decision has yet been reached. Comments one official: "The country would be darned well off to have both." Nevertheless, only one system is likely to be adopted, and *Nike B* looks like the better bet, provided it can be introduced without tremendous modifications to existing *Nike* batteries.

Navy's air-to-air *Sidewinder* missile is now operational on carriers in the Mediterranean and Far East. Formal announcement is expected shortly. It is believed to be the first heat-seeker bird to reach operational status.

Sidewinder's homing system is sensitive enough to lock on a smoldering cigarette at 100 yards. Navy wags claim it unerringly picks the hottest cylinder of a piston engine as its target. As an economy measure, drones dangle incandescent torches during firing tests. These are regularly lopped off by the Philco-produced *Sidewinders* so the drones may be used another day.

North American twin-ramjet *Navaho* probably will be the first intercontinental missile to be produced in quantity for the military arsenal. Northrop *Snark,* although ready for volume production now, looks like it will be by-passed in favor of the higher-performance NAA weapon. Latter still has many months of development work ahead of it.

Diamondback is a study project for an air-to-air missile. As the name would indicate, it is a potential successor to another member of the rattlesnake family—*Sidewinder.*

Navy *Vanguard* satellite scientists figure the first two seconds of the launching operation will be at least as critical as any other phase; the gimballed motor of the first stage cannot be swivelled more than four degrees in the early part of the flight because of the sloshing liquid propellants. Thus a vagrant wind could bring disaster in the initial instant of launching.

Air Force construction plans for intercontinental missile launching facilities provide for such tremendous dispersion that no more than one-third of any given battery's firepower would be lost in the event of a direct hit by an enemy missile with an H-Bomb warhead.

The extent of the missile's impact on USAF weaponry is revealed by these planning estimates: Eventually 90% of the missions of the Air Defense Command, 50% of the Strategic Air Command's missions and 40% of Tactical Air Command's targets will be handled by the canny birds.

SPECIAL REPORT:

RUSSIAN ATOMIC ROCKETS UNDERWAY

Soviets Join International Astronautical Federation, Will Assist in Satellite Program

By Erik Bergaust

ROME—At least two atomic rocket research projects are believed to be in the works in the United States, but even so the Russians may be ahead of us. This was revealed here during the 7th Congress of the International Astronautical Federation.

Russia's interest in satellite science and astronautics has, furthermore, been accentuated by the fact that the *Astronautics Commission* of the U.S.S.R. Academy of Science applied for and was admitted to full membership in the federation at this Congress.

Just how interested the Russians are in rocket and satellite activities during the International Geophysical Year was expressed in a statement by Professor I. P. Bardin, Russian International Geophysical Year Committee Chairman.

In his statement, given to Dr. M. Nicolet, Secretary General of the Comité Special de L'Année Internationale Geophysique, Prof. Bardin made these points:

1) In addition to the U.S.S.R. program already presented to the Barcelona International Geophysical Year Meeting, Russia's rocket-satellite program will be presented at a later time.

2) The U.S.S.R. is interested in launching a satellite by means of which measurements of atmospheric pressure and temperature, as well as observations of cosmic rays, micrometeorites, the geomagnetic field and solar radiation will be conducted. The preparations for launching the satellite are presently being made.

3) Meteorological observations at high altitudes will be conducted by means of rockets.

4) Since the participation of the U.S.S.R. in the IGY rocket-satellite observations was decided quite recently, the detailed program for these investigations has not yet been elaborated. This program will be presented as soon as possible to the Secretary General of the CSAGI.

Russian delegate to the IAF Congress, Dr. Leonid Sedov, Moscow University professor, declined to comment when MISSILES & ROCKETS asked him whether the Soviets would launch more than one satellite.

Dr. Sedov did confirm, however, that Russian atomic rocket research is progressing at various nuclear research centers throughout the Soviet Union.

● **A short time ago** Russian research engineer G. Nesterenko said that "engines performing on nuclear fuel are of great importance in our contemporary aviation and rocket engineering. Powerful and highly efficient atomic engines will enable us to build rockets that will overcome the gravitational pull of the earth."

Rocket engines with atomic reactors mounted directly in the combustion chambers have been discussed openly in Russia. Active U235 and U238 reactor mass and a graphite neutron inhibitor have been suggested. Liquid hydrogen will flow through the porous mass, cool the reactor and at the same time acquire tremendous energy. Nesterenko has calculated the exhaust velocity to be in the neighborhood of 22,000 feet per second.

Heat, Weight Problems

Heat in this type rocket reactor is controlled by movable controlling shafts prepared from porous cadmium, acting like "fire extinguishers" in regard to the chain reaction. Liquid hydrogen cools the shafts.

"The problem of heat transfer is considerably lessened by the use of porous materials in the reactor," Nesterenko said. "Such ma-

Pope Blesses Man's Efforts to Conquer Space

Pope Pius XII has given his blessing and benediction to mankind's efforts to conquer space.

"God has no intention of setting a limit to the efforts of man to conquer space," he told members of the 7th International Astronautical Federation Congress in Rome.

The 400 delegates were received by the spiritual leader of the Roman Catholic Church at his Castel Gandolfo summer residence.

"The more we explore into outer space, the nearer we come to the great idea of one family under the mother-father God," the 80-year-old Pontiff said.

"This astronautics congress has become one of great importance at this time of man's exploration of outer space. It should concern all humanity. Man has to make the effort to put himself in new orientation with God and His Universe," the Pope concluded.

Newly elected vice president of the IAF, Moscow professor Leonid Sedov, leaned forward attentively and nodded his head in agreement when other delegates translated the Pope's address from French into German for his benefit.

terials offer a large surface area for the liquid hydrogen."

● **What the Russians term** a "fluido-reactive rocket," using liquid hydrogen, must be very heavy, they admit. But ways to decrease the weight of the reactor are being sought. Nesterenko thinks the "critical dimension" can be decreased by the use of enriched uranium that contains a large percentage U235, by installing special reflectors of neutrons and by substituting the graphite with an improved inhibitor for the rapidly moving electrons, etc.

"Such measures should decrease the weight of an atomic rocket at a ratio of 10:1. Thus the construction of an atomic rocket vehicle of from 100 to 200 tons total weight is possible today," he asserted. Russian interest in atomic rocket engines is confirmed by another official who says that the biological problems, i. e., radiation hazards for passengers in atomic aircraft —whether they are propelled by jets or rockets—are under study.

When the subject of Russian atomic rocket research was discussed with Dr. Leonid Sedov during the IAF Congress, he could not confirm whether the trend suggested by Nesterenko was indicative of what type reactors and materials are being considered in Russia.

"I am not a propulsion man," he said. "I am an astrophysicist. However, I can confirm that we are very much interested in 'these things' and that they are being worked on."

● **Dr. Sedov,** who preferred to converse in German, made a considerable impression on IAF members at last year's international congress in Copenhagen, where he held a press conference at the Soviet consulate. At that time he announced that Russia was building "a satellite that might be launched sooner than the one announced by President Eisenhower."

Because of the questionable publicity Dr. Sedov was given after last year's meeting with the press, he refused to hold another press conference this year.

One of the American scientists, who carried in his briefcase a number of small transistorized telemeter units and cosmic-ray counter components of the types suitable for small satellites, was asked by Dr. Sedov if he would be willing to sell them. Said the American scientist: "I will send them to you when you send me some samples of the components you're putting into your satellite."

Dr. Sedov, who has a fine sense of humor and is very popular among American and German scientists, expressed his gratitude when the delegates unanimously approved the Russian application for membership in the IAF.

"We look forward to working with the societies from other countries," he said.

Biggest IAF Congress

Retiring IAF president Frederick C. Durant, III of Arthur D. Little, Inc. told MISSILES & ROCKETS that this congress had been the "biggest and most important" since the world organization was founded in 1950. More than 60 Americans attended, including representatives of the Air Research & Development Command, the Naval Research Laboratory, the Office of Naval Research, the Cambridge Research Center and other official bodies. Some of the eminent American scientists included Dr. Theodore von Karman, Dr. Joseph Kaplan, Krafft A. Ehricke, Dr. Homer Newell, Dr. Fred L. Whipple, Dr. Fred Singer, and others.

● **Numerous scientific papers** were presented. More than a dozen pertained to small, artificial satellites, four dealt with lunar rockets and a variety of papers discussed rocket technology and astronautical problems in general.

The Congress was held at the beautiful Palazzo dei Congressi. A record attendance of 450 delegates from 22 countries convened for a full week from Sept. 17-22. The members were welcomed by Rome's Mayor and later in the week were received by Pope Pius XII at his summer residence, Castel Gandolfo.

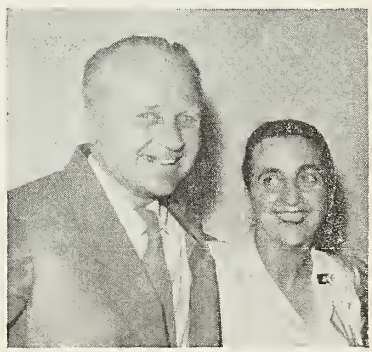
Although the U.S. earth satellite program for the IGY and the Air Force camera-equipped reconnaissance satellite have been the only two space flight projects discussed officially in the United States so far, MISSILES & ROCKETS learned reliably that there are actually several space flight

IAF Congress Personalities

SEDOV and FREDERICK DURANT
New East-West Vice Presidents.

KRAFFT A. EHRICKE
Solar power for travel beyond the moon.

DR. JOSEPH KAPLAN
Wanted: observers all over the world.



SAENGER & SAENGER-BREDT
Predicted: bright future for photons.

projects under way. Since most of these are conducted by military organizations, and since much of the vehicle technology involves missile techniques, none of them have been revealed.

● **Several of the most important American universities and several scientific organizations are said to be involved in different types of space flight studies embracing larger satellites, lunar rockets and vehicles designed to circumnavigate the moon.**

Within three or four years we are likely to go beyond this thing of sending a small, un-controlled shell to the moon, one scientist said. "If you want to go for a trip in the country and you can't afford a Cadillac, you'll use a scooter. But if you have a Cadillac you'll use that one—and that's pretty much the situation today. Our rocket industry has the Cadillac—so why bother with the small stuff?"

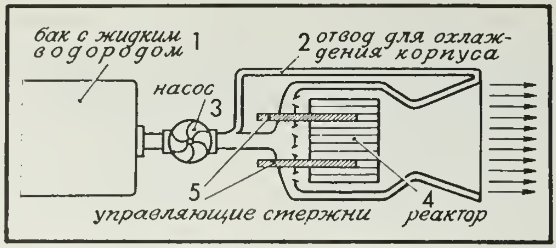
"I feel convinced that we will launch numerous larger satellites into all kinds of orbits within the next decade," Durant said in his opening speech.

● **The peaceful aims** and objects of the IAF and of astronautics as a science were emphasized throughout the congress. A Cambridge Research Center Aerobee sounding rocket at display attracted much attention.

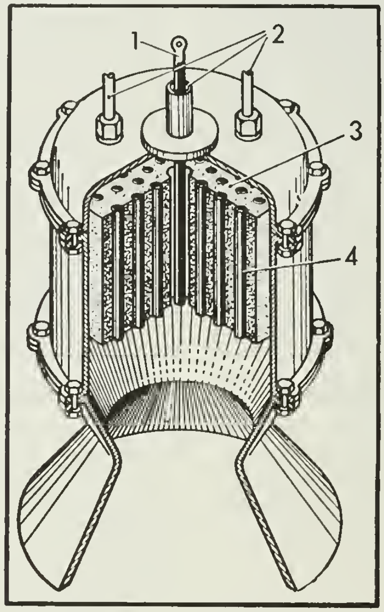
"The slogan of this congress could well have been 'Rockets for Peace" and research rockets such as the Aerobee and Vanguard prove that this is possible," Durant said. The announcement that the United States and Canada will conduct jointly a multi-million dollar program for rocket exploration of the atmosphere in the Arctic region and Russia's forthcoming meteorological program, using rockets, were among the favorite discussion topics of the delegates.

Great Interest in Vanguard

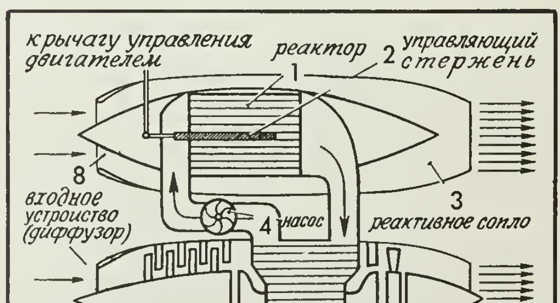
President Eisenhower's announcement July 29, 1955, that the United States would participate in the IGY with an artificial satellite program, coincided with the opening of last year's IAF congress in Copenhagen. This year technical



Schematic view of Russian "fluid reactive" engine. 1. Tank for hydrogen. 2. Regenerative cooling pipeline for hydrogen. 3. Pump. 4. Reactor. 5. Controlling rods.



Schematic view of Russian atomic rocket. 1. Control shaft (rod). 2. Pipelines for liquid hydrogen. 3. Graphite. 4. Rods of U235.



Schematic view of nuclear-fuel turbo-reactive engine with ramjet. 1. Reactor. 2. Controlling rod. 3. Exhaust nozzle. 4. Pump. 5. Turbine. 6. Heat exchanger. 7. Compressor. 8. Air intake and diffuser.

papers pertaining to the *Vanguard* were presented. Interest of the European press in the *Vanguard* program was high. Italian newspapers carried as much as a full page of reports and pictures on the subject.

N. E. Felt, Jr. of Martin, Baltimore, presented a paper on the *Vanguard* launching vehicle and revealed the basic construction of the three-stage carrier rocket. The true significance of the project is that we have accepted a challenge to create something never before seen by man, he said. "This device is something to be used for the advancement of mankind by extending our knowledge of our environment; we have taken the first step in the exploration of the universe," he said.

● **Dr. Whipple,** in charge of the visual observation of the American IGY satellite, told MISSILES & ROCKETS that the Smithsonian Astrophysical Observatory will activate some of the observer groups throughout the U.S. in November and December. These groups will start "training" and be checked out for timing and coordination. The experiences gathered will be offered other groups all over the world. The so-called "Moonwatch" program now has reached the stage at which such a nationwide practice session is both desirable and necessary, Dr. Whipple stated.

"When we activate our observer groups late this fall, this will be a full-scale rehearsal, including a communications tryout, for the forthcoming IGY satellite tracking," he said.

The Federation passed a resolution to encourage its member societies to offer assistance to the IGY chairmen in their respective countries for visual observation and tracking of the IGY satellites.

British atom-physicist Leslie Shepherd of Harvell University was elected new president of the IAF. Russian delegate Dr. Sedov was elected vice president. Four other vice presidents elected were: Durant, Gen. Paul Bergeron, Julio Marial and Prof. Teofillo M. Tabanera. Next year's congress will be held in Barcelona October 7-12. The Netherlands will be host to the 1958 congress.

NUCLEAR ROCKET RACE ON

• Atomic Energy Commission Conducts Basic Research —NACA Believed to Be Working On Second Project

In an effort to attract more trained personnel to the project, the Atomic Energy Commission has announced that two of its laboratories are engaged in nuclear rocket development projects. Work has been going on for the last year at the Livermore Branch of the University of California's Radiation Laboratory in the San Francisco Bay area, and the Los Alamos Scientific Laboratory in New Mexico, operated by UCLA.

The Los Alamos phase of the work is being conducted by the "N Division" under the direction of Dr. Ramer Schreiber. AEC officials declined to discuss either possible advantages or methods of achieving nuclear rocket propulsion. However, an obvious advantage is low fuel weight and virtually unlimited thrusts.

● **Other disadvantages** that must be overcome include development of materials or possible electrical-field methods of withstanding the tremendous heats of reaction—even greater than the sun-surface temperatures encountered in the ICBM long range missile; the heavy weight of shielding necessary to protect personnel (if the vehicle's to be manned) and instrumentation from high-intensity radiation; and development of a means of controlling the reaction.

Fuel-metering can probably best be achieved by the use of fissionable materials in solution, such as that used in homogeneous reactors. This could be sprayed into the reaction chamber from the perimeter to gather in sufficient concentration at the center to produce a "boil-up" reaction.

Another possibility is a solid hot reactor feeding into the firing chamber in the same way a self-consuming electrode feeds into an electric furnace.

Another interesting problem will be posed in flight-testing such a vehicle. Wherever it might crash, it would be troublesome.

● **Also in the field** of nuclear propulsion, the AEC in its latest semi-annual report discusses the progress of work towards controlled fusion and presents some possibilities for the far future.

It says: ". . . it is conceivable that a controlled thermonuclear reactor (burning a fuel of Helium-3, for example) might eventually be developed which would produce no neutrons at all, and for which no neutron-shielding would be required."

Such an engine would not rely on mass airflow for its propulsive medium (as will present atomic aircraft engines now being developed), but would utilize the direct energy of reaction as do today's rocket engines. Thus, it would not be limited to atmospheric operation.

And from the point of view of safety, the AEC report says it would be "extremely safe . . . fuel supply itself would be stored completely outside the machine chamber and would be completely incapable of participating in the reaction without first being introduced to the reactor and heated . . . no fission products to escape in case of an accident."

Basic obstacle to development of such an engine is the high temperature (hundreds of millions of degrees) of reaction, but AEC feels an insulating effect may be achieved through the use of electrical and/or magnetic fields. The fusion engine would be started by means of local particle excitement rather than relying on an A-bomb trigger. Power rate could be controlled by metering gas admitted to the reaction chamber.

Propulsion Notes

By Alfred J. Zaehringer

The NRL AEROBEE-HI rocket that got up to 163 miles June 29 was the result of considerable re-design after two successive failures. Blame was placed on motor—probably the injection system. Meanwhile NRL denies that the new rocket is a prototype of Stage 2 of VANGUARD satellite vehicle.

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Two plants at Niagara Falls, N. Y. are producing new propellants (for rocket and/or for "chemical fuel" air breathing jet engines). Stauffer Chemical is upping the production of boron trichloride by a factor of ten. Nearby Olin-Mathieson is producing alkyl boranes ("Zip") at a $36 million USAF plant. The OM plant was recently battered by an explosion of major proportions. (See "Industry Spotlight")

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LOX-fueled REDSTONE makes extensive use of aluminum alloys. Hints are that REDSTONE'S kissing cousin JUPITER will also be LOX-fueled but may use lighter-weight alloys such as magnesium. First firings of an entire JUPITER IRBM (FBM) and ATLAS ICBM are near. Nevertheless, there has been considerable talk that the Chrysler IRBM may also go through a parallel solid-propellant version.

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MARS is the Missile and Rocket Section research group of the University of Detroit's Research Institute of Science and Engineering. Both solid and liquid propellants will receive attention. Headed by Dr. Donald J. Kenney of the U. of D. Chemistry Dept., MARS will utilize production and test facilities of American Rocket Co. Under the joint industry-university program engineering talent will be shared.

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Capabilities of heretofore classified solid-propellant units have been revealed by Coleman Engineering, operators of the USAF SMART track at Hurricane Mesa, Utah. HVAR has been used for low-speed runs (acceleration and sustaining) and for retro-firing (braking). Burning time is 0.86 sec. New solid-propellant booster unveiled is the 224B-1 with a burning time of 4.6 sec. T-50 booster also used for the zero-length launching of MATADOR has a burning time of 2.5 sec. and is used in combination with the 224B-1. LOKI with a burning time of 0.8 sec. has also been used as a sustainer.

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Three solid propellant SMART sleds have been built. The MM-1 mounts three HVARs for acceleration, three 5KS-4500s for acceleration, and six HVARs for retro-firing braking. The 5KS sled carries twelve 5KS rockets and uses water braking. The 224B-1 sled is designed for Mach 1.7 runs but Mach 2 runs are being planned with a T-50 pre-boost sled, a 224B-1 booster sled and a forward test sled. Solid-fuel rockets give flexibility in thrust and burning time by using the various combinations. However, Coleman claims liquid-fuel rockets permit greater operational economy and variability. No details have been released about the liquid units.

BRITISH LEAD IN LIQUID RATO AIRCRAFT

FARNBOROUGH—British rocket engine progress was demonstrated here during the Society of British Aircraft Constructors' show last month. MISSILES & ROCKETS correspondent was particularly impressed by the colorful and dramatic rocket-assisted takeoff of the Vickers *Valiant* giant bomber. The British are undoubtedly ahead of the United States in the field of liquid-rocket-assist aircraft.

The mighty *Valiant,* forced to demonstrate its performance under poor weather conditions, with rain and low-hanging storm clouds, lumbered across the field to the end of the runway. The four jets reached their penultimate scream, the pilot released the brakes, and in a matter of seconds the big bird began its climb into the dark clouds.

Then came the rockets with their spine-chilling roar. Tilting upward at an incredible angle, the huge bomber zoomed aloft, the two auxiliary rockets mounted underneath each wing sputtering characteristic shock diamonds.

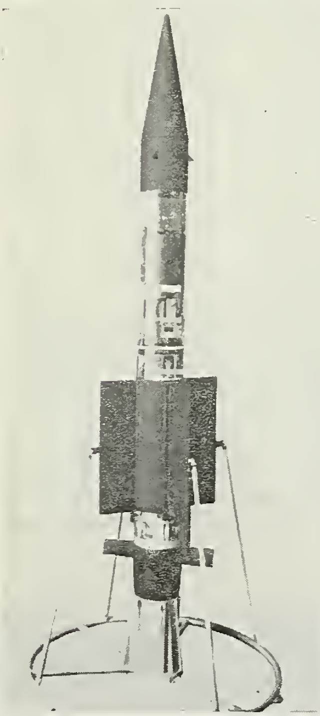
While the *Valiant* Super *Sprite* rocket engine only yields 4,200 pounds of thrust, Armstrong Siddeley has produced the *Screamer,* with a thrust rating of 9,500 pounds; this and similar engines are scheduled to be produced for several British aircraft, both fighters and bombers.

The following is an alphabetic run-down of the main missile exhibits at the SBAC Farnborough show.

● **Avro** introduced its Weapons Research Division with a simulator, a computor and a display of shock-resistant, resin-potted, transistorized circuits—a DC to DC converter stepping up 12 volts to 150 volts with a capacity of 15/20 watts at 75% efficiency: a half-cycle magnetic amplifier with a gain of 2,000: a snap-action magnetic amplifier shown operating a lamp on 0.1 volt, claimed as a gain of ten million.

● **Bristol** showed its production missile ramjet, the *Thor,* and its compact hydraulic turbo-power pack and a turbine fuel pump. Bristol revealed two coaster vehicles with cruciform low aspect ratio wings and cruciform tail blades at 45°, used for aerodynamic data gathering during a 10-sec. deceleration from an initial rocket-boosted 1,360 mph. Launching takes 2 secs., with a peak of 35g's. Bristol's extensive work on welded high-alloy steel rocket cases and pressure vessels was extensively displayed.

● **English Electric** was security-bound to a model of last year's missile, plus a very similar



Declassified photo of one of early types of control test vehicle built by Bristol Aircraft Ltd. Maximum velocity exceeds 2,000 ft./sec. Peak acceleration is 35 g's. Triplex tandem boost burning time is two seconds.

parachute-recoverable coaster used for training on a normal artillery range. A triple-rocket tail-booster gives an initial speed of 1,360 mph. The company's Mark VI temperature-controlled gyro achieves the remarkably low drift rate of 1°/hour by virtue of being immersed in a viscous fluid to resist shock and maneuvering loads. A compact exhaust-operated power pack consists of two cylindrical accumulators recirculating fluid, one to the other, through a sealed turbine under pressure from internal gas bags. Both low and high pressure filters of sintered bronze ensure continuous functioning.

● **Fairey** had its Fireflash, the RAF's first production (training) missile on the Vickers Supermarine Swift F7, the Hunter F4 and on an assembly/loading trolley and on a "yes/no" pre-launching test table. The Fireflash is a beam-riding coaster launched from an underwing position by twin cordite boosters which jettison automatically at burnout.

● **Ferranti's** connection with the Bristol missile program was emphasized by the presence of printed wiring and transistorized circuits on the latter's stand.

● **Napier** showed its production 2,000-lbs.-plus production missile rocket motors, the NRE 11 and NRE 17, the ramjet combustion test vehicle NRJ 1 and the fuel supply pack operated by ram pressure. This latter inducts air from two one-inch-diameter pitot heads, then diffuses it into a turbo-pump. Altitude and air speed regulation of the fuel supply are provided from dynamic/static pressure measurement.

● **Royal Aircraft Establishment** (Wescott)had the last word with its 50,000-lbs. thrust rocket-chamber/nozzle. This is a spherical chamber with divergent nozzle built from 32 identical individual "leaves" of argon-arc welded 18/8 stainless steel. Each "leaf" is of two skins, hydraulically inflated to provide cooling passages and molded to form. Kerosene at 800 lbs./sq. is fed through the passages to give regenerative cooling before spraying into the chamber to mix with the LOX for combustion. Instead of entering through nozzles, both propellants are injected through perforations in the inner skin of the chamber. Combustion pressure is 500 lbs./sq. in.

TEAMWORK:

Key To Success in Guided Missiles

By Dr. Wernher von Braun

Guided missile development is a young art. Certainly this makes it a rather fascinating art. Here is a fertile operating ground for creative minds and the younger generation is well aware of this. I receive many letters from young people asking advice on how to become a guided missile expert. I usually advise these inquirers that there are no such animals, for a successful guided missile system is the result of human teamwork rather than a specific idea or achievement on behalf of an individual expert.

The missile field, extending as it does into technical areas as far apart as fuel chemistry and ultra-high frequency radio, stress analysis and supersonic aerodynamics, materials research and gyroscopes, pure mathematics and shop management, cannot possibly be encompassed by a single brain. As in baseball, good players are needed but it is the quality of the teamwork among these players that de-

"You put a lot of work into it and at the end someone pushes a button and the thing is irretrievably gone cides whether they are big league or bush league.

As long as a new guided missile project is still earthbound—that is, in the stages of planning, design, manufacture, laboratory work and ground testing—we are relatively safe from serious setbacks. The acid test comes when we begin the flight testing. There are a number of reasons for this.

Intricate Relationships

● **In the first** place, there is an intricate functional cross-relationship between construction elements emerging from those vastly different scientific and engineering fields which make up the art of building guided missiles. A "bug" in a guided missile does not care how the development agency has been organized, and who was responsible for what.

Take for example: There is a vibration in a missile caused by the rocket engine. The vibration is picked up by a sensing element belonging to the guidance system, is amplified by the control circuits, and causes a hunting of the control organs which, in turn, breaks up the structure of the missile in midflight. Whose fault was it? Who is to be blamed? What is to be done about the bug? Only men working together as a team and familiar with the scientific and the hardware angles of the missile, can successfully remedy such a situation.

The Author . . .

is recognized as the world's greatest authority on ballistic missiles. MISSILES & ROCKETS *is honored to publish this article, which is the first he has written on human relations and missile developments. Dr. von Braun is a member of* MISSILES & ROCKETS' *Editorial Board. He is presently Director of Development Operations Division, U. S. Army Ballistics Missiles Agency, Huntsville, Ala.*

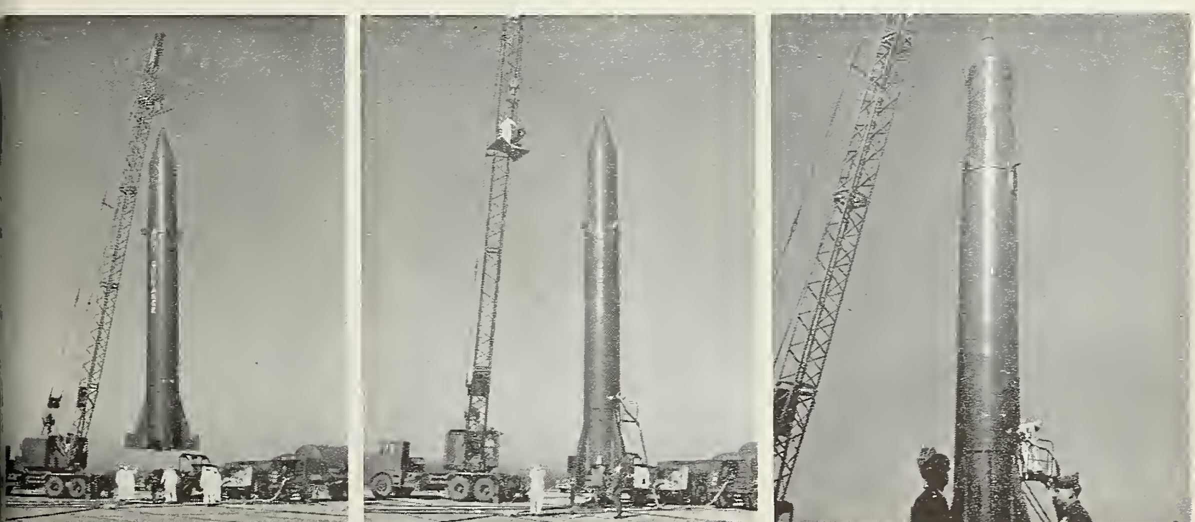
But before one can even sit down and analyze, one first must have the facts of what actually happened. The missile may have broken up above the clouds and the debris may have fallen irretrievably into the ocean. Nor is there a pilot to return to the base to report about discrepancies he may have observed prior to the break-up.

To observe the behavior of missiles in flight, we depend entirely on telemetry and tracking, both of which involve complicated electronic techniques. Telemetry radios to the ground pieces of information collected by a variety of eyes and ears, called "endorgans," which we have previously endeavored to place in strategic or critical locations throughout the missile. Alas, it is quite difficult to know in advance what will turn out to be a "critical location."

● **Management** of a successful missile program depends to a large degree on its capability of correctly and rapidly analyzing causes of malfunctions observed in test flights. It is easy to see that this task is the more difficult the more geographically and organizationally decentralized the project is handled. For more decentralization means more room for misunderstandings, less opportunity for people to grow together as a team, and less opportunity to familiarize a sufficient number of people intimately with the entire missile system, every part of which is a potential source of trouble.

It is an undisputed fact that a substantial number of test missiles must be fired before a new type missile emerges from the research and development phase. Thus, as we find it necessary today to modify the design as a result of yesterday's firing, we have to incorporate this modification into a number of missiles which, in various stages of completion, are being readied in our shops for future firings.

The period of time required for this process of analyzing flight tests, designing, building and testing the modified parts, and finally incorporating the modifications into missiles in the assembly shop is the best yardstick for any suc-



anywhere between 50 and 100 missiles for the development and another 50 to 100 for field-testing."

cessful, speedy missile system development.

Facts and Theory

All this, of course, means that production of guided missiles must begin before we know our own end product. Most production men will tell you that this is just plain nonsense and that every branch of industry will confirm that orderly documentation, meaning a complete set of drawings and specifications, is an absolute must for any successful production.

All we can say is that such production men had better learn a few things or stay out of the guided missile business. Unlike a tank, a gun or an airplane, a guided missile is a one-shot affair. You put a lot of work into it and at the end someone pushes a button and the thing is irretrievably gone. You need anywhere between 50 and 100 missiles for the development and another 50 to 100 for the field testing phase of a new guided missile system. So you have to provide not just a pilot line but a good-sized production before the design may be reasonably frozen.

Experience shows that a typical large guided missile system involves approximately 60 to 80 thousand engineering change orders on the missile alone between the first successful flight and the release as an operational weapon system. It may be a good guess to assume a similar figure for the ancillary ground support equipment.

If there were plenty of time, all this still wouldn't be too bad. We could move along cautiously and speed up this intricate process of analyzing, modifying and producing as our organization learns to function as a team.

The trouble is that we never have this time. Unless we can get a new missile system into the hands of the troops inside of five years after the development was started, the system is likely to be obsolete before it is ready for operational use. There is a saying in the Strategic Air Command to the effect that SAC has no up-to-date airplanes, that all of SAC's airplanes are either experimental or obsolete. The same can be said about guided missiles.

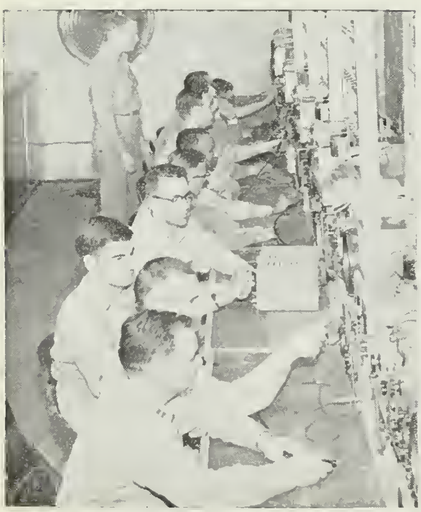
And yet, even if we are ready to accept the fact that only obsolete guided missile systems will ever attain operational readiness, we must still bear in mind that development costs for major guided missile projects amount to several hundreds of millions of dollars per system. To justify such expenses the weapons systems must have at least five to ten useful years.

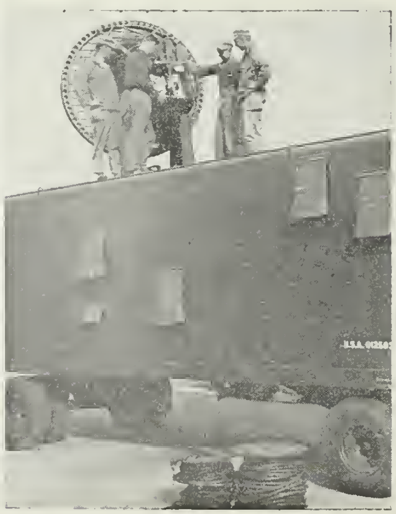
Crash Program Needed

● The conclusion is obvious. We simply cannot afford to develop a major new guided missile system on any other but a crash basis—nor may we assume that a potential enemy could not afford it. It is clear that the need for "crash" further greatly enhances the difficulties for the developing agency. Any development organization artificially pieced together by management decree does not have a Chinaman's chance to succeed in the race for superior guided missile systems. The job can only be done by a smoothly working team. What then makes a good team tick?

Any good team, no matter whether baseball or guided missile, is distinguished by certain qualities that are hard to appraise in sober scientific terms. In a good team there is a sense of belonging, of pride, of group achievement. There is an element of spontaneity in it. A good team must grow slowly and organically like a tree or a flower. All that management can provide to make a good team grow and blossom is a healthy working climate. Like a gardener, management can see to it that the flower has good soil, sunshine, water and fertilizer. Nature must do the rest.

Building a team is a slow process and there is trouble when one tries to speed it up too much. Just as one can burn a flower with too much fertilizer, one can badly hurt the growth of a healthy team by not providing sufficient time for new





TEAMWORK • • • key to missile system success—in the control room, on the tracking van, for acquisitio team members to get acquainted with each other. Whether they are scientists, engineers or mechanics, they must be given an opportunity to learn to appreciate the capabilities and accomplishments of their fellow team members. In guided missile development this is particularly important because there simply cannot be an argument as to what professional group is more important.

Once a group of scientists and engineers has learned to work together as a team they will laugh at such debates because they realize that they are dependent upon each other.

The picture of the gardener may appear a bit lyrical at a time when for sheer national survival we are faced with an urgent need for long-range ballistic missiles. And yet at this point I am tempted to quote a distinguished New England scientist who, when I asked him how long he thought he would need to complete a certain development program, replied, "Two years. But if you rush me it may take three."

The following factors are in my mind most essential and, in fact, indispensable to a successful guided missile team:

● **Maximum delegation** of authority. In a field as many-faceted as guided missiles, many, far too many, experts from various fields are needed. Men to whom leading position in a guided missile program have been entrusted should be modest enough to realize that they themselves depend on the successful and smooth functioning of the team as a whole just as much as any teammate in a lower echelon. It is impossible to run a successful guided missile program in a high-handed fashion.

● **An efficient and continuous** system of communications from top to bottom and from bottom to top. Here again the responsible team leaders must be modest and humble enough to admit to themselves that more good ideas usually originate in the working level of a technical team rather than in the management level, which is almost continuously tied up with planning, budgeting, personnel, contractual and similar problems. Therefore, if good ideas originated in the working level of a large development organization do not find their way to the top, the team will go to seed.

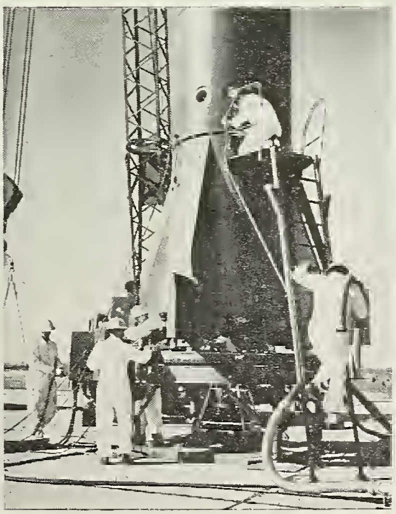
● **Loyalty, honesty and justice.** I am not using these well-worn terms just because you can't lose by stating that you are opposed to sin. There is a very practical aspect to these words in connection with a successful guided missile team.

One of our early Redstone missiles developed trouble in mid-flight. The telemeter records indicated that the flight had been flawless up to that instant, and permitted us to localize the probable source of trouble. However, the suspected area had been very carefully checked in numerous laboratory tests so that all explanations sounded highly artificial.

Several theories were advanced. Finally one theory was accepted as most likely and remedial action based on it was initiated. At this point an engineer who was a member of the firing group called and said he wanted to see me. He came up to my office and told me that during pre-launching preparation he had tightened a certain connection just to make sure that there would be good contact.

While so doing, he had touched a contact with a screwdriver and drawn a spark. Since the system checked out well after this incident, he hadn't paid any attention to the matter. But now that everybody was talking about a possible failure in that particular apparatus, he just wanted to tell me the story for whatever it was worth. A quick study indicated that here was the answer. Needless to say, the "remedial action" was called off and no changes were made.

I sent the engineer a bottle of champagne because I wanted everybody to know that honesty pays off, even if someone may run the risk of incriminating himself. Absolute honesty is something you simply cannot dispense with in a team effort as difficult as that of missile development.



ntenna operation, for launching preparation, for fueling, and for successful telemetry and guidance.

Indispensable Requirements

Loyalty and justice are just as indispensable. We must realize that every new development involves risk and the bigger the project, the greater are these risks. It would be conceited for the top management of a large development organization to believe (You sometimes hear statements to this effect!) that the man in the laboratory or behind the drawing board need not worry about the risk because the management alone is strong and brave enough to shoulder the responsibility.

Nobody can relieve a member of a team from his responsibility in his particular area. Moreover, the team member is usually quite proud of this responsibility and is only too ready to take it. But in a risky operation like a multi-million dollar guided missile project he wants to know that the management will back him up if he sticks his neck out and something does go wrong.

● **Finally a good team needs** a healthy rate of metabolism. In a dynamic team there must be chances for fair advancement for everybody. Without this chance the team will become stagnant and sterile.

The only way to maintain advancement chances is by providing a continuous influx of young people. This continuous influx of new blood makes the team less vulnerable to losses of key personnel, which may not only occur as a result of old age or death, but are unavoidable in a free economy. A healthy rate of metabolism should not be confused with personnel turnover, however. While the former is an indication of a healthy team, a high personnel turnover is a very definite indication that something is wrong.

There are only a very few experienced guided missile teams in existence in this country—experienced in the sense that they had an opportunity to see a complete guided missile system through from its early conception to operational readiness. These few coherent teams represent the greatest single asset this country possesses in the continuous struggle for international leadership in the guided missile field. Government agencies and corporations should spare no effort to protect the integrity of these teams and prevent them from disintegration and decay. This is a difficult task at a time when both the demands for better guided missiles and the willingness of industry to get into this new buisness is increasing at a much faster rate than organical growth of teams permit.

Temptations Are Great

Today the situation is such that anyone with a few years of experience in the missile business is continuously tempted to desert his team and accept a position of allegedly much greater responsibility (and, of course, much higher pay!) with one of the many companies that are desperately trying to establish themselves in the guided missile business.

I do not know of a greater single threat to this country's guided missile superiority than the danger of disintegration of the few experienced development teams under the onslaught of the gold-plated temptations offered by the fast-growing guided missile industry itself.

This is a free country. Unlike some of our competitors overseas we cannot, in peacetime, assign scientists and engineers to high priority projects and keep them there even if they don't like their jobs. It is the task of our guided missile project managements to *make* them like it.

But there is also an ethical obligation on the scientist and engineer himself. He should realize that every penny spent on guided missile development comes out of the taxpayer's wallet. In the research and development phase most guided missiles are not completely successful—but the missile itself will never learn what was wrong with it!

It is the development team that learns and widens its experience through failures in early missile testing. Consequently, any guided missile scientist and engineer playing with the thought of leaving his team should remember that he represents a public investment—not only as an individual and guided missile man—but as a member of his team. His value to the taxpayer may drop substantially if he changes his team allegiance. END.

A BOY AND HIS ROCKET

CHARLOTTE, N. C.—America's youngest rocket designer, ingenious 17-year-old Jimmy Blackmon, whose 6-foot gasoline rocket was "rejected" by Redstone scientists, is going to build another one.

"I won't build a whole missile as such," he told MISSILES & ROCKETS, "just the motor—with valve systems and injector head. Then I'll test the thing statically under 1,200 psi pressure with water and carbon dioxide to find out how I can mix propellants and control the flow into the injector head. I'll take some movies of the propellant flow and study the pattern."

Jimmy Blackmon's first rocket was rejected by the Army because high back pressure in the combustion chamber probably would have caused it to blow up.

● **The significance** of Jimmy's rocket experiments does not lie in the fact that this sort of thing can be experimented with on an amateur basis—and that our rocket-minded youngsters should be encouraged to convert a corner in the basement into a rocket lab—rather, the Blackmon case serves to focus attention on a problem that agitates the minds of many young American would-be rocket engineers.

Jimmy—and thousands of other youngsters—don't know what kind of prep-education is required for full-fledged missiles engineering studies later.

There Are Problems

Where do they start? What schools should they attend? What books should they read?

"I don't understand it," says Jimmy, "nobody can tell me exactly how I should go about becoming a missile engineer. Certainly, later on I should probably go to M. I. T. or Cal Tech or some similar university, but apparently I'm too young to even think about rocket hardware, or something. There are no books available; there is really no literature on actual design or construction of missiles and rockets."

He says there is no missile science or rocketry included in any high-school or college course.

● **"That's the reason** why I decided to start from scratch," he says. "It has taken me two and a half years to build this first rocket. The only available background information has been some basic dope on some early, unclassified rockets. I have read a lot of books on rockets, but either they don't tell you anything, or they are so technical you don't understand them. So it is quite obvious that there is no "in between" literature, something of an ABC or an introduction to "how to design a rocket."

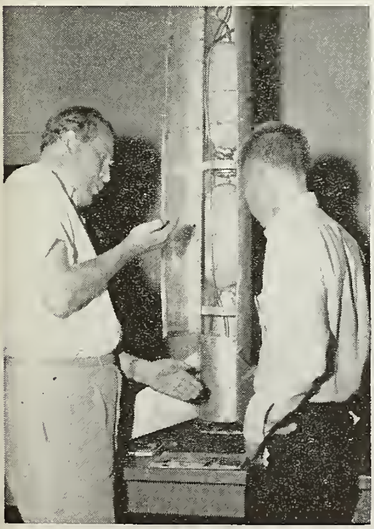
Jimmy's enthusiasm is admirable. One probably could not convince him that the art of rocket construction was never meant to be conducted in basements, even if the early pioneers did start out that way.

The fact remains that our high-schools and colleges might want to look into the vocational aspects for this new and continually growing technological area. In view of the tremendous recruitment programs of the industry, youth is becoming aware of the possibilities in the missile field, Jimmy thinks. They should get some guidance, he suggests. There should be some official or semi-official institution that could inform this country's would-be rocket engineers on how to plan for the future.

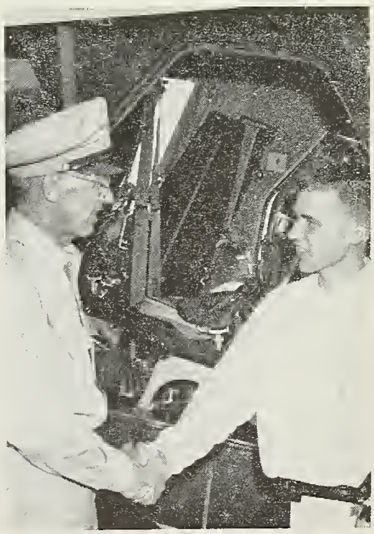
● **"I am sure** a lot of us teenagers waste a lot of time because we don't get any guidance with respect to what courses we should choose and what schools we should attend," Jimmy says.

"Furthermore, if the missile industry needs engineers so badly, why don't they let us start while we're young? I'm sure a lot of teachers would go ahead and suggest to us that we have to study the fundamentals of different sciences, and that's fine. But beyond that, I think many young boys already have so much missile and rocket know-how these days, if they're interested, that they could actually begin their applied studies much sooner."

Of course, most of our young would-be rocket engineers are not as realistic in their enthusiasm as Jimmy Blackmon. But they are still in the same position; they do not know where to go for guidance. Dr. Wernher von Braun, in his article in this issue of MISSILES & ROCKETS, points out that he receives many letters from young boys asking him "how to become a rocket expert." But it is too much of a job for one man to handle all these inquiries.



ROCKETEER VON BRAUN & JIMMY
. . . Too much back pressure



GENERAL H. N. TOFTOY
. . . Free advice to an amateur

NACA *what it's doing and where it's going*

By Dr. Hugh L. Dryden

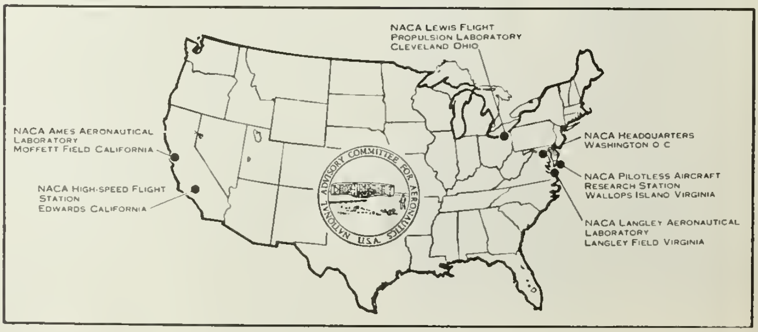
The National Advisory Committee for Aeronautics has extended its interests beyond the atmosphere to new types of vehicles in the search for ever-increasing speed and altitude. Performance goals have been boosted by an order of magnitude through the development of rocket propulsion. Increasing altitude made possible by rocket propulsion permits greatly increased speed, of course; and the attainment of the velocity required to escape from the earth's gravitational field is not too far away.

Rockets first appeared in the NACA in 1945 as a tool for research on transonic and supersonic aerodynamic problems. Available solid-propellant rockets developed during the war as ordnance weapons were used to propel models at high speed. Aerodynamic characteristics were measured by radio telemetry and radar techniques. Research on rocket engine problems began shortly thereafter at NACA's Lewis Flight Propulsion Laboratory.

● **The National Advisory Committee for Aeronautics** is appointed by the President. A 17-man Committee serves as a board of directors, establishing policies and programs for its paid staff of nearly 8,000 Civil Service scientists, engineers, technicians and other employees. Ever since its establishment by Congress in 1915, with the assigned responsibility "to supervise and direct the scientific study of the problems of flight with a view to their practical solution," the agency has been keenly conscious that it is financed by Congressional appropriation, and that it is operating for the benefit of the taxpaying public.

Using both theoretical and experimental techniques, NACA works always towards the goal of discovering how to make better aircraft. With the advancing goals of flight performance, NACA has proceeded from subsonic to supersonic piloted aircraft, to pilotless aircraft, guided missiles, and ballistic missiles. Congress has placed no restrictions of distance, or speed or altitude.

Some of the research effort is basic and long-range. Here the scientist is seeking discovery and understanding. Often the worker himself cannot foresee the possible applications of his studies, or evaluate their true worth. The path between basic or long-range research and the finally-developed product is



NACA Research Centers

seldom direct. This kind of research activity may continue to result in improvements in many products. It is, of course, possible to guide even this long-range kind of research into areas which bring productive results to a given technological field.

At the other end of the spectrum is what might be called applied research of shorter time scale. Very specific goals are set for groups of scientists and engineers conducting research directed towards early application. In performing this kind of work, it is necessary to draw upon all the existing knowledge which has been obtained by basic research.

● **During its first 25 years**—until World War II—most of the NACA's research was concentrated on aerodynamic problems. By taking bold action to provide its scientists and engineers with the novel, often complicated, and usually expensive research equipment necessary to press forward the frontiers of aeronautical science, the NACA produced a wealth of information that was used to good advantage by America's aircraft industry. This was a course of action that paid handsome dividends, in directly useful information, on the taxpayers' investment.

The Author . . .

is the well-known Director of the National Advisory Committee for Aeronautics. He has been the responsible head of this agency since 1947. Dr. Dryden majored in physics at Johns Hopkins University, where he was graduated with honors in 1918. The following year he earned his Ph.D. from the same university. He holds seven honorary degrees from as many institutions of higher learning.

We were living in a peaceful, subsonic world. Supersonic speeds were of interest only to ballistic experts and to the few enthusiasts who wanted to travel faster than would be possible in propeller-driven aircraft.

Dreams Come True

But almost imperceptibly, technological advances were made that in their sum transformed such unattainable dreams as rocket engines into practicable ideas. These technological gains were in many areas —metallurgy, fuels, chemistry, combustion, electronics, aerodynamics.

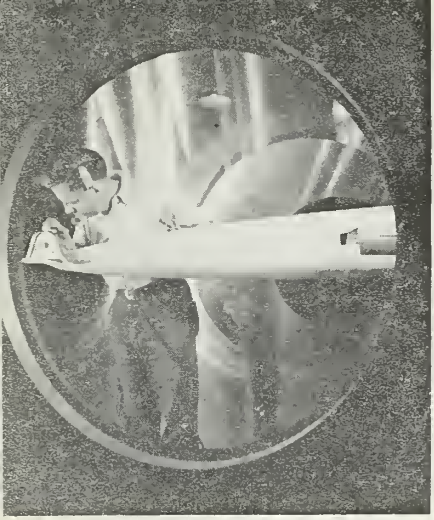
The NACA's effort in World War II was devoted largely to applied research, the business of finding "quick fixes" to improve the performance of existing airplanes and to make production engines more powerful. Fortunately, years of research had produced a sizeable backlog of readily usable design data on low-drag wings, high-speed propellers, stability and control, improved systems for cowling and cooling engines, and the like. During the war years, the NACA worked on more than a hundred airplane types.

By the close of World War II, the end had come for development of the airplane as conceived by the Wright brothers. Now, it was possible to build useful rocket engines, and with this development came the possibility of flight at velocities exceeding the speed of sound and to altitudes higher than the earth's atmosphere.

● **The problems implicit** in the speeds now within man's grasp covered the usual, accepted aspects of aeronautics—aerodynamics, structures and loads, powerplants—plus new ones, thermo-dynamics, aero-thermo-chemistry.

Instead of thinking of speed in terms of hundreds of miles an hour, it became necessary to stretch one's imagination to encompass the prob-

Staff member of the 4 x 4-foot supersonic pressure tunnel at Langley Aeronautical Laboratory of NACA checks model of research missile in test section of tunnel. Highly-reflective walls of test section are constructed of stainless steel.



Forward section of a research missile viewed through the 26″ diameter Schlieren window in NACA 8 x 6-foot supersonic wind tunnel test section. A technician is calibrating remotely controlled surface of missile.

lems growing from flight measured in thousands of miles an hour. For such speeds the rocket engine is peculiarly fitted and indeed necessary.

The earliest NACA research on rockets deal with liquid-propellants, exploring the possibilities of known compounds and of new chemicals synthesized for the purpose to give much higher performance than the alcohol-liquid oxygen of the V-2 rocket. The first work was that of theoretical computations of performance, soon followed in 1947 by experimental work in small rockets of 100-lb. thrust.

Expanding Research

Within a year experiments were in progress on rocket starting at low temperatures and pressures corresponding to high altitudes, on film cooling of the combustion chamber walls, and on photographic studies of combustion in a transparent rocket chamber. Today, research continues in propellants, materials, combustion, and cooling in facilities permitting the use of engines of larger thrust and in other fields which promise to contribute to the improved performance and utility of rocket propulsion.

The tremendous increases in speed and altitude made possible by rocket propulsion can be realized only by the simultaneous solution of many difficult aerodynamic and structural problems of the vehicle, whether aircraft or missile. High speed through the air generates heat which raises the temperature of the aircraft or missile, producing thermal stresses and loss of strength or even melting of the materials of which the structure is made. Aerodynamic heating can be avoided by going above the atmosphere—except that always we have to re-enter the atmosphere to reach our destination or target.

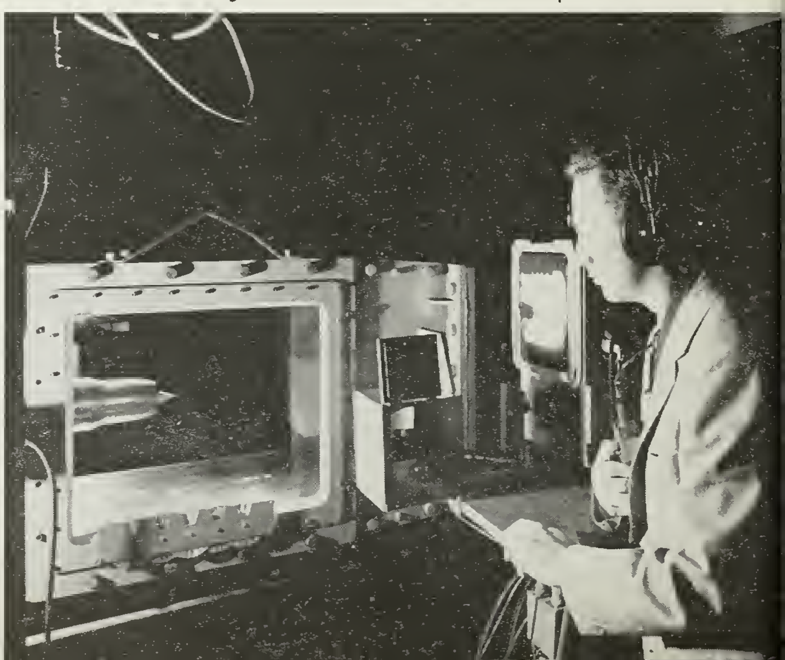
The re-entry of the nose cone of a ballistic missile is confronted with the most severe conditions. Dissociation of air molecules into atoms and the recombination of atoms, ionization of the atoms and recombination of electrons and ions, and the formation of new chemical compounds from constituents of the air—these are areas where our understanding is sadly incomplete.

● **What makes research** on such "out-of-this-world" problems so difficult is that we have had to learn how to duplicate in the laboratory the extremely high temperatures and the other conditions of future flight. Only recently have we begun to see how to design and build small, pilot models with which to prove the practicability of constructing the radical new research tools so necessary for rapid expansion of the limits of our fundamental knowledge. Much work remains to be done in this stage, the providing of tools with which to study the basic problems.

Research and development have proceeded simultaneously from the days by the design and construction of practical devices, enabling us to focus research on the important problems of applied research which lead to advances in the technology. Along with this applied research we do basic research in hypersonic aerodynamics, new fuels, combustion, and heat transfer under the extreme environmental conditions which lie in the future.

This even now, while so much remains to be done toward providing the tools required for research at the limits of technology, very large effort is being devoted to the development of prototypes of actual long-range rocket missiles. Next year, according to present commitments, we are scheduled to fire a satellite vehicle hundreds of miles into the sky. With this event, we shall open the gates to the vistas of space. END.

Conical inlet being tested in 18 x 18-inch NACA supersonic tunnel.



NACA's *DAN* EXPERIMENT

National Advisory Committee for Aeronautics has disclosed first details of successful flight tests using a combination of a *Nike* missile booster and an Allegheny Ballistics Laboratory *Deacon* sustainer as a two-stage, solid-propellant rocket for meteorological sounding at extreme altitudes.

Two test firings of *Deacon-Nike* (called Dan) rockets indicate that altitudes between 385,000 and 487,000 ft. (73 to 92 miles) may be reached with payloads ranging from 60 to 10 pounds, NACA says.

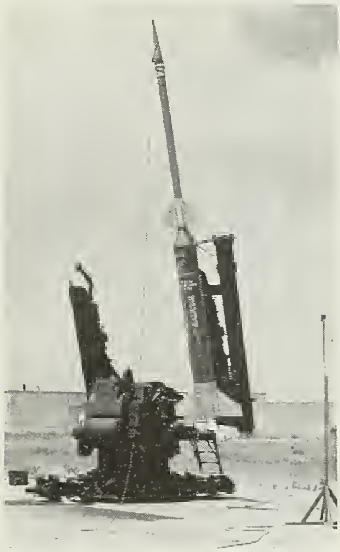
Project was conducted for the U.S. Air Force's Cambridge Research Center by NACA's Langley Aeronautical Laboratory. Actual firings took place at its Wallops Island, Va. Pilotless Aircraft Research Center late last year.

In the NACA tests, the first *Deacon-Nike* was launched at a 75° angle of elevation and reached a peak altitude of 356,000 ft. some 161 seconds after launching Second Dan rocket, launched at the same angle, attained a slightly lower altitude of 350,000 ft. in 156 seconds. But NACA scientists estimate the higher altitudes can be reached by launching the Dan vertically.

● **Design of the sounding rocket** was worked out by NACA in conjunction with University of Michigan's Engineering Research Institute. In final form, it consisted of a first-stage *Nike* booster with a second-stage ABL *Deacon* sustainer, the latter having been used previously by NACA as an aerodynamic research vehicle.

Test results showed that on each flight this combination operated entirely satisfactorily with respect to both propulsion and aerodynamics.

Ultimate purpose of the vehicle is to carry free-fall accelerometer sphere apparatus developed by the University of Michigan for measuring densities at heights between 250,000 and 375,000 ft.



Dan rocket ready for launching.

Test details, reported in Technical Note 3739 by NACA's R. H. Heitkotter of Langley Aeronautical Laboratory, show these weight specifications for the Dan rockets:

Component	Weight (lbs.)
Loaded *Nike* booster	1,170
Booster adapter	45
Booster fins	109
Complete booster	1,324
Loaded *Deacon*	151.5
Deacon fins, shroud & fairing	25.5
Nozzle extension	5
Nose cone and instrumentation	34
Complete *Deacon*	216

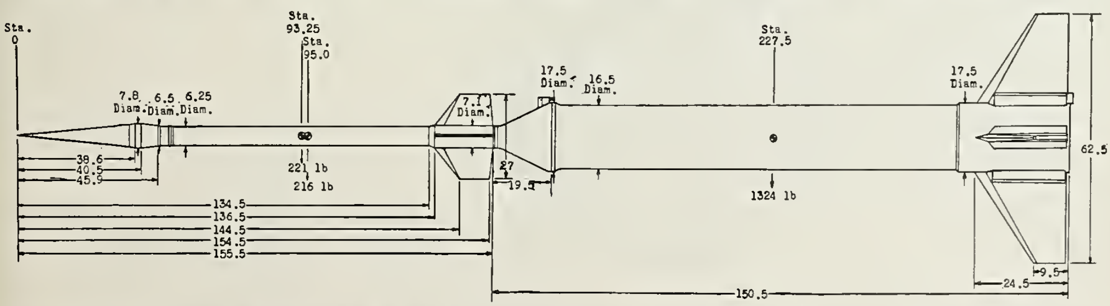
Nose cone of the *Deacon* housed AN/DPN-19 radar beacon instrumentation protected from aerodynamic heating by a 3/16-in. thick magnesium shell. The beacon signal was tracked by an NACA modified SCR-584 CW Doppler radar to obtain data on variation of speed with time for computing Mach number.

Procedure used in both tests was to allow the second-stage rockets to decelerate after *Nike* booster separation in order to reduce nose cone and rocket case wall temperatures by traversing the lower, denser atmosphere at relatively low speeds.

First Dan rocket was carried by *Nike* booster to 4,900 ft. before first-stage separation. It coasted 13.7 seconds before the *Deacon* sustainer rocket was fired and accelerated to a maximum velocity of 5,150 feet per second (approx. Mach 5) at an altitude of 47,060 ft.

After burnout, the *Deacon* coasted in free flight until the nose cone and sphere were released about 52 seconds after launching. Peak altitude of 356,000 ft. was determined from the radar beacon equipment in the nose cone 161 seconds after launching.

Second vehicle was boosted to 5,200 ft., coasted 9.45 seconds and was accelerated to a top speed of 5,289 fps at an altitude of 39,339 ft.



DEACON-NIKE rocket. Accelerometer sphere is located at bulge in Deacon immediately aft of nose cone (left).

Navigation by Satellites

By Lovell Lawrence Jr.

An Artificial Satellite Time and Radio Orbit celestial navigation system that is simple, yet reliable, may be feasible in the near future. To accomplish this, however, a very high degree of accuracy must be maintained in the electronic components. Methods for observing this high-velocity body by other than optical means will be necessary, and accurate time signals must be generated.

To utilize a stable celestial body for navigation purposes, it is necessary to know the co-ordinates of its sub-astral position at any given time, and to be able to accurately associate it to geographical locations on the earth. The orbits selected for artificial satellite around the earth, to be used as a navigation reference, should be permanent and circular (or near-circular) with an altitude that will allow visibility over the greatest area at all times. Some perturbation of the satellites and precession of the orbits due to the earth's oblateness can be tolerated, provided that these changes are slow and predictable.

Considering a 24-hour equatorial orbit, the satellite would rotate at the same rate as the earth and appear to remain motionless over one spot at all times. A proper number of these artificial bodies placed in such orbits would permit continuous navigation over the earth's surface and would greatly reduce complexity in the preparation of almanac records. However, the 24-hour orbit can be disregarded at the present time since the advancement in the art will not develop rapidly enough to permit the launching of such a satellite in the near future.

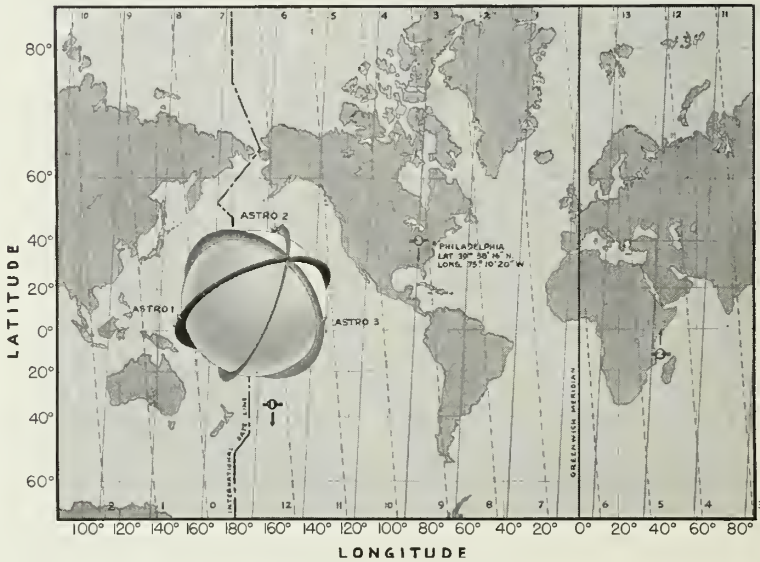


Figure 1—Mercator projection with three ASTRO satellites in their period positions eight hours apart.

● **The fact that** very delicate and complicated instruments will be necessary to maintain accurate contact with the satellite makes the venture difficult. Also, the requirement for increased power to maintain high visibility, and the difficulty that would be encountered in order to correct for large refraction errors caused by atmospheric and ionospheric disturbances would make its use untenable. Therefore, a lower-altitude orbit seems more feasible right now.

The placement of a 105-minute orbit seems possible in the predictable future, and this 600-mile altitude vehicle will establish a horizon that will allow the satellite to be visible to an observer for periods of from 6 to 16 minutes at any point

Figure 2—Estimated satellite specifications.

	Non-Directional	*Spin*
Satellite diameter maximum	3.5 ft.	3.5 ft.
Sphere weight	25 lbs.	25 lbs.
Transmitter	100 watt-10 lbs.	15 watt-5 lbs.
Power generator	12.5 watt-15 lbs.	2 watt-5 lbs.
Antenna	8—8 lbs.	1—1 lb.
Gyro	None	5 lbs.
Jet system	None	10 lbs.
Total weight	58 lbs.	51 lbs.

on the earth's surface. Three of these orbits, symmetrically placed over the poles, will permit a navigation fix at intervals of not more than 105 minutes decreasing generally toward the poles. Also, at this altitude, a satellite velocity in the order of 4½ miles per second would be expected, thus permitting the use of the *Doppler* frequency shift of a carrier on the satellite as a means for determining its relative velocity and by correlation, the position of the navigating vehicle.

● Figure 1 shows a *Mercator* projection of the world, with the three Astro units in their period positions eight hours apart. The time lines of Astro-3 are plotted, showing the co-ordinates of its sub-astral position, 21 hours after launching. The other two Astros are shown in their positions at the same hour. However, their time lines have been omitted to maintain clarity in the chart. Astro-3 will be used later when the aircraft flight plot is discussed.

To be assured of a good polar orbit, the satellite should be launched from the North Pole on the proper trajectory so that it is injected into its predetermined orbit.

It should be noted that the Astro system could readily be combined with satellites used for collecting geophysical data. However, for the purposes of this article, only the navigational application will be considered.

Satellite Designs

Two satellite designs are considered, both spherical in shape. One to be oriented, by gyroscopic means, into the plane of its orbit after being launched, spinning at the time of cutoff. The other design would be placed in its orbit without any attempt to control its altitude.

The Author . . .

is a recognized authority on rocket powerplants and missile design. He founded Reaction Motors, Inc. and served as its president and chairman of the board until 1951. A former president of the American Rocket Society, he joined Chrysler Corp. Missile Operations in 1954, where he is now Assistant Chief Engineer.

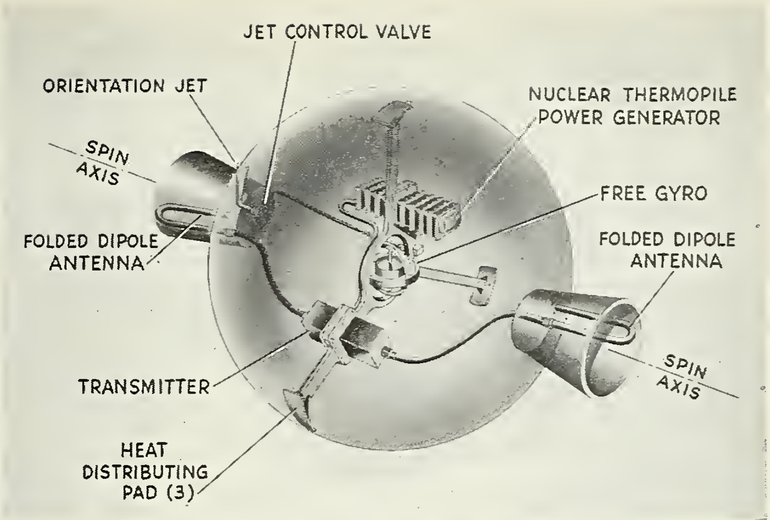


Figure 3—Reoriented satellite with spin.

The general dimensions of the satellite shown in **Figure 2** are more or less determined by the minimum surface area required to dissipate the 200 watts of heat from the thermoelectric generator. It is believed that the volume of the two-foot sphere will be of sufficient magnitude for housing the necessary equipment.

● It is conceived that the reorientated satellite would be launched with its spin axis directed into the flight path of its trajectory, in the same manner that an artillery shell is fired, **Figure 3**. After a predetermined time in the orbit, the gyro would signal the jet to force the sphere around until its spin axis was perpendicular to the plane of the orbit and it coincided with the gyro spin axis.

Such momentum as may be created by the gyro running down would then be absorbed into the satellite spin axis as an increase in its spin rate. To establish a proper wave pattern for broad coverage over the earth, two folded dipole antennas would be placed at a proper angle to the axis of spin, and the resulting pattern would laterally sweep the earth, back and forth, as the satellite moved along.

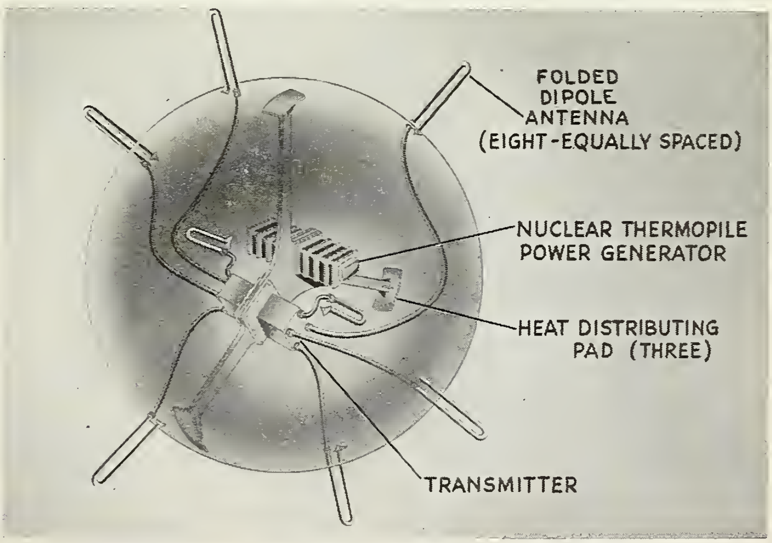


Figure 4—Non-directional satellite with eight antennas.

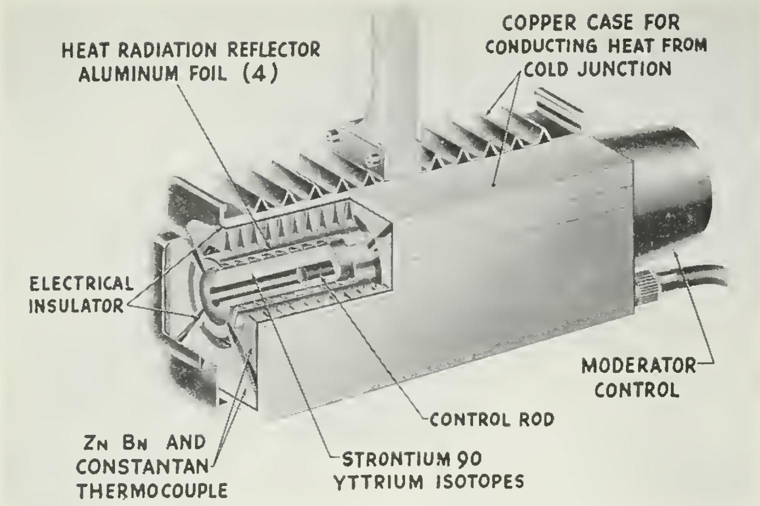


Figure 5—Thermopile satellite power package.

The folded half-wave dipole allows the use of metal sphere construction in order to contain the transmitter, gyro, power pack and high-pressure gas supply for the reorientation jet. This sphere then becomes the common ground for both antennas. Although each antenna will establish its own wave pattern, for all intents and purposes all patterns will appear to the earth as if they emanate from a single dipole.

● **Figure 4** shows the satellite with an antenna system for producing an all-directional wave pattern, using eight symmetrically-place folded dinoles arranged to permit good earth contact, irrespective of orientation or spin. The same arrangement exists except for a slightly larger powerpack and transmitter, excluding the gyro-jet reorientation system. The bracket used to attach these items to the inside of the satellite's sphere would be made of material with high conductivity so that heat may be rapidly removed from the powerpack through radiation into the void from the blackened outer shell of the sphere.

In addition to the heat-conducting frame and pads, the sphere will be charged with a liberal supply of mixed nitrogen and hydrogen gas. This mixture will materially assist in damping extreme temperature variations when the plane of the satellite's orbit was perpendicular to the sun's rays.

The nondirectional radiating satellite will require approximately 12½ watts of electrical energy to produce 15 watts of power in each of the eight antennas at 100 mc. This ratio of low-power input for high-power output is accomplished by utilizing a radar-type pulse, with a fixed width of around ten microseconds. The pulse-spacing will then be varied by an accurate and periodically-corrected timing oscillator, and used to indicate the lapsed time of each orbit period. To produce this 12½ watts of power for the transmitter, a nuclear thermopile could be used.

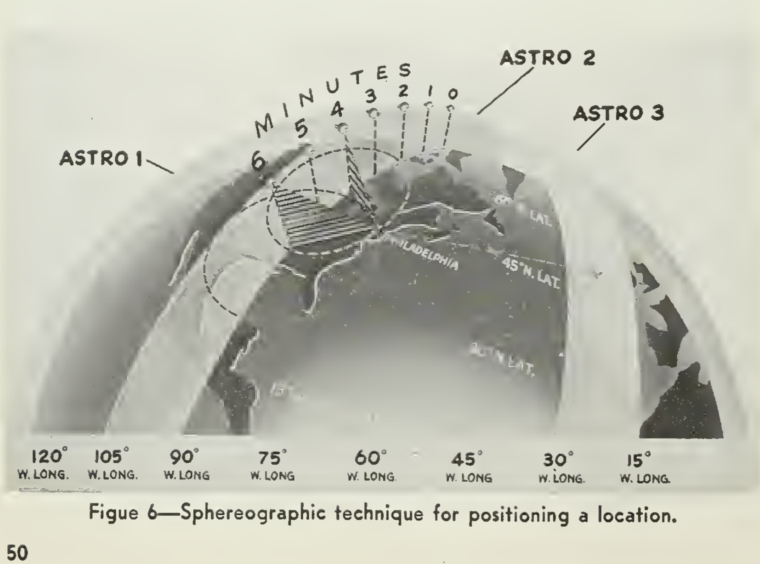
● **The isotope** to be used for the thermopile heat source calls for four pounds of strontium 90 that produces 200 watts of heat. Its half life is 20 years. This power source would also be suitable for heating the oven containing the transmitter, which maintains the high degree of accuracy required of the master oscillator crystal and timing circuits.

In view of the complexity of any other type of power package, such as a sun generator requiring controls to maintain its proper orientation with respect to the sun, the use of a thermopile seems feasible. **Figure 5.** Present thermocoupls of antimony-bismuth alloys and constantan will produce about one-tenth volt, with a 400-degree centigrade temperature differential between the hot and cold junctions, and reach an efficiency of about five percent.

Navigating with Astro

To give some idea of the Astro system of navigation, **Figure 6** depicts, graphically, a sphereographic technique for determining the position of a location on the earth with reference to the orbit at some given time. Since this form of celestial navigation is in common use today, with standard almanac tables of the stars prepared in advance, it will not be necessary to discuss its technique in detail.

For the sake of clarity, it is assumed that Astro-2 was recently launched from the North Pole and aimed along the Greenwich Meridian. If 5½ hours have elapsed, the satellite has then made 3.14 revolu-



Figue 6—Sphereographic technique for positioning a location.

tions. Since the 105-minute orbit makes approximately .57 revolutions per hour, this means that at approximately 5:15h it would be directly over the North Pole.

● **For example:** If a ship, moored in the Philadelphia Harbor, were equipped with an electronic sextant (consisting of an accurate and highly-directional antenna coupled with a pendulum for defining the horizon), it would be able to determine the satellite's altitude angle as it came into range. By referring to the almanac (to determine the satellite's sub-astral point), a line of position could then be worked out for the ship. The circle of equal altitude, established from this position, would show that the ship must be somewhere on this circle.

If another observation were made some minutes later, a second circle of equal altitude could be similarly determined. After observing the azimuth roughly, the intersection of these two circles would determine the ship's actual position, or fix.

The difficulty with the sphereographical navigation technique applied to the Astro system is that an accuracy of five places is required of the tracking mechanism in the electronic sextant. To develop reliability in such a mechanism would be difficult indeed—especially since serious errors will be introduced when the ship is pitching and rolling—resulting in poor correlation between the horizon reference and the observed angle of elevation. It is clear that a different method of navigation will be necessary to eliminate this complicated and expensive approach.

Doppler Shift

Since the velocity of a 105-minute Astro is in the order of 16,500 mph, it may be measured by observing the doppler frequency deviation of the 100 mc carrier. It is this *Doppler* shift phenomenon that makes the sound of a train whistle appear to change its pitch as it passes by. This same phenomenon is also applicable to radio waves. If the difference in frequency deviation can be detected between a satellite on an orbit passing directly overhead and an orbit observed at a distance, the relative velocity thus derived is a measure of the position distance with respect to the observer. A direct correlation can then be made between the frequency measured from the line of closest approach (or null) for each increment of lapsed time, and the required position distance in degrees of longitude or in nautical miles.

● Figure 7 shows a plot of the observed frequency deviation, versus position distance, for a number of minutes of lapsed time after the satellite has passed the sub-astral latitude position. Above this graph are shown three of the family of orbits, graphically portrayed in increments of longitude by placing them over lines that are tangent to the earth's surface. The intersections of the arcs at the tangent lines determine the Astro's visible horizon to an observer who is at the tangent position on the zero longitude line. The orbit directly overhead will remain in view 16 minutes, the most distant orbit for 6 minutes.

The line drawn perpendicular to the tangents of the horizon on these three orbits passes through the position of closest approach where both the satellite's apparent velocity and the *Doppler* shift will reach zero. Then, to obtain the accurate time of the zero beat (or null) and the correct position distance of the observer from the satellite, it will be necessary to have a computer capable of rapidly making a series of approximations. As each approximation is made, the computer corrects for the known velocity com-

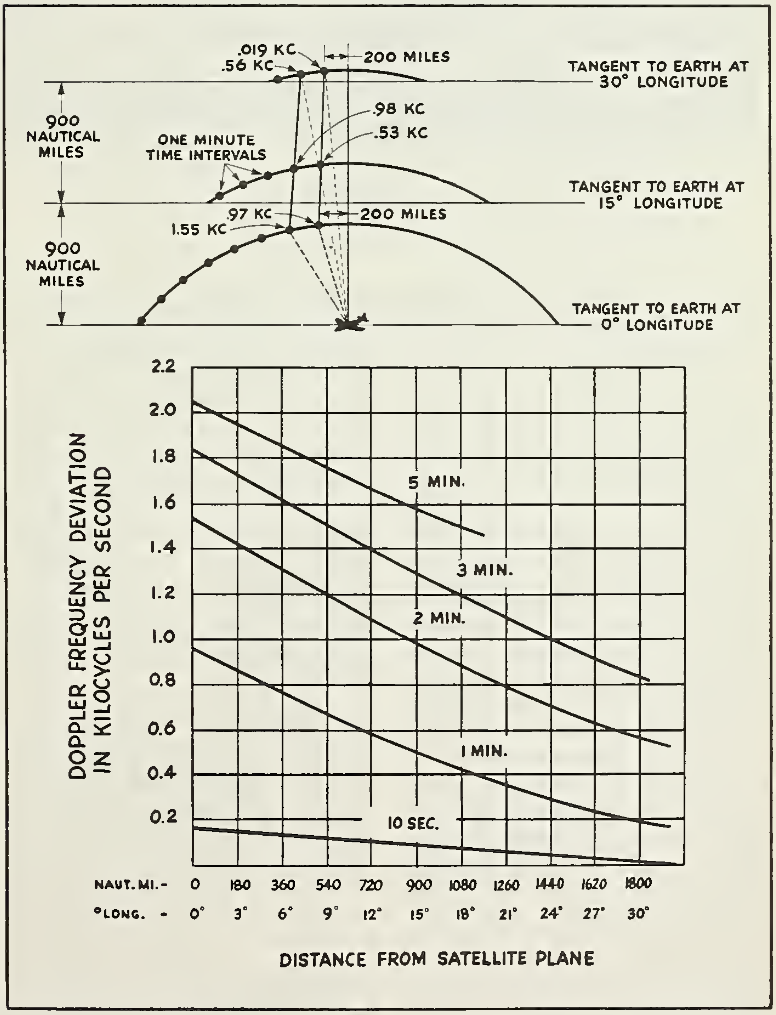


Figure 7—Plot of observed Doppler frequency.

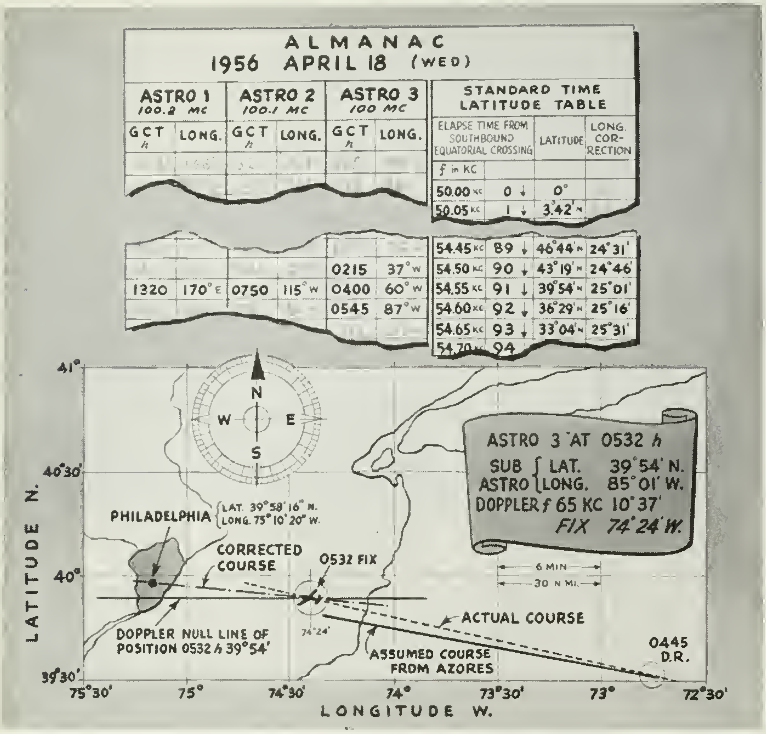


Figure 8—Depicting a flight from the Azores to Philadelphia on a Mercator position-plotting sheet.

ponent of the earth's rotation, as well as air speed, course heading and altitude; thus shrinking the error.

If the computer is allowed to function for a reasonable time after the apparent null is detected, then the corrected null and position distance are obtained, and the observer can establish a fix with a fairly high degree of accuracy. If the phase shift of the beat frequency (as it reverses at null) is detected by a phase discriminator, it is estimated that the geographical position of an observer can be determined within an accuracy of one mile by holding the satellite carrier frequency to ten cycles in 100 million.

● **As an example:** If an observer were to neglect all motion and attitude other than that of the satellite, and a frequency shift of .53kc was indicated one minute after null, then (according to the graph) he would be at longitude 15°, or 900 nautical miles from the satellite. If another observation was made at the end of the second minute, the same reading would be obtained.

Figure 8 depicts an aircraft flight from the Azores to Philadelphia on a *Mercator* position plotting sheet. Since it is probable that no Astro will fall exactly into its predetermined orbital altitude and, because each one is launched at different intervals, all these orbits must be recorded for each day of the year. The almanac page shows the Greenwich Mean Time and longitude of their sub-astral position as the satellites pass over the equator. There will be approximately fourteen 105-minute periods of revolution to be listed for each day of the year.

The column at the right of the double line is the Standard Time latitude table for each minute which is always predictable for any permanent orbit period of revolution. This table could be placed on the inside cover of the almanac; but, to make for simpler reference during this discussion, both tables are placed side-by-side. Since it is also necessary to establish Astro-3's longitude coordinate for each increment of time from its last southbound equatorial crossing, this last column on the right gives the correction to be applied.

● **The Astro's** transmitter sends a time reference signal by varying the pulse spacinb, indicating the lapse of time for each rotational period.

An oscillator, modulated by an accurate timer and corrected every 105 minutes as the satellite passes over the North Pole, will vary between 50 to 55 kc as each minute has elapsed. This variation, when properly interpreted once the Astro has been calibrated, will produce directly the latitude coordinate as well as the correction for the longitude coordinate. It would then be possible to introduce this signal into the computer as a function, without further reference to a table.

The *Mercator* position plotting sheet shows aircraft has been in flight in dense fog for a number of hours, and a dead reckoning plot was made at 14:45 hours. The course has been continued until 05:05 hours, when the Astro-3 signal was detected. After listening to the drop in pitch of the beat frequency between the satellite's transmitter and the receiver's oscillator, (while properly determining the azimuth), the apparent null occurs at 05:31 hours.

After the computer is allowed to operate for one minute, the receiver tells us that 91 minutes have elapsed since the satellite's last equatorial crossing, and the corrected position distance is 10°37'. Now, upon referring to the standard table, the satellite's sub-astral latitude coordinate is 39°54'N. If the longitude correction of 25°01' is added to the longitude figure of 60°W (derived from the almanac table after determining the Greenwich time of the satellite's passage over the equator), then the sub-astral coordinates of the satellite are established.

By drawing an Earth Parallel from the satellite's sub-astral point on Mercator position plotting sheet, the observer can define his line of position. By subtracting the corrected position distance of 10°37' from the satellite's sub-astral longitude coordinate, an accurate fix is made at longitude 74°24'W on the latitude 34°54'N line of position. The navigator can now correct his course. END.

Martin's TITAN project

By Henry T. Simmons

Denver residents will be hearing a new sound not so many months from now. It will resemble the low rumble of a freight train in the far distance.

But it won't be a freight train. It will be the shattering exhaust of a rocket engine doing its stuff on a test stand tucked away in a Rocky Mountain canyon many miles to the southwest of the city.

Though distance and the natural acoustical effects of the mountains will soften the engine's blast to a gentle murmur, the sound will nonetheless signify a new era for the military potential of the United States as well as the economy of the Colorado capital.

With construction of its new plant near Denver racing to completion, the Martin Co., Baltimore, Md., may begin preliminary manufacturing operations before the end of this year on the airframe of the *Titan* intercontinental ballistic missile.

Titan is Martin's entry in Uncle Sam's forced-draft program to achieve a ballistic vehicle capable of transporting a thermonuclear warhead at least 5,000 miles. Its chief competitor is the *Atlas* ICBM vehicle which Convair Division of General Dynamics Corp., is building.

The Baltimore aircraft company and Convair are two of 16 major contractors engaged in the Air Force drive to develop and introduce the so-called "ultimate weapon" ahead of Soviet Russia. The other companies are working on complex guidance techniques, immensely powerful rocket engines and nose cones which must withstand terrific temperatures in bringing the thermonuclear payloads back through the atmosphere after their brief journey in space.

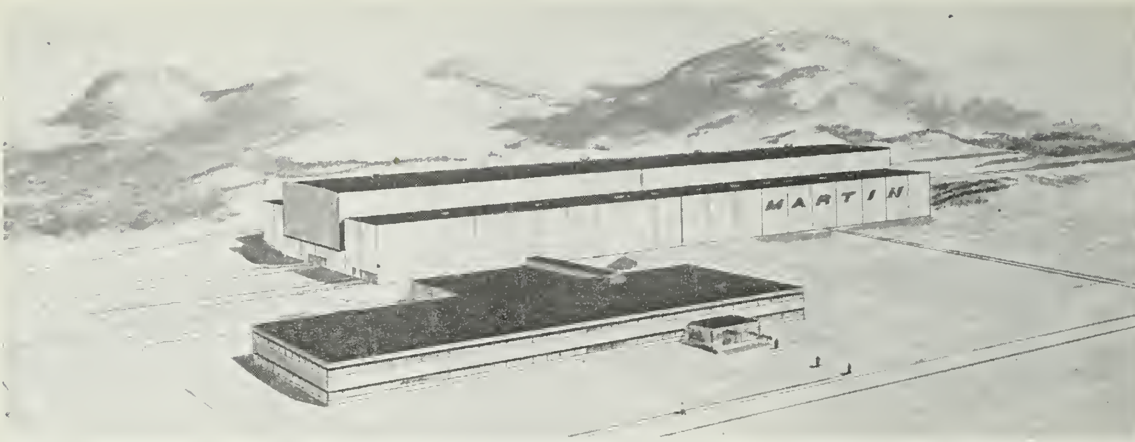
● **As expected,** details of the *Titan* are shrouded in military secrecy. But Dr. Walter Dornberger, formerly commander of the German V-2 rocket center at Peenemunde and now a missile consultant for Bell Aircraft Corp., has given this rough description of the ICBM: It will be more than 100 feet long, some feet in diameter and will weigh several hundred thousand pounds when fueled.

Though only an approximation, this description does suggest something of the magnitude of the job facing Martin's new Denver Division, set up early this year to develop and produce the *Titan* airframe. Work on its new facilities is running well ahead of schedule, according to local reports. All buildings are scheduled to be ready by January 1, less than one year after the start of construction, and some portions of the plant may be available as early as November 1.

Martin Investing $10 Million

Martin is putting $10 million of its own funds into the *Titan* project, which will occupy a 4,400-acre site in the "front range" of the Rocky Mountains in the vicinity of Waterton, Colo., about 20 miles southwest of Denver. A total of 408,300 square feet of plant space is now under construction, including a complete and modern factory of 306,700 square feet, an administration and engineering building of 88,400 square feet and a cafeteria of 13,200 square feet.

Supporting facilities include a steam plant with a capacity of 84,000 pounds of steam an hour, a 300,000-gallon water tank, an incinerator and plants for garbage disposal and sewage treatment. A parking lot with space for 750 cars is also planned, but this will undoubtedly have to be expanded as the plant builds up to its anticipated maximum of 5,000 employees by



Martin's New Denver Facility for Titan ICBM Development.

1960.

● Martin is also building a number of test stands for checking out engines and other systems of the completed ICBM weapons prior to their shipment for test firing or to storage in regular launching sites. The *Titan* test facilities will be located in canyons surrounded by high mountains so that the ear-splitting noise of the engine tests, according to the Denver University Research Institute, will be largely dissipated in the immediate area.

Construction Work Under Way

Meantime, construction work on access roads and bridges by State and County authorities is keeping pace with work on the Martin project itself. Ultimately, this work will have a most important bearing on the *Titan* operation since transportation of the huge, unwieldy missiles will be an acute problem. Barring accidents, it is unlikely that a *Titan* will ever leave the factory under its own power.

General Manager of the *Titan* project is Albert L. Varrieur, 39, a veteran Martin engineer and operations manager for a number of important company projects, including the B-26 bomber of World War II, the 404 commercial airliner and the P6M-1 jet flying boat.

Chief Engineer of the Denver Division is William G. "Mister Viking" Purdy, 38. He joined Martin in 1941 and became project engineer for the company's *Viking* research rocket program in 1947. He held that post until his promotion to the Denver position.

Varrieur and Purdy were among a nucleus of 249 Martin personnel who moved to Denver early this year to make ready for the day when the division's new facilities would be ready for use. Until that time, the Martin people are occupying four interim facilities in Denver: the Shell Building, the Keith Building, a manufacturing facility and a laboratory located in the suburb of Englewood.

● Other key personnel of Martin's Denver Division include Roy G. Andrews, Manager of Industrial Relations; Robern N. Blakey, Manager of Manufacturing; Dan L. Burford, Division Counsel; Hugh P. Campbell, Manager of Quality Control; Don P. Herron, Supervisor for Information Services; Ross B. Hooker, Director for Procurement and Facilities; Thomas P. Hudock, Division Controller; William C. Ruckert, Manager for Customer Relations; Robert G. Swope, Manager for Master Planning; Charles H. Williams, Jr., Director for Service and Test; James L. Burridge, Assistant Chief Engineer, and George Derr, Engineering Administrator.

Principal engineers include William E. Brown, Guidance and Control; John D. Goodlette, Airframe; Walter O. Lowrie, Flight Mechanics; Marvin Pitkin, Operational Engineering; Beal M. Teague, Ground Support; Harrison C. Wroton, Test and Reliability, and John R. Youngquist, Propulsion.

Why Denver Was Picked

Martin selected Denver as the location for its new division after a study of 94 cities in 33 states. It gives no less than 10 reasons for its choice:

1. Denver is a metropolis in a remote area.
2. The Rocky Mountain terrain is conducive to the testing of powerful engines.
3. Labor situation is good.
4. The climate is such that many people—including engineers—are willing to work in Denver on a permanent basis.
5. Colleges and universities in the area are exceptionally good.
6. Adequate rail, motor and airline transportation.
7. Sufficient fuel, gas, electricity and water supplies.
8. Highly cooperative attitude of the State and County highway departments.
9. Cooperation of the Chamber of Commerce and other civic organizations.
10. The area affords the high degree of security essential to the job of developing and producing ICBM weapons.

Martin is not the only aircraft-missile company in recent years to fall under the spell of Denver and the surrounding area as a desirable site for industrial operations.

Four other companies are already at work or building facilities there. They are Stanley Aviation Corp., Sundstrand Aviation Division of Sundstrand Machine Tool Co., Beech Aircraft Corp. and Ramo-Wooldridge Corp. The last company, incidentally, is technical monitor for the ICBM program for the Air Force, but it is prohibited under the terms of its contract from supplying any of the hardware for the weapon.

we can build a moon rocket NOW

By Kurt R. Stehling and Richard Foster

As a result of recent openly discussed progress in rocket research, it is now feasible from an engineering standpoint to send a solid-propellant rocket vehicle with a small payload to the moon.

Lunar rockets have been discussed openly for many years. But the usual schemes have involved large multistage vehicles beyond contemporary engineering feasibility.

It is quite probable that an attempt will be made to launch a moon rocket—or a circumlunar orbiter—when ICBM hardware is operational and available. Some scientists are inclined to think that such ventures may be realized in 1959-60. However, a smaller experimental vehicle can be built now.

In this article, which is based on a paper presented at the International Astronautical Federation Congress in Rome last month, Kurt R. Stehling and Richard Foster explain how a low-cost small lunar rocket program could be launched. The authors' plan is certain to arouse world-wide interest.

When carried aloft to 70,000 feet by a huge four-million-cubic-foot *Skyhook* balloon, a solid-propellant step-rocket will be capable of bringing a four-pound payload to the moon.

The booster vehicle needed for this task consists of a cluster of three large solid-propellant units with a total impulse of 472 x 10^4 lbs./sec. On top of this first-stage unit is mounted a second-stage solid-propellant rocket with a total impulse of 28 x 10^4 lbs./sec. A third stage consists of a solid-propellant rocket with a 1.1 x 10^4 lbs./sec. total impulse. This rocket carries a four-pound payload.

● **Such a combination of** rockets should reach a final burnout velocity of 37,500 feet per second, which is sufficient to propel the final stage and the payload to the earth-lunar gravitational neutral point. From this point the moon's own gravity will attract the last stage to the lunar surface at a terminal velocity of 7,920 feet per second.

Skyhook balloons of 3 x 10^6 cubic feet volume have been built and launched already. As a matter

Cross section—vehicle is approximately 35 feet in length. Rockets shown with high drag nose section.

of fact, small solid-propellant rockets have been carried aloft and launched from *Skyhook* balloons many times.

In the case of the lunar rocket, as proposed here, it might be necessary to employ a cluster of smaller balloons, rather than one big one. Of course, numerous launching difficulties must be encountered, whether one uses one big or several smaller balloons. Among the launching difficulties are such problems as keeping the vehicle stabilized under conditions of high winds. Shipboard-launching at a relative zero wind velocity may reduce such difficulties.

Wind loads on the balloon and suspended payload during ascent must also be considered.

At launching, the rocket boosters must point vertically, i.e. on the radius from the earth's center. To achieve this a suspension platform stabilized by gyro flywheels or small pitch and yaw rocket jets probably will be required. Engineering-wise this is no great task, since such stabilization platforms already are familiar to guided-missile engineers.

The Authors . . .

are introducing their private proposal for an extension of the plan presented in 1955 by Kurt R. Stehling and Raymond Missert for a balloon-launched orbital vehicle. Stehling, formerly with Bell Aircraft Corporation, is now Propulsion Head, Naval Research Laboratory. Richard Foster, ARS student-award winner, is a member of the NRL propulsion staff. The opinions are those of the authors and are not to be construed as official or as reflecting the views of the Navy Department.

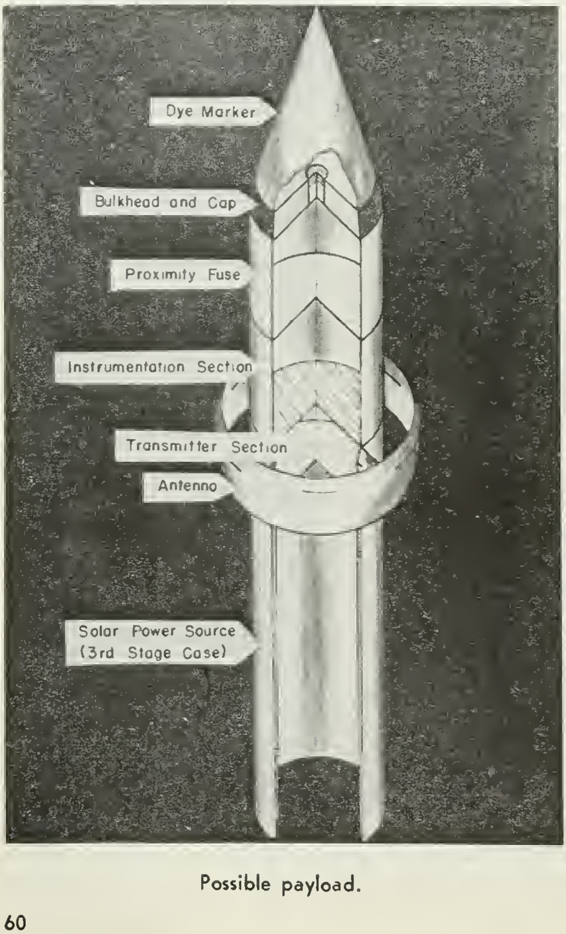
Rocket Zooms Through Balloon

An interesting aspect of this rocket configuration is that the whole vehicle, when launched by remote control from the surface, will zoom straight through the *Skyhook* balloon. The takeoff velocity is so great that the direction of firing will not be affected by the balloon. This method has been successfully demonstrated by the University of Iowa *Rockoon* experiments.

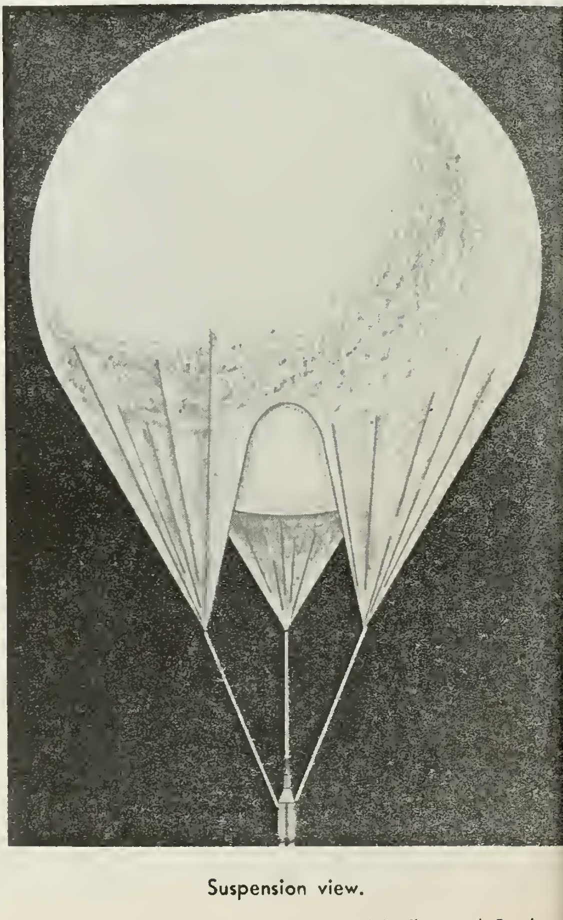
● **The three boosters** in the next stage will be manifolded together to minimize the initial overturning movement which normally results from unstable or non-simultaneous ignition, with subsequent uneven thrust development.

To stabilize the second and third stages of the launching vehicle, these rockets could be made to spin at some predetermined rate. This spinning creates so-called projectile stability. This principle is employed in the *Vanguard* satellite vehicle.

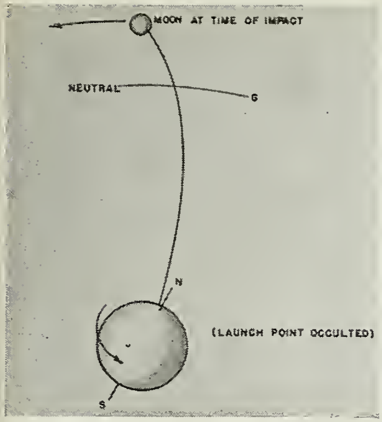
The coupling and release of large solid rockets is a formidable task. Since a high-altitude launch is presumed in this case, elaborate streamlining skirts and shields may not be necessary. As a matter of



Possible payload.



Suspension view.



Optimum impact trajectory.

fact, the second stage could nestle within or on top of the first-stage cluster, held only by the slip-joint of two concentric skirts. The exhaust jet of the second stage could issue through the triangular hollow column between the three first-stage boosters.

Similarly, the third stage could be ejected by gas pressure generated in the support structure which will provide rotational "hold," but no longitudinal "hold." This method would allow the third stage to spin with the second and yet permit separation at second-stage burnout. The gas pressure could be generated by a pyrotechnic squib in series with the third-stage igniter.

Ground command or a balloon-based timer could send the ignition signal for the first stage. Acceleration-sensitive switches could ignite the second and third stages on burnout of each respective carrier stage. A back-up system of long-burning fuses could also be used.

No provision is made for flight-path control of the last two stages. Other than the gyro stability of the spinning rockets, no electronic or other guidance is involved.

It is estimated that with a perfect launching and vertical flight path and a burnout velocity of 37,500 feet per second, the third stage—with its small payload—will hurtle toward the moon with sufficient accuracy to reach the neutral gravitational point.

● **The flight path** is influenced by the translational and rotational velocities of the earth. These are imparted to the radial velocity of the launching vehicle. The path is further influenced by the rather weak attraction of the sun and the stronger attraction of the moon.

If the velocity of the moon rocket's last stage at the gravitational neutral point between the earth and the moon is slightly greater than zero, the vehicle will actually reach a point of no return. A deficit or excess velocity at that point should result in either an earth or lunar orbit, a parabolic path around the moon and back to earth, or an impact upon the moon.

If the last stage returns to earth, it is possible that it will break up in the denser layers of the earth's atmosphere because of the great aerodynamic heating.

Mis-orientation of the vehicle at launching, thrust misalignment, unequal thrust levels and other instability factors will all determine dispersion and trajectory.

Solid-Propellant Moon Rocket Specifications

	Stage I	Stage II	Stage III
Gross Weight	26574 lbs.	1574 lbs.	64 lbs.
Structure Weight	200 lbs.	10 lbs.	0 lbs.
Payload Weight	1574 lbs.	64 lbs.	4 lbs.
Specific Impulse	245 sec.	245 sec.	245 sec.
Stage Mass Ratio	0.81	0.82	0.81
Firing Time	20 sec.	20 sec.	10 sec.
Peak Acceleration	42 g	40 g	91 g
Burnout Velocity	12,964 fps	13,474 fps	13,066 fps
Burnout Altitude*	180,000 ft.	280,000 ft.	352,000 ft.
Drag Velocity Loss	400 fps	0 fps	0 fps
Gravity Velocity Loss	644 fps	644 fps	322 fps
Thrust	236,000 lbs.	14,000 lbs.	1,100 lbs.

** Assumes 70,000-ft. launching altitude*

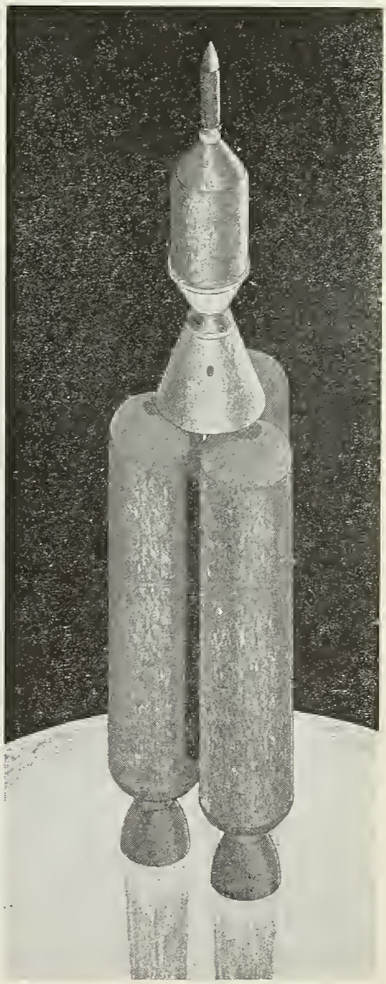
Velocity Available	39,504 fps
Escape Requirement	—36,700 fps
Gravity Velocity Loss	— 1,610 fps
Drag Velocity Loss	— 400 fps
Excess	794 fps

Landing on the Moon

It is difficult, within the limitations of this brief article, to specify the proper time and place for launching of this type of lunar rocket. It may be said, however, that time and place would have to be determined by the juxtaposition of the moon and the sun and the possible requirement of observation of the landing by stations on the earth.

If one assumes that the payload consists of nothing but a charge of metallic dust—such as magnesium—or a fluorescent powder, the impact or "landing" on the moon's surface may be observed as a large bright flash. It is assumed that the landing takes place on the darkened

Takeoff—vehicle shoots straight through balloon.



surface of a segment of the "new" moon.

● **In all probability**, once a moon rocket with a four-pound payload capacity is available, the ingenuity of interested physicists and others will result in different kinds of "useful" payloads. Although metallic or a fluorescent powder would permit observation of the time and point of impact, which is important enough in itself, it is also feasible to design a more complex unit with a small one-function telemetering transmitter powered by solar "generators" or "batteries."

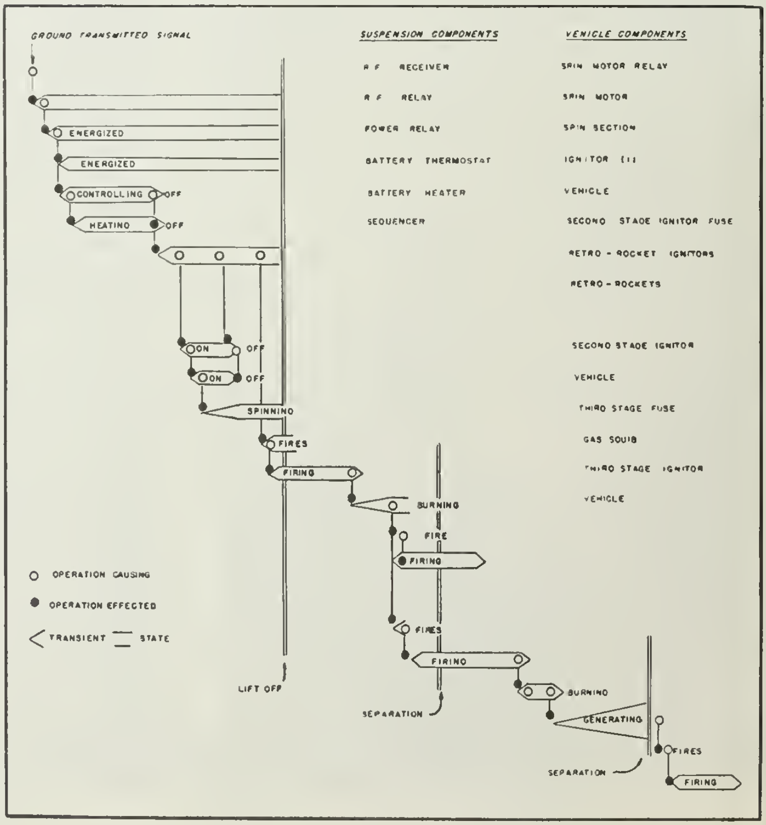
In the beginning such a transmitter could be active as a tracking and telemetering unit during the flight. It is, of course, questionable whether the reduced radiation efficiency of an antenna buried in or on the moon's surface would permit the reception of a readable signal on earth. Larger rockets employing a retro-thrust braking system during the descent to the moon probably could reduce the impact sufficiently to land a transmitter undamaged on the lunar surface.

Although the proposed lunar vehicle described here is rather simple in design and concept—and although the vehicle employs hardware, material and propellants which, considering unclassified information, may be readily available at a low cost—one should expect some "misfirings," or several launchings, to achieve one successful mission. First of all, the behavior of the rocket boosters is indeterminate because of intrinsic mechanical misalignment of the booster cases and their nozzles and the boosters with respect to themselves.

Furthermore, intricate design and split-second operational precision are requirements for the small retro-rockets that would be needed to retard the first stage and permit the spinning second stage to continue under its own momentum until this rocket unit is free and clear of the parent stage. However, the difficulties involved may not be greater than anticipated for many of today's missiles.

The success of a lunar rocket experiment, as outlined here, is a challenge to our engineers. It might well open up new vistas for science and help clear the path for further advancement in astronautics. END

First interplanetary body to be contacted from earth?



Flow chart of full firing sequence. Simplicity is apparent.

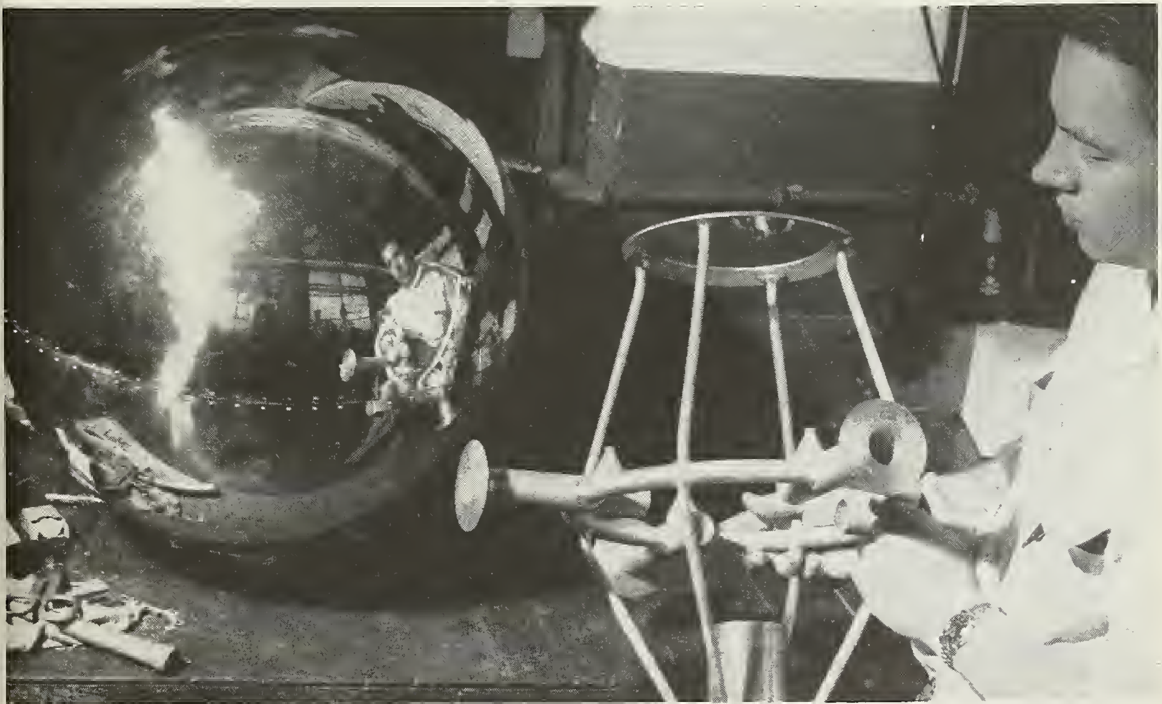
Hours of tedious work go into manufacture of hemispheres which are joined to form 20-inch Vanguard satellite. Sidney H. Braddy, NRL machinist, presses piece of sheet aluminum against large dome revolving in a fast-moving lathe. Metal is gradually worked closer to domed form to produce hemisphere.

First Pictures

BUILDING FIRST

What might well become the most significant scientific venture of our century, Project Vanguard, is reported to be progressing according to schedule.

The significance of the Vanguard satellite program is, of course, that our military agencies under the Department of Defense are working hand-in-hand with scientific organizations—and that



Robert H. Baumann, mechanical engineer, examines supporting structure and inner framework that will go into the satellite. The 29-year-old engineer has had many years' experience with rockets, having worked on Vikings, V-2s, Aerobees and others. He is currently Satellite Group Head under the Engineering Consultant for Project Vanguard.

THE SATELLITE


Joseph Y. Yuen, left, showing Vanguard Minitrack Transmitter to Erik Bergaust, Managing Editor of MISSILES & ROCKETS. Yuen, one of the developers of the tiny transmitter, points to circuitry.

the scientific data obtained from the satellites will be made available to all countries.

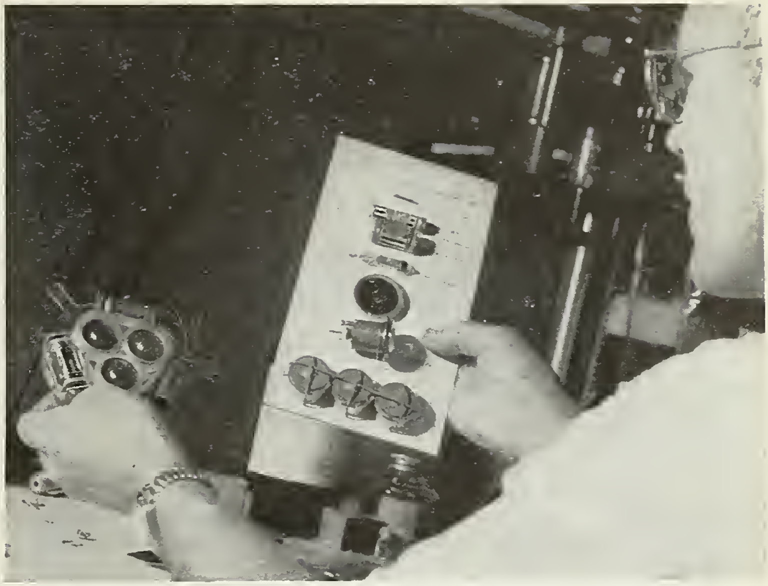
MISSILES & ROCKETS will keep abreast of the Vanguard program as it progresses and keep its readers posted in every forthcoming issue. Much of the work pertaining to the launching vehicle is considered classified information, since many of the techniques employed are in


Robert H. Peterson, 34, instrument maker, is shown putting in final screws to fasten together two hemispheres of test model satellite. Peterson started to work at the laboratory in 1945 and has had many years experience in field of guided missiles and rockets.

the area of missile technology. But the satellite itself and the experiments that will be attempted with it are unclassified. MISSILES & ROCKETS will publish as much information about these as possible.

It is too early to say when the first instrumented satellite will be launched.

N. Elliot Felt, operations manager of Project Vanguard for The Martin Co., disclosed that first firings in connection with the satellite program will take place at the Air Force Missile Test Center at Patrick AFB, Cocoa, Fla., this fall. His announcement was made at the recent International Astronautical Federation Congress in Rome. The first propulsion unit to be tested will be the third-stage solid rocket, which will be carried in a modified Martin *Viking* rocket.



E. T. Byram, NRL scientist, holds model of Lyman-Alpha equipment which is likely to form one of the experiments with the satellite. Byram compares components of Lyman-Alpha gear with assembly on the lucite wafer.

Project Vanguard scientists discuss design and performance of tiny transmitter which will send signal to ground from earth satellite. Joseph Y. Yuen and Martin J. Votaw discuss the relative merits of the various circuits and different components being tested for use in the Minitrack oscillator. At least 12 different experiments will be attempted with Vanguard satellites.

World Astronautics

By Heyward E. Canney, Jr.

The U.S. Air Force has officially stated it could use $39 million for earth satellite research. However, no money has been allocated for the next fiscal year.

Research at the Armour Foundation with heat and dust erosion suggests that much thicker meteor shields may be required for space vehicles. Copper and aluminum plates have been penetrated or badly pitted by particles travelling at 4,000 fps.

Last March 14 an Air Force Aerobee rocket discharged 20 pounds of compressed nitric oxide 60 miles above Holloman AFB. Catalytic action caused monatomic oxygen to recombine into conventional molecules. This action, which produced a disk four times the diameter of the moon, and at least half its brilliance, was confirmation of earlier laboratory experiments which lead to the suspicion that enough energy may be picked up in the ionosphere to power a rocket. If possible, this could lead to satelloids of indefinite duration.

This brings to mind the analagous proposition of a cosmic ramjet of the distant future whose main powerplant was replenished from cosmic dust taken in at enormous speeds. These, together with solar batteries, breeder reactors, and other devices, seem to be generating for the layman the optical illusion that science is on the verge of finding how to get something from nothing.

Pondering the globe-girdling aspect of the artificial satellite, the International Civil Aviation Organization, meeting in Caracas last June, decided that the matter of sovereignty of outer space above the several nations was within its competence. The term "outer space" may disturb the fastidious astronaut, who recalls the immensity of the universe. In the cosmic view, true "outer space" may be that between the galaxies, "middle space" that between stars of a galaxy, and "inner space" the realm within a system of planets, such as the Solar System.

A similar discrimination may be called for in the matter of man-made "moons." In this connection, accurate terminology may require some such distinction as the following: "artificial satellite"—any artifact in Keplerian orbit, "satellite vehicle"—any artificial satellite which carries a useful load (i.e. instruments), and "space station"— any artificial satellite offering a service on which other space vehicles (such as space ships) operationally depend.

Transistorized helmet radios designed for combat GIs by the Signal Corps have a one-mile range and are presumably hard for the enemy to intercept. Space suit designers may find this a convenience, and one less external component to upset balance, impede movement in cramped quarters, or to invite damage by bumping. RCA's new 19-lb. TV transmitter, which also has a one-mile range, may eventually find a place in the space man's practical equipment after a size reduction of one further order of magnitude.

Tracking the IGY Satellites

By Henry P. Steier

A very small and very simple assembly of electronics components will probably be history's reference point to mark the beginning of astrionics technology as a vital aid to man in his conquest of outer space.

Key to knowing whether the tremendous efforts of Vanguard rocket engineers have paid off will be wrapped up inside a little cylindrical, gold-plated aluminum can containing the circuit of a transistorized radio transmitter.

Minitrack transmitter. Circuit assembly in foreground. Batteries at right.

The sub-miniature transmitter is called the Minitrack. Designed by the Naval Research Laboratory, Minitrack will be the first electronics system to penetrate outer space and stay there for any appreciable time.

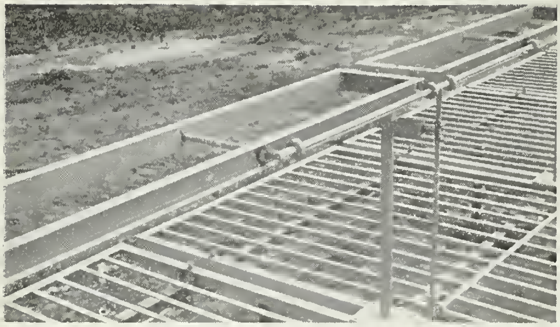
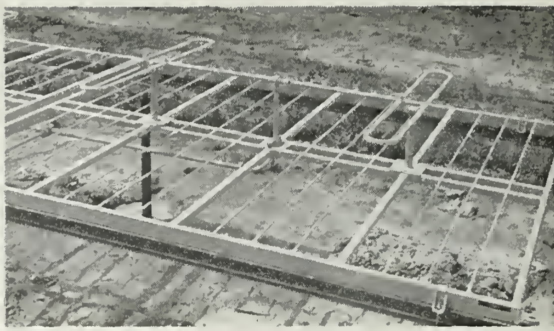
From inside its approximately five-inch-long by three-inch diameter cylinder housing, carried inside the magnesium shell satellite, Minitrack will emit a continuous 108-megacycle signal.

● **After nearly one orbit** is completed the world will begin to know if the satellite is in truth orbiting or whether something went wrong at the first *Vanguard* launching. After a few orbits, of course, the world will better know how well the satellite is orbiting.

Before the orbiting is finished and the magnesium shell is consumed by heat during its plunge to earth, scientists will have added a fund of important information to the limited store of information about the physics of outer space, as well as of the earth itself.

Use of radio in the satellite has two purposes. Once on its own, the shiny 21-inch sphere could get lost. Finding it has been compared to the problem of finding a golf ball traveling at Mach 1 at an altitude of 60,000 feet.

● **The first problem** is to acquire information on the satellite's location. After this is done, the next problem is to determine its

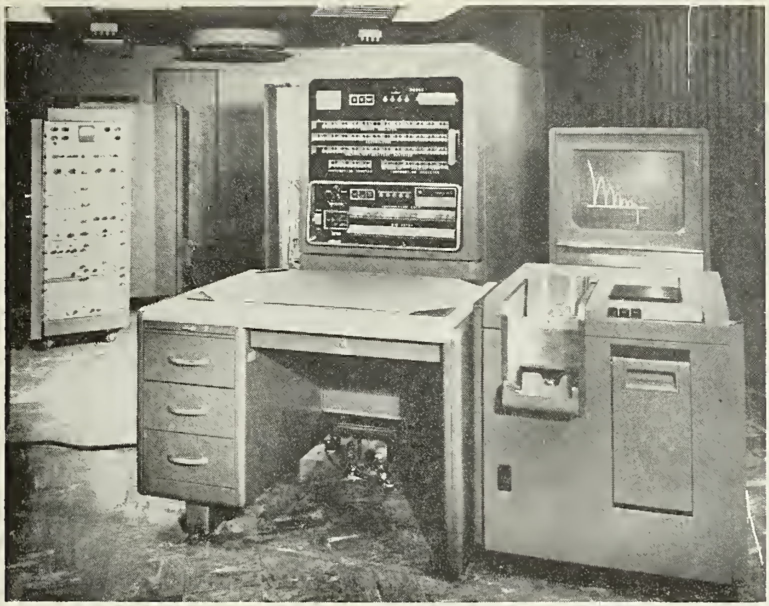
Details of prototype Minitrack ground station antenna arrays. Left: folded dipole array. Right: driven lot array.

ephemerides. By definition empheme-rides are the assigned places of a celestial body for regular intervals.

These are needed since two tracking methods will be employed to get the most accurate physical data from the satellite's performance. These are radio and optical tracking. The optical system, oddly enough, will be the most accurate. However, its use is feasible only when the sun position, satellite position and ground optical tracking system are in favorable relationship.

Under other conditions Minitrack ground stations will keep track of the satellite's whereabouts. During night, cloudy weather and under clear weather conditions, for a period of about three weeks, the signal will be available.

● **Despite all conjectures** on what the satellite will carry and how many different scientific readings it will take of conditions in its orbital path, there are still many uncertainties. What the first satellite will carry, will probably be a letdown to many. However, subsequent satellites undoubtedly will carry more and more instruments.



Dr. Paul Herget, Vanguard computation expert, says a cathode ray tube is planned for satellite data display. IBM's 704 Output Recorder was designed for use with a computer. Theoretical path of a bouncing ball is shown.

Although the possibility is still open for a zero-payload satellite, the probability that the first one will carry a Minitrack transmitter is good. At the present state of the electronics art, the transmitter weighs only 13 ounces. Carriage of this small payload seems feasible to rocket engineers.

Minitrack System

At this time Minitrack is a one-stage crystal-controlled oscillator designed to use one transistor and to be powered by seven 1.2-volt mercury batteries built by Mallory and Co., Inc. Power output would be 15 milliwatts. Transistors built by Western Electric Co. and the Philco Corp. are being considered.

A frequency of 108 mc was chosen as a compromise between transmitter weight and efficiency, and effects of the ionosphere on tracking accuracy. Although the ionized layer of gases at the proposed 300-mile altitude is essentially a "window" for radio energy at 108 mc, a certain amount of refraction is expected, just as with light through a glass window pane.

● **During the International Geophysical Year** the sun-spot cycle is expected to be at or near maximum. This means ionosphere activity will be at maximum and high electron densities are expected during daytime observations. This would cause an apparent shift in the angular position of the satellite when the signal is picked up by the ground stations.

Measurements on ionosphere errors to be expected have been made this year in *Rockoon* and *Rockaire* studies and will continue. More and more data will be collected pertaining to predictable and variable factors that would influence tracking errors. These could be used to correct readings from ground stations.

A lower frequency than 108 mc would mean more refraction and higher frequencies would mean less power from the transmitter for a given weight. The antenna system on the satellite is planned as a four-element array arranged in 90-degree steps around the sphere. The four 1/4-wave antennas would be folded and, upon release of the satellite, would spring into place.

The diminutive size of the Minitrack transmitter belies the vast and complex information acquiring, transmitting and data processing facilities it will set into operation.

To acquire the Minitrack signal a complex of ten prime Minitrack ground stations is under construction in the U.S. and South America. They are located over an area that stretches from Blossom Point, Md. to Santiago, Chile in a north-south direction and from San Diego, Calif. to Antigua Island, B.W.I. in a west-east direction.

Vanguard will be launched at an angle of 35 to 45 degrees to the equator in a southeasterly direction. During each orbit of the satellite the earth will have moved about 1600 equatorial miles to the east if the orbit requires an hour and a half.

● The effect of the earth movement means that the satellite's path will scan the areas where the stations are located. Stations are located at: Blossom Point, Md.; Fort Stewart, Ga.; Batista Field, Havana; Rio Hata, Panama; Mt. Cotopaxi, Quito, Ecuador; Ancon, Lima, Peru; Antofagasta, Chile; Peldehue Military Reservation, Santiago, Chile; Coolidge Field, Antigua; Naval Electronics Laboratory, San Diego, Calif.

Eight Antennas

Located at each station will be an array of eight antennas designed to measure the north-south and east-west angular position of the satellite as its signal illuminates them. They are arranged in the shape of a cross.

The antennas are multi-element arrays. Two types are being tested at the Blossom Point location. Prototypes have been developed by the Technical Appliance Corp. and the D. S. Kennedy Co. One uses a 12-element dipole array and the other an eight-element driven lot array.

Measurement of the satellite's angular position will be made by comparing the electrical phase of the signal arriving at one antenna of a pair compared to the phase at the second antenna of the pair.

● **Located at each station site** will be a complete Minitrack Electronic Unit mounted in an air conditioned trailer. Contractor for these units and other station units is the Bendix Radio Division, Bendix Aviation Corp. It includes communication and telemetering equipment together with the Minitrack Electronic Unit phase comparison equipment.

The communication set includes 15-kw transmitters, receiving and transmitting rhombic antennas plus a telemetering antenna system and ground stations. Communication and telemetering units will be housed in a building which also contains office, parts, storage and sleeping facilities. Living arrangements for personnel will be obtained locally.

Telemetering equipment is being provided since although the first satellite may not include telemetering gear, subsequent satellites will.

Data Handling

At the "Fire!" signal for launching the *Vanguard* vehicle two auxiliary stations will go into operation. Located at the Air Force Missile Test Range on the islands of Mayaguana and Grand Turk in the Caribbean, these stations will receive signals from telemetering equipment in the vehicle and, after burnout, will receive signals from the satellite.

From these down-range stations will come the first information that tells of success or failure. The information will be radioed to a central *Vanguard* computing facility. Probably this will be located in Washington, D. C. From then on until the satellite falls to earth the computer and the Minitrack ground stations will operate on an around-the-clock basis.

Three bits of information from the Minitrack stations will be repeatedly sent to the computation center by radio and teletype. Two angular measurements and the precise time of passage over the zenith of the stations will be sent.

● The computer "brains" will do what men could not do—keep ahead of the satellite so that information on where the satellite *was* can be transformed into information on where it *will be*. This is needed to alert both the optical tracking stations and the Minitrack stations as to where the satellite is going to be at a specific time.

Optical stations, using 20-inch Schmidt photo-optical telescopes and equipped with automatic tracking gear, must know exactly where to look since the satellite will pass from west to east in two or three minutes. The stations will be operated under the direction of the Smithsonian Institute and will be located throughout the world where the satellite can be seen.

Dr. Paul Herget, consultant to the Naval Research Laboratory, will head the *Vanguard* computation facility. Back and forth, between it and between optical tracking stations and Minitrack stations, information will flow.

It will go from the center to the stations for alerting them as to satellite arrival time; from stations to the center to keep the computer up-to-date on changes in speed, altitude or direction.

● **Two classes of computations** are planned: in-flight calculations to aid and insure observations by optical means, and those from which scientific conclusions will be drawn.

Equations will be juggled to fit new conditions constantly occurring. More and more refined data will be accumulated, calculated and stored in the memory of the computer. When the end of the Minitrack transmitter battery life comes, the calculated data will still be available for alerting the optical stations for the next satellite passage and for the public to try to view the satellite.

Persons favorably located geographically during twilight and sunrise periods in good weather will be able to see the shiny ball with the aid of binoculars as it goes overhead.

Even if the satellite stays up much longer than the few weeks predicted, the available data, more refined after each satellite orbit, may be of a high enough order of accuracy to insure optical tracking for the entire satellite life. END.

NRL Planning Plug-in Satellite Instruments

During an interview with MISSILES & ROCKETS, Dr. Herbert Friedman, who heads the Naval Research Laboratory's scientific instrumentation group for the IGY satellites, said the plan is to modularize astrionics according to a definite pattern.

In this way, by using the Minitrack transmitter as the radio frequency generator, various plug-in devices could be placed in different satellites to read different information scientists need. With appropriate coding and modulating techniques, the information could be relayed to earth through the Minitrack transmitter.

Many groups in the IGY endeavor want to "get on board" the satellite. Who will get on board and when is not definitely known. Advances must be made in micro-miniaturization, power sources, data storage and telemetering. Weight is extremely critical.

Who gets in first depends on the state of the instrument and electronics art, and many programs are under way in industry and at NRL to speed up this development.

Typical devices suggested are:

1. **Meteoric Collision Amplifier**—Signal from microphone detects collision with micrometeorites and provides input to meteoritic storage.
2. **Meteoritic Storage**—Magnetic cores form collision memory, store number of counts from collisions and transmit signals representing four decimal digits on four telemetering channels.
3. **Telemetry Coding System**—Successively samples various signal input channels and modulates the Minitrack for transmission of scientific data to earth.
4. **Lyman-alpha Storage**—Peak memory unit using cores to store and code the telemetering system with a signal representing maximum input value reached during one satellite orbit for subsequent read-out when passing over recording stations.
5. **Lyman-alpha Current Amplifier**—For measuring ionization produced by ultra-violet solar flare radiation.
6. **Ion Chamber-Narrowband**—For ultra-violet detection by having peak sensitivity at the hydrogen Lyman-alpha line.
7. **Thermistors**—A mixture of metallic oxides used for temperature measurements. Resistance changes with temperature.
8. **Erosion Gauge**—Nichrome ribbon evaporated on glass. Measures surface erosion caused by impact from micrometeorites. Resistance of ribbon increases as film is pitted.
9. **Solar Cell**—Peak memory reset for storage unit. Causes reset once each orbit on transition from light to darkness.

Government Holds 10% Of Electronics Patents

The Federal Government held more than 10% of the total of 3,130 electronics patents issued in 1955, according to an analysis by Information for Industry, Inc. The analysis shows that in the first six months of 1956, 3,084 U.S. electronic patents were issued, with a slight increase shown in the percentage assigned to the government.

Of the 321 government-held patents issued in 1955, 150 were issued to the Secretary of the Navy, 80 to the Atomic Energy Commission, 46 to the Secretary of the Army, 22 to the Secretary of War, 10 to the Secretary of the Air Force, 8 to the Secretary of Commerce, 2 to the Secretary of Interior, and one each to the Secretary of Agriculture, Reconstruction Finance Corp. and United States of America.

The largest number of patents have been issued to companies whose major endeavor is in the entertainment and appliance fields. These total 674, compared to 264 in wire communication, 220 in atomic energy, 151 in aircraft and guided missiles, 92 in petroleum, and 72 in business and office machines. The remainder were general patents.

Navy Seeks to Block Long Island Building

The Navy has asked the Senate and House Armed Services Committee for authorization to spend funds in buying land to discourage real estate development around the Navy-owned Grumman Aircraft Engineering Corp. plant and its adjoining airfield near Riverhead, L. I., N. Y.

To block residential construction, the Navy proposes to buy a small amount of land outright, and in other cases to pay landowners for two types of restrictions on the deeds to their property: restrictive convenants under which owners would agree to keep their land in its present agricultural use, and flight clearance easements that would limit the height of any buildings erected in landing and takeoff paths. Several thousand acres would be affected.

New 11,000 MPH ARDC Windtunnel

The Air Research and Development Command of the Air Force has disclosed that a blowdown windtunnel at Arnold Engineering and Development Center, Tullahoma, Tenn., has achieved simulated velocities up to 11,000 mph and temperatures up to 15,000°F on more than 100 successful test runs.

Known as "Hotshot," the hypersonic tunnel is capable of simulating the fantastic temperatures and velocities in store for the warhead of an intercontinental ballistic missile upon its re-entry into the atmosphere.

● So great is the heat produced by the tunnel, a part of ARDC's Gas Dynamics Facility, that portions of the tunnel ducting melt away during test runs, striking the models and interfering with test results. "However," the Air Force said, "this contamination develops later than it normally does in shock-tube tunnels, and is preceded by a longer, more uniform flow in which valid test data may be recorded."

Here is how Hotshot works:

Air is pumped into a storage chamber and sealed off from the downstream portion of the tunnel by a light plastic diaphragm. The downstream section is then pumped down to one-millionth of an atmosphere to accelerate the airflow when the seal is ruptured. At this point, a powerful electric charge of more than one million amperes is triggered into the air storage chamber, boosting the air temperature to 15,000°F and the air pressure to 20,000 psi.

The heated air immediately breaks through the plastic seal and flashes down the tunnel, accelerating as it moves through a conical nozzle in front of the model mounted in the test section. Instruments measure temperature, air flow and other details during the test, and photographs may be taken of the model in the luminous glow created by the super-heated, pressurized air blast.

Astrionics

By Henry P. Steier

ICBM tests will force astrionics engineers to brand-new concepts of telemetering accuracy. Dr. H. L. Rauch, University of Michigan missile telemetering scientist, points out that a 1 ft./sec. velocity error in a missile sent to a point one-quarter way around the earth would cause a target miss of about one mile. To measure such a slight velocity error, telemetering would need better than 1/100th of one percent accuracy, Rauch says. Accuracies of one to five percent are normal now.

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Lest anyone doubt what can happen in three years when scientists take over promotion and management and invade the field of big R&D business, a movie made by Ramo-Wooldridge Corp. and narrated by Dean E. Wooldridge, president and treasurer of R-W, shows the company offices in 1953. It is now a barbershop. In June 1956, R-W had 2,000 employees. By the end of 1956, it will have 600,000 square feet of R&D building space in Los Angeles on a 40-acre site. Under construction also is a manufacturing building facility in Denver, Colo. that will initially have 150,000 square feet on a 640-acre site.

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The same phenomenon may occur soon again. Aeronutronics Systems, Inc. was organized in 1956 as Systems Research Corp. Headed by scientists Dr. Ernest H. Krause, vice president, Dr. Montgomery H. Johnson, director of research, and Gerald J. Lynch, director of Ford Motor Co.'s office of defense products, Aeronutronics is now a subsidiary of the Ford Motor Co. From its present store-front headquarters in Van Nuys, Calif., the company is expanding to take over the former Glendale Airport terminal, which will house laboratories and offices for its work in aeronautics-nucleonics-electronics.

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Heat generated by astrionics equipment in satellites will be a major problem. With no means of transferring heat to the atmosphere under near vacuum conditions at satellite altitudes, heat would build up inside the satellites. Bendix Pacific Division, Bendix Aviation Corp. has taken a first step toward a solution with development of a water-evaporative heat dissipator. Heat from astrionics gear in a missile test vehicle raises temperature and pressure of water vapor in a sealed telemetering system. Water vapor is dumped overboard at 5 lbs./sq. in. absolute pressure.

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Latest approach to the problem of reducing friction in gyros to obtain more accuracy in inertial platforms is work toward a means of suspending the gyro in a vacuum by means of a magnetic field. Except for electrical contacts that might be required, such a gyro would have nearly infinite accuracy. At the same time, non-electrical gyros are being designed which are spun by pneumatic, spring-wound, or pyrotechnic means in a missile prior to firing. Ideal for small missiles since power supplies are not needed, and since they come up to speed in milliseconds, "self-energized" gyros are coming into the forefront. Electrical gyros sometimes take a full minute to come up to speed in the order of 10,000-20,000 rpm.

International News

By Anthony Vandyk

Four SNCA du Nord missiles are in operational service with the French forces—the 5201 (surface-to-surface), 5210 (air-to-surface), 5103 (air-to-air) and CT-10 (formerly designated 5501). The CT-10 is used as an anti-aircraft target.

The Royal Air Force will soon be equipped with its first missile—the Fairey *Fireflash*. It will be fitted to fighter aircraft within the next few months. Fairey is also working on a longer-range version of the *Fireflash*.

Bristol's *Thor* ramjet makes use of the cheapest and simplest methods of manufacture. It is strictly a missile unit with Mach 2 to 2.5 capabilities but it could easily be refined to give it a long life and thus make it suitable for powering aircraft. One Bristol official claims it would be more economical than a turbojet at Mach 3.

Napier's ramjet test vehicle, the NRJ.1, is not a missile but a plain "flying engine" for fuel control research, designed and built for Britain's National Gas Turbine Establishment. It is unique in having a diametric airfoil in the intake to generate its compression shock pattern. The NRJ.1 is about 20 ft. long and 18 in. in diameter.

British government's decision to declassify the Armstrong-Siddeley *Screamer* rocket engine indicates that the United Kingdom has abandoned LOX as an oxidant in favor of HTP—as used in De Haviland rocket motors. The current model of the *Screamer* delivers 9,500 lbs. thrust at 40,000 ft. It is a compactly-grouped motor 78 in. long, 28 in. in diameter and weighing 470 lbs.

For those who can read German the papers of the Deutsche Versuchsanstalt für Luftfahrt are available once again. The technical reports by the 44-year-old research establishment are now appearing regularly. They are published by Westdeutscher Verlag, Ophovenerstrasse 1, Opladen, West Germany.

How much does a missile cost? Colonel Franco Fiorio, formerly assistant Italian air attache in Washington, reckons about $150 per lb. for surface-to-air vehicles or $200 for air-to-air missiles. Fiorio is one of the foremost Italian Air Force experts on guided weapons.

Svenska Aeroplan (SAAB) is working hard in the missile field. The Swedish government's 1957-58 air budget includes $1,600,000 "for continued development of an interceptor missile." It is expected that the total cost of this project will be some $6 million. The major missile item in the budget is $28 million for the procurement of guided missiles for aircraft.

Russia has tested a 900-mile range ballistic weapon which was developed from Germany's V-2. Reliable sources indicate that between 1945 and 1950 the Russians built at least 2,000 V-2s.

France's SNECMA is the only manufacturer specializing in pulsejets. Its Ecrevisse series includes units ranging in thrust from 22 to 330 lbs. It is possible that the Ecrevisse will be built under license in Holland to power the Aviolanda target missile if the latter is ordered into production.

点は陸より「みくら」に連絡し，回収のためカッターを下したが，波打際の近くに落下したのでヘリコプターに回収を依頼し，ヘリコプターより鈎のある竿を出し海面すれすれの位置からパラシュートを鈎に引掛けてこれを回収した．ロケット・ボーン・カメラのフィルムは直ちに秋田市で現像し，6枚の空中写真撮影に成功したが分った．雲高が低かったため発射後すぐ雲に突入が，雲にはいるまでの間に撮影したものでき．

観測班：丸安班は開傘後これを捕え海面落　追跡できたが，発射後雲突入までは追跡できなかった．水野班は発射後雲に突入までを追跡，それ以後は発見できな

JAPANESE rocket research

By Frederick C. Durant, III

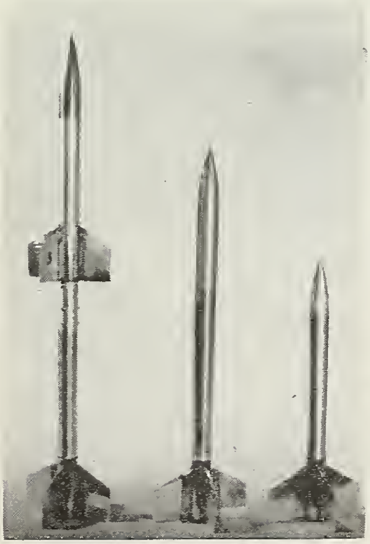
Two years ago there was no rocket research in Japan. Today, sounding rockets are being developed in an intensive, well coordinated program. Remarkable progress has been achieved in all phases on budgets which are miniscule by U.S. standards.

The program stemmed from the decision last year of the National Science Council of Japan to participate in upper atmosphere observations during the International Geophysical Year. In keeping with the times, the Japanese did not want their observations limited to research balloon altitudes. They decided to use sounding rockets. It was an ambitious decision since there had been no Japanese rocket development since World War II.

● Even during the war the Japanese had not made significant progress in rocketry. Developments were limited mainly to rocket artillery, solid-propellant JATO units and the Kamikaze BAKA bomb. The BAKA was a human-guided rocket-propelled flying bomb. Air-launched from Betty-type bombers at 25,000-27,000 feet, these suicidal attacks on U.S. Naval vessels were quite effective until adequate countermeasures were achieved. Liquid-propellant rocket development was apparently limited to development of a rocket powerplant for the Shusui airplane in the design stage in 1944-1945.

At the close of the war, of course, all rocket development stopped. None was permitted dur-


Baby rocket in launching rack.


Kappa rocket series.


Telemetering unit for Baby rocket.

Launching of Baby rocket.

Tracking and reception antennas.

Photo-theodolite tracking rockets.

ing the period of U.S. occupation. Therefore nearly ten years elapsed before the opportunity arose for renewed effort on rockets, this time for purposes of scientific research. Throughout the post war period, however, Japanese physical scientists and engineers kept abreast of rocket developments in the rest of the world. Scientific journals and professional society reports reported significant data and test results as rocketry advanced to its present state of relative complexity. How well these advancements were absorbed, however, can be appreciated in the remarkable rate of development of the Japanese rocket program since last year.

A Special Committee for the Sounding Rocket Program was organized in January 1955. Research began in February. Budgeted funds were $140,000 for 1955 and $250,000 for 1956. Chief Scientist of this Special Committee was Dr. Hideo Itokawa, Professor of the Institute of Industrial Science, University of Tokyo.

● Dr. Itokawa was an ideal choice for this post. Forty-four years old, he received his aeronautical engineering degree from the University of Tokyo, and during the period 1935-1945 designed fighters at the Nakajima Aircraft Co. After the war Itokawa joined the staff of the University of Tokyo, received his Ph.D. at its Institute of Aeronautical Science and conducted theoretical research on aerodynamics, guided missile systems and target aircraft. His interests were far-ranging, carrying him into such ancillary fields as acoustics and medical engineering. Then the National Science Council tapped him to direct its sounding rocket program.

Supporting the development of rocket vehicles for the program was the Institute of Industrial Science, University of Tokyo. Aiding in related phases were:

1) Institute of Astronomy, University of Tokyo: Solar Radiation.

2) Kagaku-Kenkyusho Corp.: Cosmic Rays.

3) Department of Geophysics, University of Tokyo: Pressure.

4) Institute of Radio Wave, Department of Communication: Ionosphere.

5) Department of Electronics, University of Kyoto: Temperature and Winds.

A four-to-five-year plan was mapped out. Two preliminary programs, PENCIL and BABY, have been completed. During these tests, basic rocket design criteria evolved and telemetering range systems were developed. KAPPA, SIGMA and OMEGA projects will be the programs to obtain scientific data at high altitudes.

The Author . . .

is a staff member of Arthur D. Little, Inc. Cambridge, Mass. He holds a degree in chemical engineering from Lehigh University. He is a past president of the American Rocket Society and of the International Astronautical Federation. He will be contributing a series of articles on international developments in forthcoming issue of M/R.

PENCIL Rocket Program

The PENCIL program was devised to obtain basic test data on rocket design elements. A miniature model was developed measuring 9 inches long, 0.7 inches diameter, weighing only half a pound, including the solid-propellant motor. Aerodynamic configuration, internal and external ballistic characteristics, motor and nozzle design were studied in a horizontal track test range 30-160 feet long. Completely but simply instrumented, in-flight photos were made by Fastax cameras. Velocity and dispersion data was obtained as the rocket passed through a series of six wired paper targets. Booster rocket length, tail-fin configuration, material of construction and other factors were studied to determine their effects upon center of gravity location and in-flight shift.

Of particular interest were ballistic characteristics of booster stages after separation. Because of the lack of deserted land for future large rocket tests, these data were necessary for range safety.

More than 150 PENCIL rockets

(*Continued on Page* 98)

(*Continued From Page* 94)
were made and fired. The average cost of manufacture and test of a PENCIL rocket was $15.

BABY Rocket Program

With the basic design data obtained and experience gained in measuring techniques and test firings a larger rocket series was designed. Four to five feet long, not including a short booster rocket, this series weighed about 20 pounds. There were three major types: BABY-S (Simple), BABY-T (Telemetering) and the BABY-R (Recovery).

Initial test firing of Japan's first military rocket, the "TMA-O-AC" took place a few weeks ago at Ojoji proving grounds in northeast Japan. The rocket is a military version of one constructed for the Institute of Industrial Science by the Fuji Precision Machinery Co.

Officials of the Japanese Defense Agency who watched the rocket zoom to an altitude of 13,000 ft. termed the experiments successful. Other details were not immediately available, our correspondent in Japan said, but data gleaned from the trials is expected to pave the way for Japanese-built guided missiles.

Now the program moved out of the research laboratory into development phase. A launching site was selected in the north facing the Sea of Japan.

Six BABY-S rockets were fired in August 1955, only seven months after the initiation of the basic studies. These firings checked the launching stability and dispersion of this larger test design. In addition, equipment was developed for optical and DOVAP tracking, a launching tower constructed and range crews trained.

In September, six BABY-Ts were fired to study the fundamentals of rocket telemetering systems. Rocket-borne instrumentation was designed and tested. Four channels were commutated—velocity, acceleration, pressure and temperature—on 415 MC frequency.

During the next two months the BABY-Rs were launched. Since no land-firing ranges exist in Japan, it was recognized that recovery of non-telemetered flight data would have to be made from the sea. An ingenious but simple parachute and self-inflating buoy system was packed into the nose to be explosive-separated after maximum altitude was reached. A dye type sea marker completed the recovery unit. A 16mm camera and film was used as payload in these early shoots. Range firing trajectory data was radioed to the aircraft, helicopter and coast guard ship recovery unit. Two out of the three payloads were successfully located.

● **The Kappa Project** phase of the sounding rocket program is currently under development. Designed for the IGY program upper atmosphere measurements, this series of rockets will be three-staged, ground-launched and powered by solid-propellant motors. Length, less two booster stages, is 6.5 feet; diameter, 5 inches; weight, 80 pounds. It is designed to carry 11 pounds of payload to an altitude of 70-95 miles. Only one measurement will be made with each firing.

● **The SIGMA Project,** a rockoon system, utilizes a balloon for altitude launch. Basic studies and test data of Dr. James A. Van Allen of the University of Iowa are used in this project. Either the KAPPA main stage or a two-staged BABY rocket will be used. Design altitude: 50-65 miles.

● **Still in the study stage,** the OMEGA Project is aimed at altitudes over 150 miles. It probably will not be completed in time for the IGY.

To anyone familiar with the cost of overall sounding rocket programs in the U.S. the success of this program will be impressive. True, the Japanese had the benefit of much published data on the test programs of other countries. However, their work was not imitative. They have shown that they understand the basic factors involved as well as laboratory and field techniques. Further, they have recognized the present and future capabilities of solid-propellant rocket systems. END.

INDUSTRY SPOTLIGHT

By Joseph S. Murphy

BORON BUSINESS BOOM

In screen-testing today's array of miracle chemicals and wonder metals for roles in the billion-dollar guided missiles program, one old, but current big-time, performer should command much attention on the part of the investor. This candidate is boron—an element which, along with sodium and oxygen, gives us borax, the long-time cleaning companion of housekeepers everywhere.

Last year boron production hit a peak of nearly one million tons—three times the 1945 output—and recent estimates placed domestic and export sales in excess of $30 million annually. Broken down among end uses, boron consumption is as follows:

Industry	Type of Use	Estimated % of Total
Glass	Borosilicate Glass & Glass Fibers	30
Ceramics	Ceramic Glazes & Porcelain Enamel	25
Agricultural Chemicals	Fertilizers and Herbicides	15
Soap	Soaps & Cleaning Compounds	10
All Other	Flameproofing Agents, Adhesives, Gasoline Additives, etc.	20
		100

As these products (glass fibers, for instance) find new applications, they in turn will provide a still greater base for boron demand.

New Uses

Remarkable hardness and resistance to heat and corrosion places boron steel and other boron alloys in demand for jet engines and rockets. The fact that $100 million has been allotted for procurement, research and development of non-ferrous metals and alloys during 1957 gives an impressive indication of what is in store for metals that meet the desired specifications.

In addition, the 1957 defense budget for guided missiles earmarks another $70 million to the development of high energy propellants. Research indicates that since 1952 experiments involving boron compounds have progressed from the laboratory, through pilot-plant stage and are now in the tonnage-plant stage.

Although information on these projects is classified, there have been some significant and foretelling developments. For instance, the Navy recently announced the awarding of a $38-million contract for a plant at Muskogee, Okla.; Olin-Mathieson Chemical revealed a contract to build a $36-million plant near Niagara Falls; Stauffer Chemical recently embarked on a proposed ten-fold expansion of its Niagara Falls boron trichloride plant; and it is rumored that American Potash is starting up a semi-commercial plant in Los Angeles to make boron trichloride.

Informed opinion is satisfied all these operations embrace boron compounds to make high-energy fuels. And it is already known that

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Swift Carries Fireflash

Vickers-Supermarine *Swift* MK7 supersonic fighter, fitted here with two Fairey *Fireflash* air-to-air guided missiles, was unveiled at recent SBAC Farnborough exhibition. It is the second British fighter to mount *Fireflash*, the other being the Hawker *Hunter*.

Fireflash is a supersonic air-to-air missile measuring 90 inches in length with cruciform wings of 28-inch span. It is powered by solid-propellant rockets and warhead is proximity-fused to explode when missile is within lethal range of target.

Guidance for the missile is a beam-rider type system. Electronic equipment was developed by E. K. Cole, Ltd.

First production order for the *Fireflash* was awarded to Fairey early this year and deliveries to Royal Air Force Fighter Command are due within the next five months. Fairey is one of the forerunners of some 150 British firms engaged in missile work, with most activity in the air-to-air and surface-to-air categories.

Army Rocket Sled Attains 1,300-MPH

This new rocket sled, built under Army direction by Aircraft Armaments, Inc. reached speed of 1,300 mph during recent tests at Naval Ordnance Test Station, Inyokern, Calif. The 7,000-pound sled, powered by three solid-propellant rockets, reached this velocity in less than 2.5 seconds. This particular test vehicle was designed for the Army for testing operation of aircraft and missile components at high speed. Aircraft Armaments, a Baltimore firm, is understood to be planning to better the 1,300-mph mark, presumably with an advanced sled design, as part of an overall rocket test vehicle development program.

(*BORON cont. from p.* 100)
boron polymers, such as pentaborane and decaborane, have a high energy content and desirable physical properties.

Another amazing discovery is the fact that boron hydrides and boron hydride derivatives react violently with water, and offer possibilities as fuels for underwater rockets.

Investment Possibilities

It seems almost certain that the boron industry offers intermediate and long-term possibilities for extraordinary capital appreciation. Buttressed by currently expanding uses, boron's potential seems virtually unbounded in the added area of jet-rocket requirements.

About 90% of the world's boron production is in the United States. Not too many companies participate in this output; however, the following companies are available for consideration by the investor:

	Percentage of Total U.S. Production	Recent Price Aug. 15, 1956	Where Traded*
Operating Co.			
U.S. Borax & Chemical	66	48	O/C
American Potash & Chemical	26	49	NYSE
Stauffer	8	75	NYSE
Holding Co.			
Borax Holdings, Ltd.	†	39	LSE

* O/C—Over the Counter.
NYSE—New York Stock Exchange.
LSE—London Stock Exchange.
† Owns 74% of U.S. Borax plus more than 15% of the remaining world supply of boron.

U.S. Borax & Chemical—the amalgamation of Pacific Coast Borax and U.S. Potash produces two-thirds of our domestic output and owns approximately 60% of the world's boron supply. It is said to have more than a 200-year supply of reserves.

$4.2 Million Contract To Douglas

DOUGLAS AIRCRAFT CO. Santa Monica, Div. has received a $4,279,692 Air Force contract for air-to-air rockets, presumably in *Sparrow* series.

Minneapolis-Honeywell To Build Fla. Plant

A new $4-million aeronautical plant for development and production of highly advanced aerial navigation equipment will be built by Minneapolis-Honeywell Regulator Co. near St. Petersburg, Fla. The new plant will provide 207,500 sq. ft. of floor space on a 95-acre site.

About 1,500 engineers and skilled workers will be employed when full-scale production of the inertial guidance systems begins, probably by the middle of 1957. Construction of the firm's first Florida facility will be started immediately.

Paul B. Wishart, president, said the company's decision to build a major new plant was prompted by extra government contracts and Honeywell's plans for expanded activity in the inertial guidance field.

Convair Awards Contract For $40-Million Plant

Convair Division of General Dynamics has awarded a general contract to McNeil Construction Co. of Los Angeles to build its new $40-million Astronautics facility for *Atlas* intercontinental ballistic missile development.

Plant site is a 252-acre plot northeast of San Diego. Partial occupancy is expected by next spring.

The Astronautics facility will provide nearly 1,000,000 sq. ft. of floor space. It will consist of a one-story, high-bay manufacturing plant of about 500,000 sq. ft., two six-story office buildings for administrative and engineering staffs, a 147,000-sq. ft. engineering laboratory, a cafeteria-auditorium, an instrument and computing center, plus other special-purpose buildings.

Raymond Rosen Firm Now Tele-Dynamics, Inc.

Raymond Rosen Engineering Products, Inc., producer of telemetering equipment for such missiles as the *Nike*, *Terrier*, *Matador* and *Firebee*, has changed its corporate name to Tele-Dynamics, Inc. with headquarters in Philadelphia.

The new firm remains a wholly-owned subsidiary of Raymond Rosen and Co., Inc. and will retain a west coast office in Sherman Oaks, Calif.

Industry Well Represented At Venice AGARD Meeting

U.S. companies were heavily represented at the four-day Guided Missiles Conference which ended last Thursday in Venice, Italy. Of the 23 papers presented at the meeting, about half came from American engineers and scientists.

The unclassified meeting was sponsored by the Advisory Group for Aeronautical Research and Development (AGARD) of NATO. Its principal theme was missile guidance, and the papers covered virtually the entire field of guidance problems.

Weapons system philosophy and guidance techniques were the principal subjects covered on the first day of the meeting, Monday, Sept. 24. Papers presented on Tuesday discussed use of digital computers, problems of gyro-stabilized servo platforms, inertial guidance and linear homing navigation. Missile instrumentation, field testing and reliability were covered on Wednesday, while Thursday was devoted to papers on the pitfalls of missile control, effects of airframe characteristics on guidance, flight evaluation of guidance components and new principles of missile guidance.

Reeves Instrument Has Five Major Projects

Recent disclosure of the $10-million development and production by Reeves Instrument Corp. of the world's largest chain radar tracking system at USAF's Patrick AFB missile range brings to five the number of major projects tackled by the Dynamics Corp. of America subsidiary.

Earlier it contracted to build a million-dollar electronic test and flight simulation laboratory at the AF's Wright Air Development Center for research on aircraft and missile design problems.

In its own project "Cyclone" computer, built for Navy Bureau of Aeronautics in 1946, it reportedly has solved for as little as $50,000 a design problem that would have cost $100 million in a comparable flight test program.

New NACA Employment Program For Military Scientific Personnel

National Advisory Committee for Aeronautics, hard-pressed earlier this year by the threat of a mass loss of scientists to private industry, has found a new answer to its employment problem.

Under a cooperative NACA-Pentagon venture, Defense Department is making available to NACA qualified military personnel for assignment to scientific research projects. About fifty officers from the Army, Navy and Air Force are expected to enter the program by early next year.

The move has two-fold benefits, NACA says. It not only supplies it with hard-to-get technical and scientific talent, but also provides active-duty scientific training for a select group of military personnel.

As a result, various military departments are supplying NACA with volunteer lists of volunteer eligible officers from which it may select candidates. They are expected to be assigned to NACA research activities dealing with military's long-range plans for aircraft, missiles and rockets.

Here's how individual services are handling the program:

Army—Provides NACA with names of ROTC graduates who will be offered 18 months active duty with NACA after completing six-month duty in Army training.

Navy—Will submit list of qualified officers with aeronautical engineering degrees who have two years additional obligated service, or who indicate desire to extend their tour of duty to accept NACA assignment.

Air Force—Provides NACA with list of officers who volunteer for two-year NACA duty.

In each instance, officers assigned to the program will, for all purposes, be NACA employes. Pay, allowances and other costs will be reimbursed to the particular service.

The Defense step is the most recent of a number of moves aimed at relieving NACA's scientific personnel problem.

Earlier, in a session-ending measure, Congress authorized NACA 20 additional "Public Law 313" jobs. Although NACA had asked for 50 such positions, the 20 voted by Congress gives it 30 jobs in the $12,500 to $19,000 a year category.

Added to this, most widespread improvement throughout NACA's organization stemmed from action by the Civil Service Commission in late August. This authorized NACA to pay top-of-grade salaries to some 1,625 NACA research scientists effective September 25.

As a result of this last measure, here's how the new grades now pay within NACA: GS-9—$6,250; GS-11—$7,465; GS-12—$8,645; GS-13—$10,065; GS-14—$11,395; GS-15—$12,690; GS-16—$13,760; and, GS-17—$14,835.

CALENDAR

OCTOBER

1-3—National Electronics Conference and Exhibition, sponsored by AIEE, IRE, Illinois Institute of Technology, Northwestern University and University of Illinois, Hotel Sherman, Chicago.

1-3—Canadian IRE Convention and Exposition, Automotive Building, Exhibition Park, Toronto.

2-6—National Aeronautical Meeting, Aircraft Production Forum and Engineering Display, sponsored by SAE, Hotel Statler, Los Angeles.

8-10—Second Annual Symposium on Aeronautical Communications, sponsored by IRE, Hotel Utica, Utica, N. Y.

10-12—National Transportation Meeting, sponsored by SAE, Hotel New Yorker, New York City.

10-12-16—NACA triennial inspection of Langley Aeronautical Laboratory, Langley, Va.

15-19—Second annual world-wide conference of USAF Flying Safety Officers, Keesler AFB, Biloxi, Miss.

15-17—Fall radio meeting of Radio-Electronics-Television Manufacturers Assn., Hotel Syracuse, Syracuse, N. Y.

16-19—Conference on Magnetism and Magnetic Materials, sponsored by IRE, AIEE, APS and AIMMEE, Hotel Statler, Boston.

22-23—Radio Technical Commission for Aeronautics fall meeting, Hotel Marrott and CAA Technical Development Center, Indianapolis.

25-26—Aircraft Electrical Society annual display of electrical equipment, Pan-Pacific Auditorium, Los Angeles.

29-30—Third Annual East Coast Conference on Aeronautical and Navigational Electronics, sponsored by IRE, 5th Regiment Armory, Baltimore, Md.

NOVEMBER

8-9—National Fuels and Lubricants Meeting, sponsored by SAE, Mayo Hotel, Tulsa, Okla.

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.

JANUARY

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

New Communications *Concept*

for exchange of information amoung missile engineers

By Arthur W. Steinfeldt

In the midst of an explosive growth, communications within the missile industry have not been able to keep pace with the rapid technical advances and specialization. Due to the interdependence of missile technologies, progress in one area must be quickly communicated and integrated into the programs of other technologies. However, the missile industry is finding it increasingly difficult to digest and assimilate the specialized knowledge pouring forth from scientists and engineers drawn from diverse and esoteric fields.

Sources of basic, unclassified information are widely scattered geographically and the dissemination of material is often in a random, haphazard fashion. This is further complicated by the fact that most of the established periodicals, scientific journals and societies are directed either toward one small segment of missile technology, or are so general as to include the entire aviation industry.

The establishment of the Missiles & Rockets *magazine by American Aviation Publications is further recognition and response to the need for better means of communication in this rapidly maturing industry, and I am pleased to write for this first issue of the magazine concerning the initiation of an experiment in technical communications undertaken by the Special Defense Projects Department of the General Electric Company.—A. W. S.*

It is apparent that engineers and scientists in the missile industry must know not only their own field but should be aware of the knowledge, contributions and problems of other related technologies in order to make a maximum contribution themselves. This is especially true in an industry where technology is expanding rapidly. Long-standing demarcation boundaries between sciences are being rapidly changed and modified and entire new sciences are being born.

It has been obvious that there is a need for a program (1) to facilitate the flow of current information among engineers and scientists in the missile industry, (2) to provide knowledge as to where related technical work is being conducted, (3) to show how diverse technical fields are related and integrated in the missile industry, and (4) to stimulate engineers and scientists into thinking more about the relationship of their effort to other technical fields and common missile problems.

General Electric's Special Defense Projects Department decided to attack these problems on a modest basis by undertaking a series of *technical forums*. Four forums were planned as a series, each one in a different city with new speakers and a new program. The forums were announced in newspapers and tickets sent to qualified engineers and scientists. Over 1,000 attended the series.

● There were a number of practical considerations which led us to organize the forums as outlined above. GE wished to make attendance at the forum as convenient as possible and appeal to a wide range of engineers and scientists. To do this, it was necessary to bring the forum to them in the localities where they worked and lived. GE felt this approach would enable many persons to attend who would not have the opportunity otherwise. This required that the forums be unclassified and, of course, this brought the question of security to the forefront.

How often when discussing the national security aspects of missile work has one heard phrases such as, "Everything interesting in the missile field is classified," or "I wish the security people would declassify some of my work so I could prepare it for publication." I believe this sentiment is quite common and deserves more thought. Scores of worthwhile articles related to missile work are being published each month in unclassified journals. Many more would be available but are not because of individual inertia rather than security limitations.

Security Problem

Security people are fully aware of the necessity for exchanging scientific and technical information where no classified material is involved. GE found them most helpful and cooperative in clearing talks for presentation and publication. It takes time and effort to accomplish this, but our experience has shown that it can be done and that most of the effort need not consume the time of our professional technical people.

● **To meet our objectives,** it was necessary that the presentations be of high caliber and of interest to an audience differing widely in background. It was decided that rather than have our speakers deliver a highly specialized talk, each would attempt a technical presentation of interest to the entire audience. This was not entirely possible but most of each presentation was understood by the audience generally. Sufficient time was scheduled to permit detailed discussion of the subjects for those who wanted to explore them in depth.

In order to overcome some of the barriers between various sciences, the technical forums were organized to present a number of papers from diverse fields. This diversification can best be illustrated by the subjects that were treated at the various technical forums by the speakers who were selected from the Special Defense Projects Department.

At the first forum held in New York City, Systems Engineering, Hypersonic Experimentation and Mass Accelerators and Aerophysics were discussed. At the second forum in Buffalo, our speakers treated the subjects of Missile System Testing, Aerophysics and Stress Analysis. The third forum in Washington. D. C., covered Structures, Aerophysics, and Recording and Recovery of Missile Data. The fourth and last forum of the series in Boston discussed Missile Reliability, Instrumentation and Hypersonic Experimentation.

Numerous visual aids, including colored slides, models and mock-ups, were used to further interest the audience and stimulate discussion. Each presentation was limited to 30 minutes in length and a discussion period was allowed after each talk. A general discussion period followed the last speaker.

● **Each person** attending the forum was asked to fill out a brief questionnaire. This was done to measure the effectiveness of the forum and to obtain suggestions for improving future forums. A very high return, approximately 65% of the questionnaires per forum, was obtained.

Here are the conclusions based upon the reaction of the engineers and scientists who attended our first series of forums:

1) There was almost unanimity of agreement (97%) that the forums were worthwhile and that those attending would attend future forums if they were offered the opportunity.

2) Those in attendance felt that the information offered was current and of interest to them.

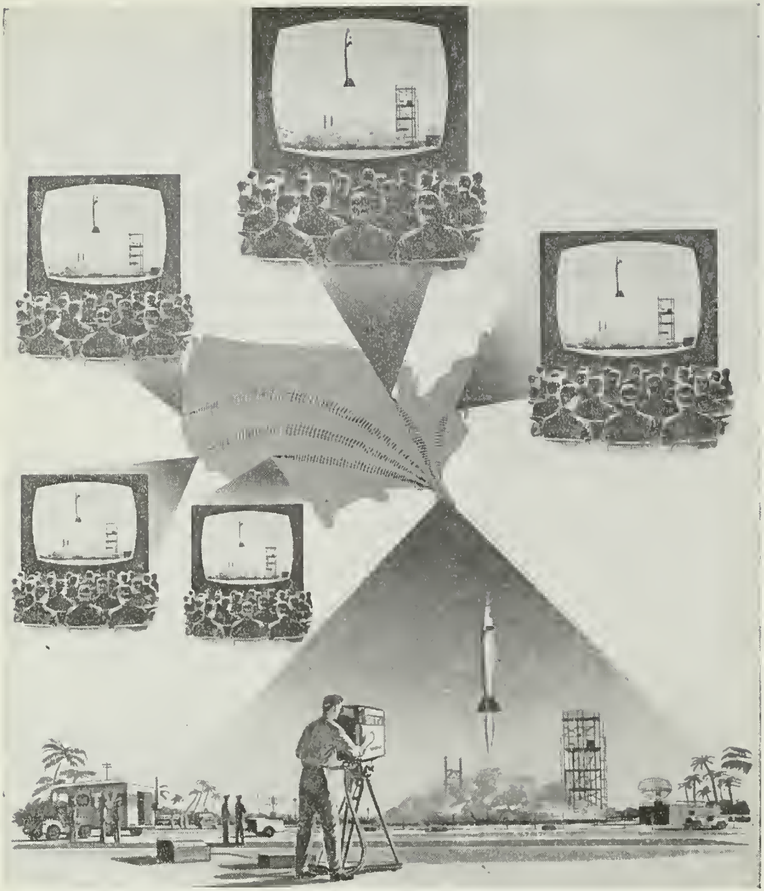
3) A substantial portion of the audience was quite amazed how closely seemingly diverse fields were related and integrated. They felt they obtained valuable information from presentations made by specialists in fields they normally considered outside of their particular sphere of activity.

4) They obtained considerable information from both the speakers and others in attendance about where technical work was being conducted of which they had no prior knowledge.

5) In indicating what fields should be discussed at future forums, the audience indicated that they would like to continue to have covered more than just their own technical field if they continued to be handled properly.

Tremendous Potential

As part of the forum program, our marketing organization scheduled press conferences where our participants matched wits with both the technical and non-technical press. This they found especi-



Nationwide closed circuit television would permit scientists to be "present" at important events and thus get firsthand information.

ally stimulating. In two cities they were asked to appear on television. Several of the presentations have already been published in technical journals and others are slated for future publication. Our marketing people were also pleased with the favorable publicity that was obtained in the daily newspapers and in non-technical and technical magazines.

● GE has come to realize that industry-sponsored efforts in technical communications have tremendous potential and it is a function which can no longer be left to chance. The missile industry has a direct interest and responsibility for doing its part in filling the communications' void resulting from ever increasing specialization and rapid technological advances.

A number of techniques could be employed. I would like to offer one for consideration. A series of technical forums could be planned on an industry-wide basis. Each industrial organization involved would schedule technical forums of its own in the local area. Engineers and scientists in the surrounding area who are interested in missiles, or already engaged in the field would be invited to attend. Then, to tie the entire effort together, a closed-circuit television program could be developed. Each company would select one or two subjects for presentation on the industry hook-up. The TV broadcast would originate from laboratories or missile proving grounds throughout the country. In a matter of minutes, each person attending would be tuned in on the latest scientific developments.

Imagine the inspiration and clash of ideas that could result from researchers all over the country actually watching—in a sense participating—while the nation's leading scientists demonstrate a problem or experiment. Exposing ideas to the fierce glare of the television camera and to hundreds of scientists in the field would be the quickest way I know of to separate out good ideas from the bad.

The forum idea could also be expanded to help the missile industry in the tremendous training job that has to be done. Each year thousands of engineers and scientists are brought into the industry and must be quickly integrated. Much of the orientation and training they receive is of an unclassified nature. Why not use closed circuit television to bring the best speakers from industry, government and universities to conduct appropriate sessions with a nationwide audience?

I have mentioned only a few applications of the use of industry forums and closed circuit television to improve communications. Actually the possibilities seem almost limitless. . . . END.

NAA Employs 500 In Summer Program

More than 500 students and faculty members from colleges and universities throughout the country have been on North American Aviation's summer payroll this year as part of the manufacturer's new long-range recruiting program. Breakdown of this temporary employment is as follows: Los Angeles division, 249; Rocketdyne, 115; Autonetics, 69; Missile Development, 66; Atomics International, 17.

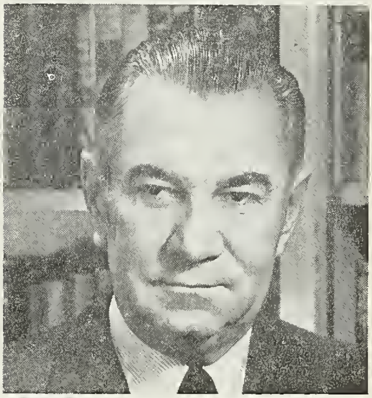
Mac Wright, coordinator for the program at Los Angeles, said the wide-scale summer work program was helpful to NAA in various fields and at the same time gave potential employes a chance to get to know the company. Hiring of faculty personnel, he said, is good for both teachers and the company in giving teachers practical experience in the application of their academic courses.

Technical Employee Increase

LOCKHEED AIRCRAFT CORP. estimates that one person in every eight it now employs is a technical employee. In 1943 only about one in every 100 was a technician or engineer.

PEOPLE

Lawrence D. Bell, president of Bell Aircraft Corp. since he formed the company in 1935, has resigned for reasons of health. He has been elected

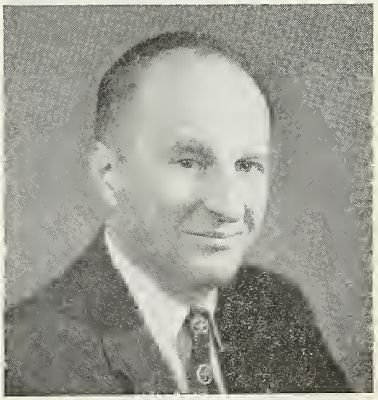


Lawrence D. Bell

chairman of the board. One of the few surviving pioneers of the industry era prior to World War I, 45 of his 62 years have been spent in aviation. **Leston P. Faneuf** will succeed him as president and will continue as general manager of the company.

Alexander Satin, well-known research engineer, has been appointed Senior Scientific Advisor to Lockheed Aircraft Corp., Burbank, Calif.

Formerly Chief Engineer of the Air Branch, Office of Naval Research in Washington, D. C., Satin



Alexander Satin

was recently presented with the Meritorious Civilian Service Award for his "outstanding leadership in initiating and coordinating a comprehensive research program in aerodynamics, structures, powerplants, instruments, experimental airplane, helicopters and other techniques and equipment used in naval air warfare."

Satin has been credited with the initiation of several scientific Navy and Army research projects, including rocket devices, short-takeoff-and-landing aircraft experiments, jet-lift and ducted fan propulsion and satellite research.

Marvin B. Ruffin, vice president-customer relations since April 1955, has been promoted to vice president and gen. mgr. of Summers Gyroscope Co.

Republic Aviation Corp. has named **Robert W. Boesel** chief project engineer for its guided missiles division.

Boesel

Ruffin

Daniel A. McBride and **Eugene L. Olcott** have joined the Chemistry Division of Atlantic Research Corp., Alexandria, Va., McBride as project coordinator and Olcott as metallurgical engineer. **Dr. Joseph B. Levy** will conduct research on the kinetics of solid-propellant combustion and of high-temperature gaseous reactions.

Clare W. Harris has been appointed a project engineer for Lockheed Missile Systems Division, while continuing to serve as asst. to the director of engineering; **Harry W. Kohl** was named division engineer for the newly created Bay area project at San Jose. **Dr. Samuel B. Batdorf,** formerly with Westinghouse Electric Co., has joined the division as consulting staff scientist.

Dr. Daniel T. Sigley, formerly chairman of the Guided Missile Steering Committee and associate director of the General Engineering Laboratories for the American Machine & Foundry Co., has been appointed chief engineer for the Guided Missiles Division of Firestone Tire & Rubber Co. of California.

Sigley

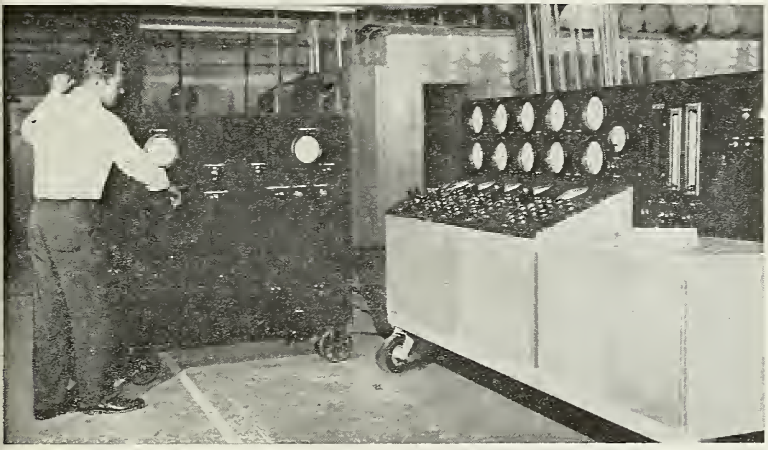
Steinhardt

Lawrence R. Steinhardt has been appointed president of Narmco Metlbond Co., which makes "Multiwave," a sandwich core material used in aircraft and missile structures.

William C. Foster is the first formally-elected Chairman of the Board of Directors of Reaction Motors, Inc.

William M. Duke, former vice president of the Cornell Aeronautical Research Laboratory, has been named program director for the "Titan" Intercontinental Ballistic Missile program of the Ramo-Wooldridge Corp.'s guided missile research division.

NEW MISSILE PRODUCTS

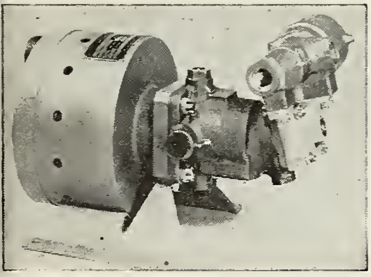


A substantial number of these mobile pneumatic and electrical test stands (right) have been produced by Lear Aircraft Engineering Div., Santa Monica for North American Aviation's Rocketdyne Division to check out rocket engines without firing. Complexity and high-performance requirements of their operation led to design of another auxiliary test stand (left) to check them out.

POWER PACKAGES

Vickers, Inc. has unveiled a series of hydraulic-powered electrical power packages for use in aircraft and missile systems. Although originally designed in the 0.5 to 3.0 kv output range, a larger unit of 10-kva capacity has been adopted for a specific missile installation.

Basic system consists of a permanent magnet, 400-cycle generator directly driven by a flange-mounted Vickers constant-speed



hydraulic motor. Speed control reportedly is within + or —2 1/2% regardless of load and special adaptations will maintain 400-cycle frequency within + or —0.1 percent.

Weight of a 0.5 kva power package is seven pounds whereas a 3.0 kva unit weighs 19 pounds. The larger missile installation in use weighs 40 pounds. Write: Vickers, Inc., Dept. M/R, Box 302, Detroit 32, Mich.

MISSILE CABLE

A new cable especially designed for guided missile motors and electronic controls is available. Designated as Type SP-132, the cable is a four-conductor type with tinned copper conductors, tinned copper braid, polyethylene insulation and a polyvinylchloride jacket. The cable has a minimum outside diameter of 0.275". Write: Federal Telephone and Radio Co. Dept. M/R 100, Kingsland Road, Clifton, N. J.

MISSILE CONNECTORS

Scintilla Division of Bendix Aviation Corp. has introduced two new series of electrical connectors for application in missile ground and airborne systems.

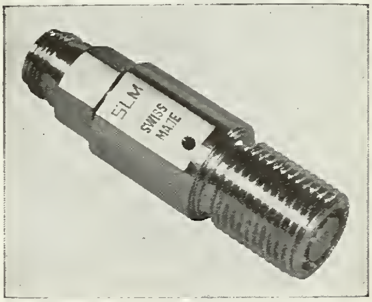
Scintilla's QWL type (illustrated) is designed for heavy-duty use with multi-conductor cables in missile ground launching equipment and ground radar. Tests have indicated absence of thread wear after being subjected to 2,500 coupling and uncoupling cycles.

Other Scintilla series is the "Pygmy" connector intended for miniaturized missile electronic equipment. These are available in "A" and "E" styles, in a series for potting, with jam nut receptacles, and with hermetically sealed receptacles. Write: Scintilla Division, Bendix Aviation Corp., Dept. M/R, Sidney, N.Y.

PRESSURE TRANSDUCERS

New series of Swiss-made miniature SLM pressure transducers available from Kistler Instrument Co. covers a range of pressures from .01 to 100,000 psi. Models are classed as blast gauge, shock-tube gauge, ballistics gauge and hyper-ballistics gauge.

The SLM series is said to be rugged enough to withstand explosions, yet sensitive enough to measure pressure variations in sound waves generated in rocket motors. Units are designed to operate at temperatures up to 600°F and to measure variations as low



as 0.1 psi in fuel systems and combustion chambers at any pressure level to 3,000 psi.

Write: Kistler Instrument Co., Dept. M/R, 15 Webster St., No. Tonawanda, N.Y.

HITEMP DECALS

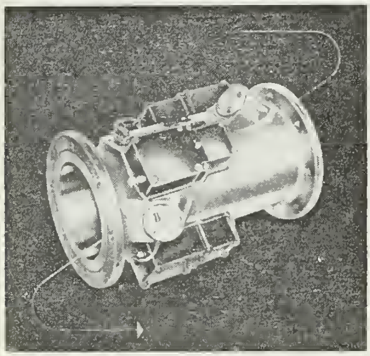
New series of heat and solvent resistant decals designed to withstand higher temperatures of jet aircraft, rockets and missiles have been announced by The Meyercord Co. Applications include engine housings and hot parts, electronic equipment and a variety of situations involving extreme heat.

Three available types of Meyercord decals include: HR—Suitable for most surfaces which will withstand temperatures in

400°F range. SHR—Designates sustained heat resistance. For smooth rigid surfaces under constant operation in 500° to 600°F range. HHR—For high heat resistance. Withstands temperatures up to 1,000°F intermittently. Suitable for rigid surfaces.

Write: The Meyercord Co., Dept., MR, 5323 W. Lake St., Chicago 44.

MISSILE FLOWMETER



An ultrasonic flowmeter marketed by Maxson Instruments Div., The W. L. Maxson Corp., provides simultaneous readout of mass flow rate, mass totalization, volumetric flow rate, volumetric totalization and fluid density in a direct reading instrument for missile fuel gauging systems.

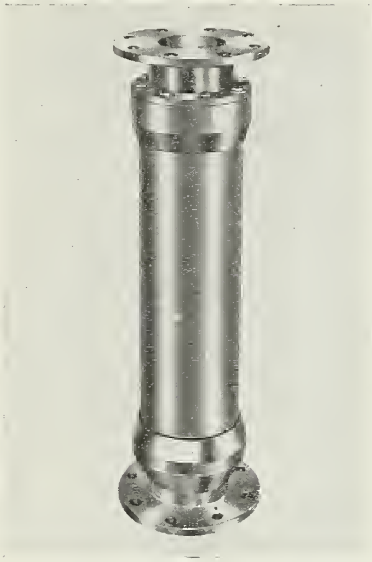
The unit uses ultrasonic energy to determine volume or mass of fluid passing through a smoothbore sensor. It is said to handle up to 720,000 lbs. or 90,000 gals, of jet fuel per hour at an accuracy of 1%. Weight is 10 lbs.

Write: Maxson Instruments Div., The W. L. Maxson Corp., Dept. MR, 47-37 Austell Place, Long Island City 1, N. Y.

LOX STRAINER

A new in-line type stainless steel strainer designed primarily to filter liquid oxygen at extremely low temperatures is marketed by Harman Equipment Co. The Harmeco Model 33008 strainer, said to have application in the ICBM program, is also usable for handling petroleum-type fuels.

New strainer features flanged ends constructed of extremely dense, close-grained stainless steel castings welded to a body of stainless steel pipe. Unit is said to be leak-free at temperatures of —350°F and below.



Four available types having optional flange and strainer assemblies all measure four inches in diameter. Weights range from 112 to 135 pounds. Literature available.

Write: **Harman Equipment Co., Dept. MR, 3605 E. Olympic Blvd., Los Angeles 23.**

GEAR TRAIN

Sinite D-10-S bearings are a feature of a new minute gear train announced by Booker-Cooper, Inc. The Sinite material, used by major missile producers in liquid oxygen applications, is a compaction of 50% bronze and 50% lubricative pigments.

Sinite used in bearing applications is said to operate over a wide temperature range at speeds in excess of 3,000 rpm without additional lubrication. Temperatures range from —300°F to +500°F. The material is available in bar stock or is machined to specifications. Write: **Booker-Cooper, Inc., Dept. MR, 6940 Farmdale Ave., No. Hollywood, Calif.**

THERMOCOUPLE JUNCTION

A miniature, multi-channel "hot" thermocouple reference junction which the manufacturer says is rugged enough for missile use operates from ac or dc and is stable to 1.5°F.

The unit can be provided for any type junction such as iron-constantan, chromel-alumel, copper constantan and others. The unit replaces ice bottles and temperature compensators. Write: **Arnoux Corp., Dept. M/R Box 34628, Los Angeles, Calif.**

INSULATED CABLE

New series of single and multi-conductor Teflon-insulated cables for missiles and radar applications, high temperature instrumentation and telemetering devices is marketed by Tensolite Insulated Wire Co., Inc. Standard and custom-designed constructions varying from one through 37 conductor assemblies are available.

New cable features parallel-wrapped Teflon, but spiral-wrapped or extruded Teflon primary insulation may be specified. Write: **Tensolite Insulated Wire Co., Inc., Dept. MR, 198 Main St., Tarrytown, N. Y.**

MISSILE TUBES

A new line of seven subminiature tubes for guided missile applications has been announced by Sylvania Electric Products Co. The line includes rf pentodes, beam

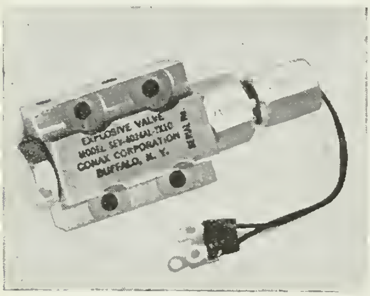
(More New Products, Page 125)

power pentode, audio amplifier, medium and high μ single and double triodes.

Design features include a shorter mount for rigidity, wide element spacings and vibrational noise control over a wide frequency spectrum. Although developed for guided missile application, the tubes are expected also to find application in telemetering and vehicular use. Write: **Sylvania Electric Products Co., Dept. M/R, 1740 Broadway, N. Y. 19, N. Y.**

EXPLOSIVE VALVE

A new normally-closed explosive valve announced by Conax Corp. is designed to provide a dead-tight, shut-off valve for long or short-term storage of gas or liquid under high pressure. When fired by a small integral squib, it opens the equivalent of a 9/32-inch diameter orifice in .002 seconds. Only 1/2 ampere is needed to fire the squib.

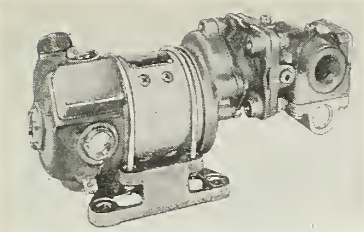


Smallest Conax valve weighs five ounces and is a 1-inch hexagon measuring 3 1/2 inches long. Maximum operating pressure is 5,000 psi and proof pressure is 10,000 psi. Literature available. Write: **Conax Corp., Explosive Products Div., Dept. M/R, 7811 Sheridan Drive, Buffalo 21, N.Y.**

FUEL PUMP

Lear, Inc., Lear-Romec Division has developed a nine-pound rotary vane-type pump designed to supply smoke fuel for guided missile tracking systems. An electric-motor-driven type, it cycles on and off at two-second intervals to create a vapor trail from the tail end of a missile.

Unit is designated Model RG-15800. It has a rated capacity of 4.1 gpm at 27 volts d-c and 13.5 amps pumping Corvus Oil and JP-4 fuel at a two-to-one volume mixture. Displacement is 0.386 cu. in. per



revolution, and a relief valve by-passes full flow at 120 ± 5 psi.

Explosion-proof motor for the RG-15800 is rated at 0.34 hp at 3,000 rpm and 27 volts d-c. Literature available. Write: **Lear, Inc., Lear-Romec Div., Dept. MR, Elyria, O.**

SWIVEL JOINTS

Barco Manufacturing Co. has introduced a new series of aircraft-type swivel assemblies said to provide unlimited flexibility in piping or tubing lines of airborne equipment and track vehicles.

Two basic types provide AN flared or Ermetto fittings in aluminum, steel and stainless steel for pressures up to 4,000 psi. Units are available for handling hydraulic, air oxygen, fuel and acid applications and for temperatures ranging from —300°F to +700°F. Write: **Barco Manufacturing Co., Dept. MR, Barrington, Ill.**

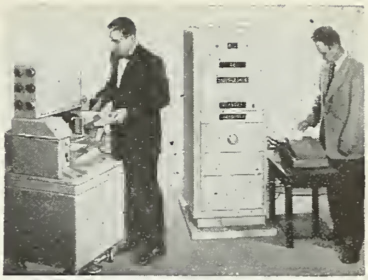
VACUUM PUMP

A new rotary-vane type vacuum pump developed by Beach-Russ Co. for aircraft and missile applications weighs 7 lbs., complete with 28-volt d-c motor. Overall dimensions are 7" x 4" x 6". Write: **Beach-Russ Co., Dept. M/R, 50 Church St., New York 7, N.Y.**

MISSILE CHECKOUT SYSTEM

An automatic system for checking dc and ac voltages and frequency values, together with go/no-go checks has been developed by Electro Instruments, Inc. Both printed and indicator readings are provided. Three groups of devices are used for checkout. These are program, control, and measurement. Programming is done by a punched tape memory.

According to the manufacturer, the system provides dc voltage checks to an accuracy of 0.01% and ac checks to 0.1%. Frequency deviation in percent from

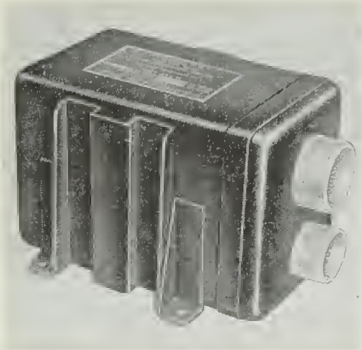


400 cycles is provided with 1 digit accuracy. One hundred channels may be checked. Testing is done automatically and prints identification of tests showing either values or go/no-go indication. Write: **Electro Instruments, Inc., Dept. M/R, 3794 Rosecrans St., San Diego 10, Calif.**

MISSILE FIRE CONTROL

An intervalometer developed by Abrams Instrument Corp. provides automatic programming for missile launching. Opening of rocket pods, rocket-launcher extensions and other functions in sequence are controlled to millisecond accuracies, according to the manufacturer.

No special shock mounts are



required for the unit design to meet MIL-E-5272, Procedure L. Timing is done by a "Chronopulse" time generator. This is a high accuracy dc time base developed by Abrams. Write: **Abrams Instrument Corp., Dept. M/R 606 E. Shiawassee St., Lansing 1, Mich.**

VIBRATION PICKUP

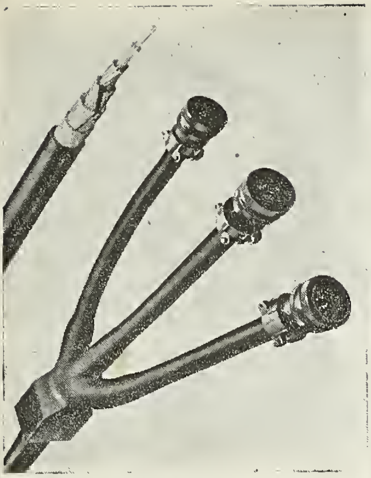
A vibration pickup preamplifier manufactured by Bruel & Kjaer is being marketed by Brush Electronics Co. for use as a link between accelerometers or any type of vibration pickup. The Model BL-1606 is a two-stage unit with high input impedance and allows vibration pickup to be carried out to very low frequencies at extended distances from the measuring instrument.

A built-in calibration unit, consisting of a vibrating disc suspended on a metal strip brought

into resonance at the line frequency gives direct calibration of the combined accelerometer, accelerometer, preamplifier and measuring instrument before the measurements are carried out. Write: **Brush Electronics Co., Dept. M/R, 3405 Perkins Ave., Cleveland 14, Ohio.**

BREAKOUT CABLES

Pacific Automation Products, Inc. is producing a neoprene-sheathed, water-tight "breakout"



cable for missile wiring that contains 141 conductors. It is designed to withstand short-term exposure to oils, acids, alcohol, ozone and water as well as long-term exposure to sunlight.

The multi-branch, multi-conductor cable is layed by a specially constructed planetary strander. It is said to retain flexibility from —65°F to +175°F. Write: **Pacific Automation Products, Inc. Dept. M/R, 1000 Air Way, Glendale, Calif.**

● RADIO RECEPTOR CO., INC. has developed a 2.5-pound airborne miniature radar beacon AN/DPN-43 for ground-crew tracking of missiles in flight. Fully transistorized, it contains more than 120 components in a 6-in. high, 2.5-in. diameter package. Write: **Radio Receptor Co., Inc. Dept. M/R, Brooklyn, N.Y.**

● High "g" event recorder introduced by PHOTRON INSTRUMENT CO. weighs less than 6 lbs. and is said to have recorded thru-shocks in excess of 3,000 g's in actual tests. Unit records up to 21 channels on electro-sensitive paper. Write: **Photron Instrument Co., Dept. M/R, 6516 Detroit Ave., Cleveland 2, O.**

● Specialized line of explosive igniters for initiating solid propellants and liquid fuels are available from McCORMICK SELPH ASSOCIATES. Where igniter requires less than five grams of explosive, squib is integral. For larger sizes, provision is made for thread-in squib. Write: **McCormick Selph Associates, Dept. M/R, 15 Hollister Airport, Hollister, Calif.**

Missile Literature

TEST CHAMBERS. Four-page bulletin describes test chambers built by Inland Testing Laboratories to satisfy virtually any combination of environmental conditions. Refer to Newsletter 3-556. Write: **Inland Testing Laboratories, Dept. MR, 1457 Diversey Blvd., Chicago 14.**

SERVO MOTORS. A 16-page booklet outlines specifications and design details of a line of servo motors and generators. Write: **G-M Laboratories, Inc., Dept. MR, 4300 No. Knox Ave., Chicago 41.**

COMPUTERS. Bulletin illustrates computers, recorders, servos and integrated systems. Write: **Mid-Century Instrumatic Corp., Dept. MR, 611 Broadway, New York 12, N. Y.**

HI-TEMP ALLOY. Alloy R-235, a wrought, nickel-base aluminum and titanium bearing precipitation-hardening alloy for temperatures through 1,750°F is described in new 12-page booklet. Write: **Haynes Stellite Co., Dept. MR, 30-20 Thomson Ave., Long Island City 1, N. Y.**

MISSILE SUPPORT EQUIPMENT and airborne electronic equipment manufactured by Hallamore Electronics Co. is illustrated in new 20-page brochure. Write: **Hallamore Electronics Co., Dept. MR, 2001 E. Artesia St., Long Beach 5, Calif.**

RECORDING SYSTEM, Project Digest PD-21 published by Cook Research Laboratories, Inc. describes newly developed three-channel and six channel magnetic tape recording units for missile instrumentation where space limits are severe. Write: **Cook Research Laboratories, Inc., Dept. MR, 2700 N. Southport Ave., Chicago 14.**

PRECISION SEALING RINGS. Eight-page brochure available from Precision Piston Rings, Inc. gives specifications on eight types of wrought-alloy rings including Haynes Stellite, rated for temperatures of 2,000°F. Write: **Precision Piston Rings, Inc., Dept. M/R, 1417-1423 Commerce Ave., Indianapolis 1, Ind.**

Industry Highlights

By Fred S. Hunter

The Santa Susanna hills on the fringe of Los Angeles used to be a favorite location of the movie makers. You've seen them on the screen of your neighborhood theater—or on your television screen—many times; you just thought that was Montana or Wyoming you were viewing. But now the pop of the cowboy's trusty six-gun has been silenced by the shattering blasts of rocket engines echoing over the hills. For this one-time scene of the old west is today a symbol of the new west. Here is the biggest rocket engine test center in the Western Hemisphere—Rocketdyne's field test laboratory. Here, power for the so-called ultimate weapon, the ballistic missile, is being developed.

•

Out to catch up with North American's Rocketdyne in the development of big liquid rocket engines for the ballistic missile program is Aerojet-General, whose test facility is in the old gold-mining country east of Sacramento. When complete, these huge rocket engine test installations will provide Aerojet's Sacramento plant with 24 test positions, the largest of which can handle engines up to 1,000,000 pounds thrust. Like North American, Aerojet has production contracts for rocket engines for the Air Force's long-range ballistic missiles, including the ICBM Atlas and Titan and the IRBM Thor.

•

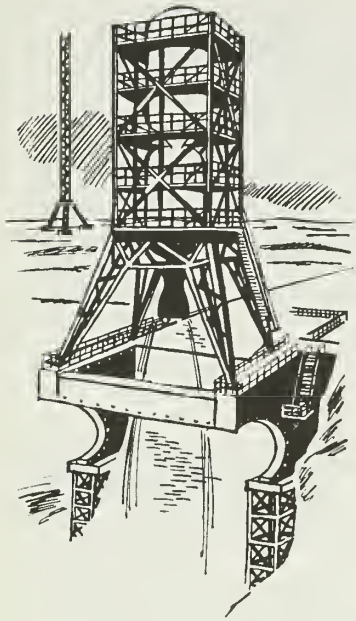
A new $13,000,000 manufacturing plant to be completed in the spring of 1957 will boost the total investment in facilities at Aerojet's Sacramento location to $50,000,000. Originally Aerojet was to have operated a similar $13,000,000 plant at Neosho, Mo., but after construction was started the Air Force decided to divert this one to North American, which is already turning out production type engines, and let Aerojet build another plant in conjunction with the facility it already had at Sacramento.

•

Turbo division of American Machine & Foundry is planning a superenvironmental test chamber capable of simulating the rapid temperature, atmospheric pressure and relative humidity changes encountered by a ground-to-air missile flashing from sea level to 110,000 feet altitude in 100 seconds for its new plant at Pacoima, Calif. AMF's Turbo division is moving up fast. Three years ago at this time, it was a department of the company comprised of 17 people. Now it is heading toward a payroll of 500. It attained division status in the AMF organization last spring and dedicated its new plant in August. Turbo makes accessory power drives for the Nike and has a development contract for units for the ballistic missile program.

•

Horning-Cooper's ASP (Atmospheric Sounding Projectile) developed for the Navy to gather meteorological information and study upper atmosphere cosmic ray and geomagnetic phenomena, also is expected to find additional uses in the hypersonic testing field because of its high velocity. Powered by a high-performance solid propellant developed by Grand Central Rocket Co., the ASP will reach speeds of Mach 5 and better within a few seconds after launching.



NEW STEEL

FOR

TEST STAND, LAUNCHER AND GANTRY TOWER CONSTRUCTION

Heat No.	Plate Thickness, inches	Hardness, RC	Ductility-Transition Temperature, °F
35P489	½	23.5	−195
29S144	½	20.3	−170
35S463	½	22.0	−152
35S463	½	24.4	−162
36S462	½	25.0	−210
37S532	½	28.5	−175
29S515	½	27.9	−235
37S525	½	27.1	−208
34S477	¾	27.0	−195
41S463	¾	25.5	−220
47S464	¾	25.0	−175
41S451	¾	22.5	−205
35S476	¾	24.1	−245
36S462	¾	20.2	−255
29S515	¾	22.9	−225
29S144	1	21.0	−195
34S267	1	24.0	−248
34S477	1	22.9	−190
35S476	1	27.0	−195
27S564	1	26.5	−252
37S532	1	23.6	−242
32U029	1	24.0	−230
73U115	1	25.9	−175
31U033	1¼	24.8	−210
29S144	1¾	24.4	−212

Ductility-Transition Temperatures and Hardness of T-1 Steel Plates

Increased activity throughout the United States in construction of missile- and rocket-launching sites, exceptionally large test stands, gantry equipment, heavy ship launchers and related components will grad-

Need for new materials for the missile and rocket industry is consistent. High temperature and great stresses, fine tolerances and extreme precision are typical requirements. These parameters are indicative of the challenge that materials manufacturers are faced with, and they involve problems of design, material selection, application and fabrication techniques.

MISSILES & ROCKETS' editors, as a special service to its readers, will introduce the many new materials applicable to the M & R industry on these pages in forthcoming issues. Metals/alloys, synthetics and chemicals all will receive attention.

ually yield more business to the steel industry.

In this connection MISSILES & ROCKETS' survey of available new constructional steels focused on T-1, a low-carbon, quenched and tempered alloy that is finding wide use in special construction. The properties of T-1 seem to suit it especially to application in pressure vessels, test stands, cranes, gantry towers, liquid gas tanks and general industrial equipment.

This new, all purpose steel was developed to meet the need for a steel, primarily in plate form, possessing a very high yield strength (90,000 psi or more) and yet tough enough to withstand unusual impact or abrasion abuse or pressures at either low or high temperatures.

● **In equipment fabrication**, the use of T-1 steel makes possible lighter weight equipment because of the unusual yield strength of the steel, which permits reduced plate thicknesses in comparison to the thicker and therefore heavier plates of carbon steel ordinarily used. This can result in substantial over-all savings in material, fabrication, construction and maintenance.

T-1 has a yield strength three times that of ordinary carbon steel according to the manufacturers. Fabrication is no problem to the equipment builder, because T-1 steel is readily welded without preheating or stress-relieving. Its toughness and resistance to the combination of wear and impact abuse cut maintenance and replacement costs, lengthen equipment life.

In the construction industry, where field work is an extremely important facet on nearly every operation, T-1 steel seems to offer many advantages. With no pre- or post-heating required in most cases, equipment can be easily fabricated right on the job site or in the weld shop—whichever is more convenient and less costly.

When the high strength of T-1 steel is used to reduce the thickness of welded sections, welding time and the amount of welding rod needed are reduced.

Lighter weight construction with T-1 steel reduces shipping, handling and material costs, and, in addition, reduces the cost and weight of any foundations and supports that might be needed. Static test stands, for example, are a good example of how T-1 steel can be used to advantage. Parts of large towers and test stands, particularly tension members, subject to high working stresses, as well as parts where resistance to atmospheric corrosion is important or where welding is involved, are suitable for the substitution of T-1 steel.

● **In wind tunnels**, too, T-1 steel apparently can pay off in long-term economy through lengthened service life.

One major advantage that T-1 steel has over ordinary carbon steel is in its resistance to atmospheric corrosion. Designed to include this cost-saving characteristic among its many unusual properties, T-1 steel is suitable material for test stands and equipment used outdoors year-round.

The results of recent short time exposure tests by Lukens Steel Corp. are shown here. In these tests, this new steel was compared with structural copper steel, as well as with Cor-Ten steel. Structural copper steel is assumed to have twice the atmospheric corrosion resistance of carbon steel. Cor-Ten has four to six times the atmospheric corrosion resistance of ordinary carbon steel.

Based on the following test data, it is conservatively estimated that T-1 steel has at least four times the atmospheric corrosion resistance of ordinary carbon steel.

Temperature °F	Stress, psi	Time to Rupture, hours	Elongation in 1 inch, per cent	Reduction of Area, per cent	Minimum Rate of Extension, per cent per hour
900	80,000	2.95	18.0	63.4	0.9333
900	77,500	49.8	15.8	47.2	0.0351
900	75,000	108	8.0	28.2	0.0231
900	70,000	252	5.2	11.1	0.0100
900	60,000	818	1.2	1.2	0.0022
1000	75,000	0.27	18.2	63.0	7.6
1000	60,000	13.4	6.2	11.8	*
1000	50,000	35.6	3.8	3.3	0.572
1000	35,000	190	2.0	2.8	0.0089
1000	24,500	797	2.8	0.41	0.0023
1100	60,000	0.1	18.4	59.6	32.0
1100	40,000	3.2	5.8	6.9	1.04
1100	30,000	12.9	4.9	4.9	0.1530
1100	20.000	66.6	4.2	3.7	0.039
1100	10,250	963	11.8	8.3	0.0062

Results of Creep-Rupture Tests

Steel	Test Temperature, °F	1% Creep in 10,000 Hr.	Stress, 1,000 psi for Rupture in 1,000 Hr.	10,000 Hr.
"T-1"	700	96.0	98.0	94.0*
"T-1"	900	44.0	59.5	44.0
"T-1"	1,000	10.5	23.0	13.8
"T-1"	1,100	2.3	10.0	5.8

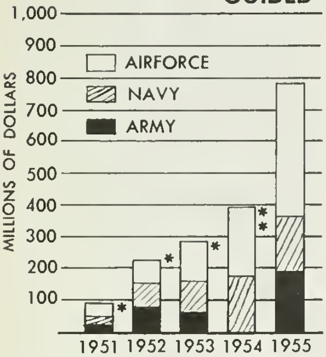
Creep and Creep-Rupture Data

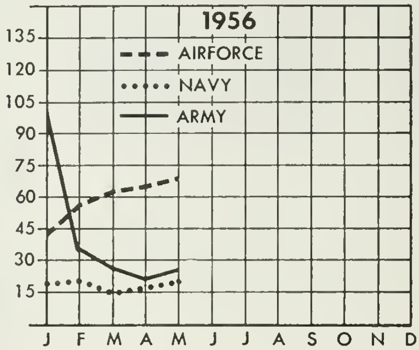
Location of Test Rock	Kearny, N. J. .5 yrs.	Kearny, N. J. 1.5 yrs.	Kure Beach, N. C. .5 yrs.	Kure Beach, N. C. 1.5 yrs.	South Bend, Pa. 1.5 yrs.
"T-1" Steel	5.0	8.2	2.8	5.9	7.1
Str. Copper Steel	7.9	17.0	3.9	10.2	9.8
Cor-Ten Steel	5.1	7.5	2.7	5.6	6.3

Loss of Weight, Grams per 4-x-6-inch Specimen

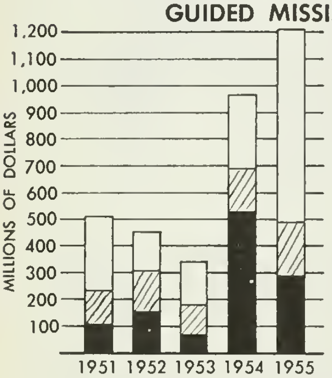
INDUSTRY BAROMETER

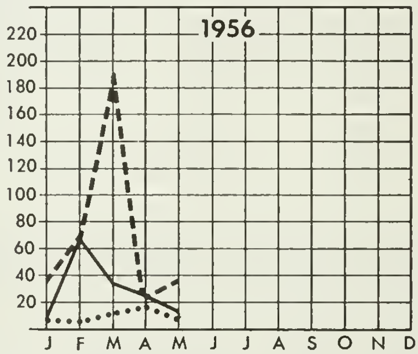
GUIDED MISSILE EXPENDITURES



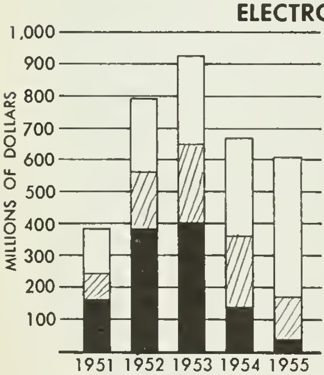


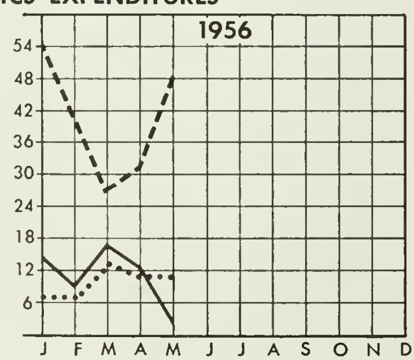
GUIDED MISSILE OBLIGATIONS INCURRED





ELECTRONICS EXPENDITURES





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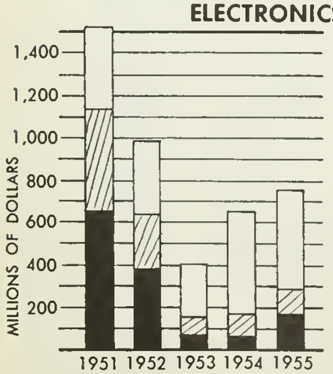

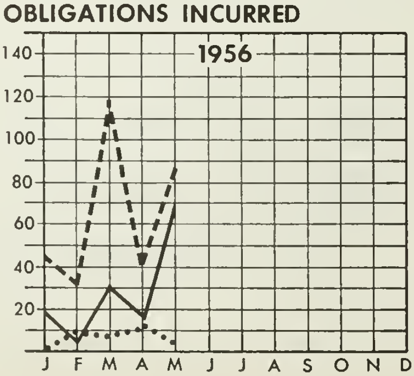

How is the Government spending our money for guided missiles? This is a question that has been agitating the minds of engineers and management personnel as well —ever since the overall missile budget exceeded the billion-dollar mark.

MISSILES & ROCKETS has taken a close look at the total picture and has compiled the facts and figures graphically. Since electronics and communications equipment are closely allied to missile development and production, Department of Defense expenditures and obligations for this industry have also been summarized.

A comparison of programmed R & D obligations by fiscal year for missiles and aircraft is shown. These figures are presented as a guidepost to total activity in missile R & D. Recent testimony before Congress indicates that additional obligation funds can be and have been transferred from other budget categories to meet extraordinary missile R & D demands. The Department of Defense does not release expenditure data on missile R & D.

The minus $456,000 expenditure by the Army for 1954 represents a gain in funds rather than an expenditure figure. In January, February, May and June of 1954 the Army received substantial reimbursements for work performed for the Navy and the Air Force. More than one missile program was involved in these reimbursements. The electronics and communications expenditures account includes money spent for radar, electronic and electromechanical computers, radiation aids to aircraft and navigation, radiation aids to fire control and bombing, radiation countermeasures, meteorological equipment, etc. It is apparent that large electronics purchases by the Army are likely to take place during the next few months.

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* Estimated

** Includes—$456,000 Army expenditures Army deobligated $15 million in May '56 (See graph titled "Guided Missile Obligations Incurred.")

Book Reviews

ROCKETS AND MISSILES. *By John Humphries, 229 pp. $6.00. Ernest Benn Ltd., London. Distributed by The MacMillan Company, New York.*

This book is a rather simple introduction to the subject matter. The publisher says it is written mainly for engineers and technicians, but the material actually is handled in a semi-technical manner. Of particular value are the numerous cutaway drawings of rockets; an extensive bibliography is of considerable interest. The photographs are not too significant, but many of the graphs are good.

The first half of the book covers propellants, motors and components, the second the applications of these to missiles and aircraft.

The chapter on testing of motors and liquid propellants is quite interesting. In general, the book may merit consideration for vocational purposes, since it covers many outstanding basic phases of the missile and rocket industry of importance to the engineer who is about to enter the field or to the student who plans to do so.

THE MEN BEHIND THE SPACE ROCKETS. *By Heinz Gartmann, 185 pp. $3.95, David McKay Company, Inc., New York.*

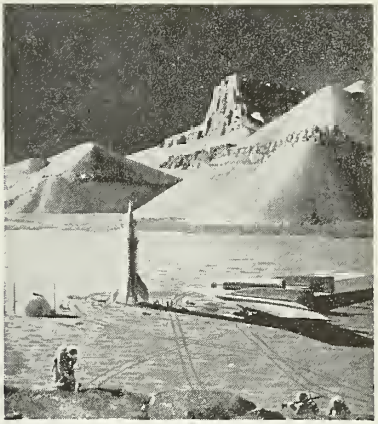
Although this edition of Gartmann's original *Traumer, Forscher, Konstrukteure* is somewhat condensed, the translators have done a good job.

The book is excellent. It gives a concise, interesting biography of some of the most eminent rocket researchers of our time. Gartmann describes the work and lives of the scientists with whom he has worked and who have devoted themselves to the great ideal of the conquest of space.

The biographies include those of Hermann Ganswindt, Konstantin Eduardovich Tsiolkovski, Robert H. Goddard, Hermann Oberth, Max Valier, Eugen Saenger, Helmut Philip von Zborowski and Wernher von Braun and give an interesting rundown on early German rocketry. The chapters on Dr. Saenger and Helmut von Zborowski are of particular interest in view of their current work on advanced missile and rocket projects.

THE EXPLORATION OF MARS. *By Willy Ley and Wernher von Braun. Paintings by Chesley Bonestell. 176 pp. $4.95, The Viking Press, New York.*

This book belongs in every rocket and astronautics enthusiast's library. Ley and von Braun have succeeded in introducing a down-to-earth approach to the long-awaited trip to Mars. Sticking strictly to engineering knowledge available today, the authors have outlined a master blueprint for man's first voyage to Mars.



Landing on Mars

The text is supplemented by a Mars bibliography of great value, tables, diagrams, historical and modern maps, and five black and white and 16 full-color reproductions of paintings by Chesley Bonestell of usual superb quality.

CONTROL OF NUCLEAR REACTORS AND POWER PLANTS. *By M. A. Shultz, 313 pp, $6.40, McGraw-Hill Book Co., Inc., New York. Number two of a series in Nuclear Engineering.*

Based upon recognition that the nuclear-power business is in the transition stage from physicists to the engineers, the book gives an elementary picture of control systems. The approach is: Given the reactor, how to control it?

Control problems described are handled through conventional and elementary servo forms and language. This is done despite the fact that synthesis and design of reactors is steeped in mathematics and clothed in security.

Because of this, certain assumptions and simplifications about the reactors are made in regard to design of the control systems for them. The book is an excellent exercise in the philosophy of designing for the new field. A chapter is devoted to an exercise in design of electronic simulation techniques for study of control problems. For use in teaching, a section is given to question problems related to each chapter.