M/T JULY, 1957

missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS

AN AMERICAN AVIATION PUBLICATION

FIRST ANNUAL ENGINEERING PROGRESS ISSUE

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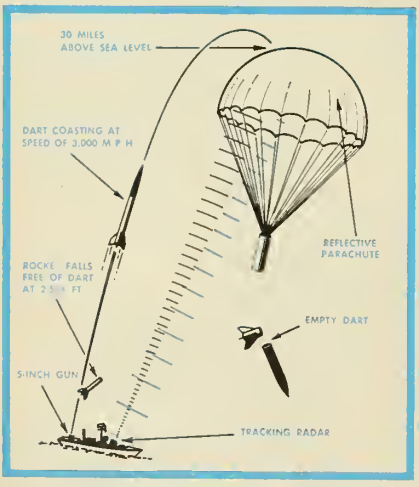

THE WASP IS A SINGLE-STAGE SOLID PROPELLANT ROCKET
LENGTH: 103"; DIAMETER: 3"; WEIGHT: 22.5 LB.

That's a radar reflective chute just ejected from a CDC rocket launched only 60 seconds ago. Far below, a Navy research team is getting instantaneous answers to important weather questions—filling gaps in man's knowledge about wind profiles between *50,000* and *200,000* feet.

This missile system is currently performing useful research tasks for NOL, ONR, Redstone and the Signal Corps. It also is being employed in the IGY program. Redesigned from the LOKI missile developed by Cal Tech Jet Propulsion Lab for Army Ordnance, it is an outstanding example of CDC creativity. CDC offers full services in design, development, instrumentation, fabrication, field testing and data evaluation. How can CDC serve *you?*

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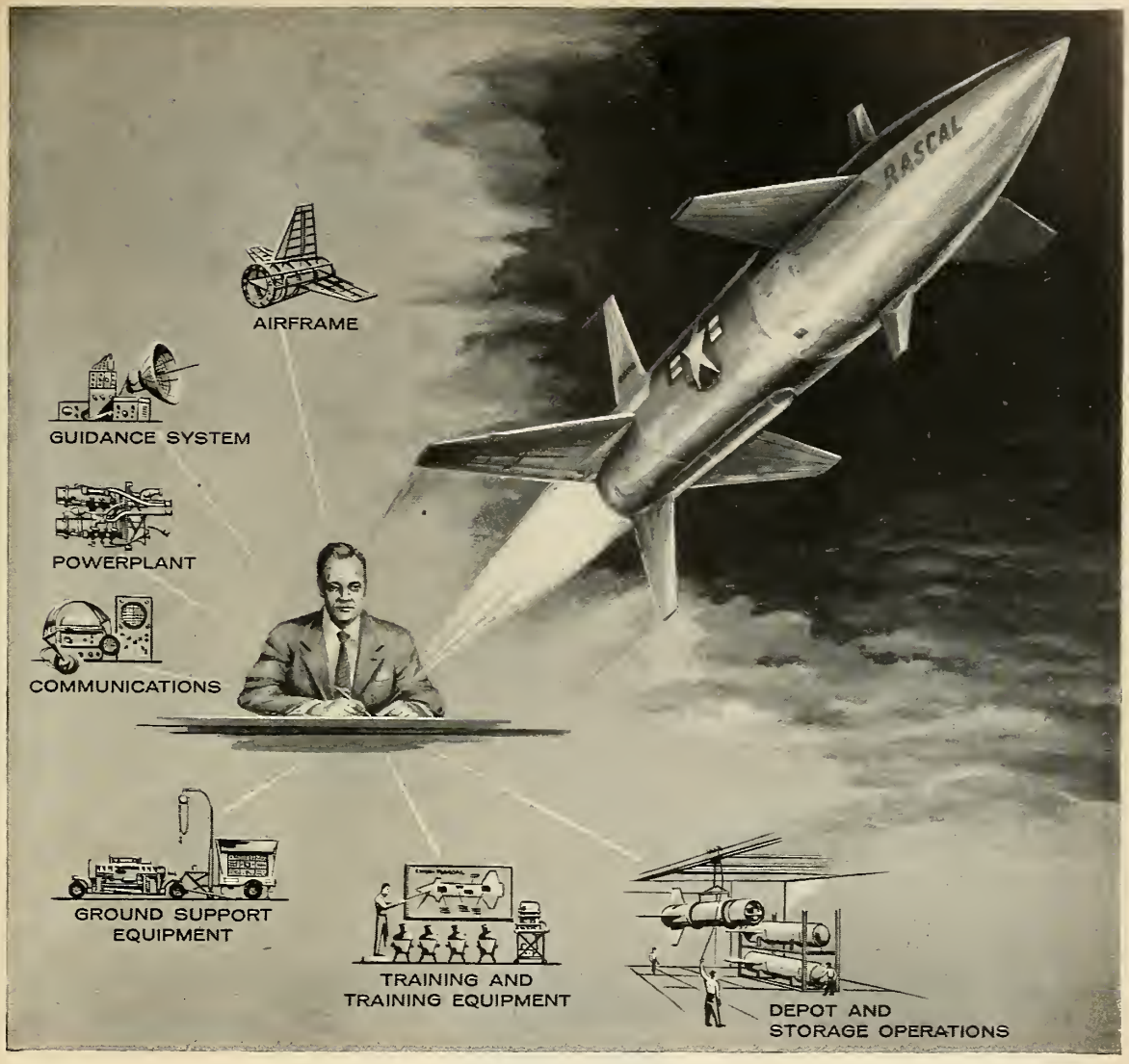

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BELL Aircraft CORP.

Guided Missiles Div.
BUFFALO, N. Y.

missiles and rockets
Magazine of World Astronautics

July, 1957 Volume II, No. 7

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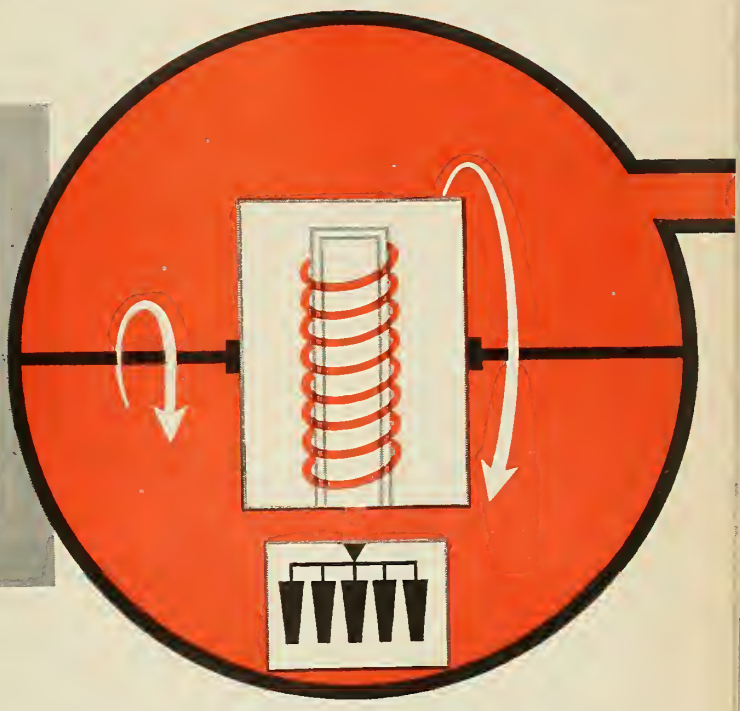
design with austenal in mind



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Discuss this new Austenal development with your Austenal representative. Vacuum melting may be the way for you to obtain higher performance in designing parts for tough jobs of the future.

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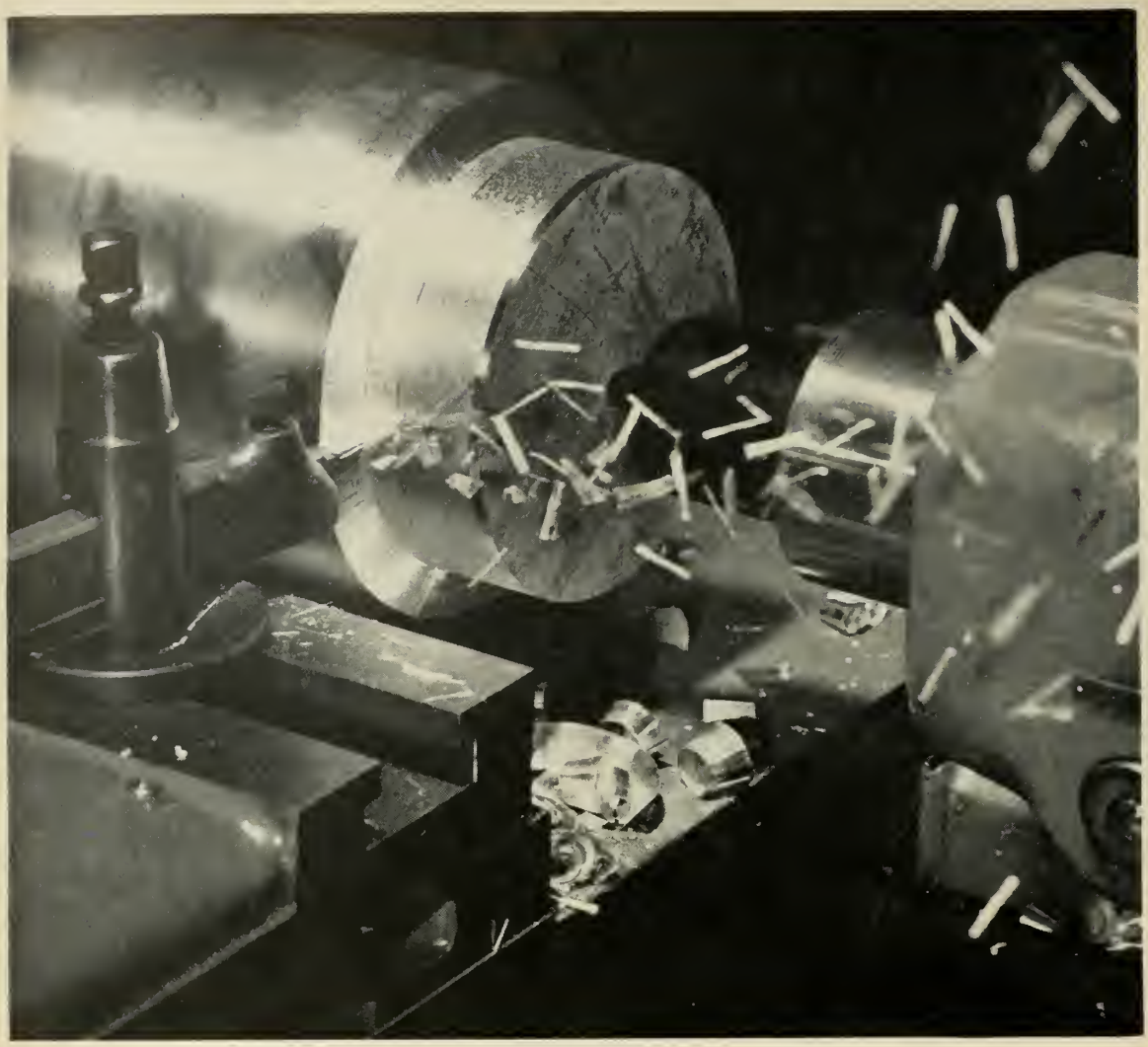

Speed! Of all structural metals, Magnesium costs less to machine

In the picture above, a lathe is making a roughing cut of 0.800″ in an eight inch magnesium billet. The feed is 0.030 inches per revolution at a speed of 630 feet per minute. In finishing operations, cuts of 0.500″ can be made with a feed of 0.003 ipr and a speed of 5,000 fpm.

That's real speed and efficiency—the kind you can always expect when you machine magnesium. This remarkable metal can be milled, drilled, sawed, reamed, bored, planed, tapped and threaded faster than any other structural metal!

Faster machining means easier machining and lower cost machining. It means more production per hour and per dollar, and longer tool life.

The following table shows how well magnesium compares to the others:

METAL	RELATIVE MACHINABILITY
magnesium	1.0
cast aluminum	1.8
brass	2.3
cast iron	3.5
rolled aluminum	5.0
mild steel	6.5

Let us give you more information about the machinability of magnesium. Contact the nearest Dow sales office or write to THE DOW CHEMICAL COMPANY, Magnesium Department, Midland, Michigan, Dept. MA 1404G.

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missiles and rockets

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guest editorial

Science and Common Sense

Radioactivity was discovered by Becquerel and explained by Lord Rutherford before 1900. In 1905, Albert Einstein postulated the equivalence of mass and energy according to the relationship $e=mc^2$. In 1945 a group of scientists crouched in Alamagordo's damp predawn to watch the world's first man-made nuclear blast sear the blackness. Nearly half a century elapsed from basic concept to weapon, although the same Albert Einstein advised President Roosevelt of the feasibility of an atomic bomb.

Today we would like the gap between idea and hardware be reckoned in months. The pace of development accelerates. To be sure, the scientist doesn't pull the trigger, or push the button, but he peers over the shoulder of the man who does.

We believe that the world is secure from nuclear self-annihilation only so long as the West maintains a weapons superiority that is obvious to the enemy. In general, this superiority is equidependent on: The discovery of new and better concepts; industry's ability to engineer and produce the hardware based on those concepts; and finally on men in authority recognizing the "next step" when they see it.

The need for people with a high degree of technical training is evident. Slowly, however, the problem of numbers is being solved. Missiles, rockets and space flight have fired the fancy of young America. More and more students in high school will tell you: "I want to be a missile engineer." Or, "I want to be aboard the first flight to the moon."

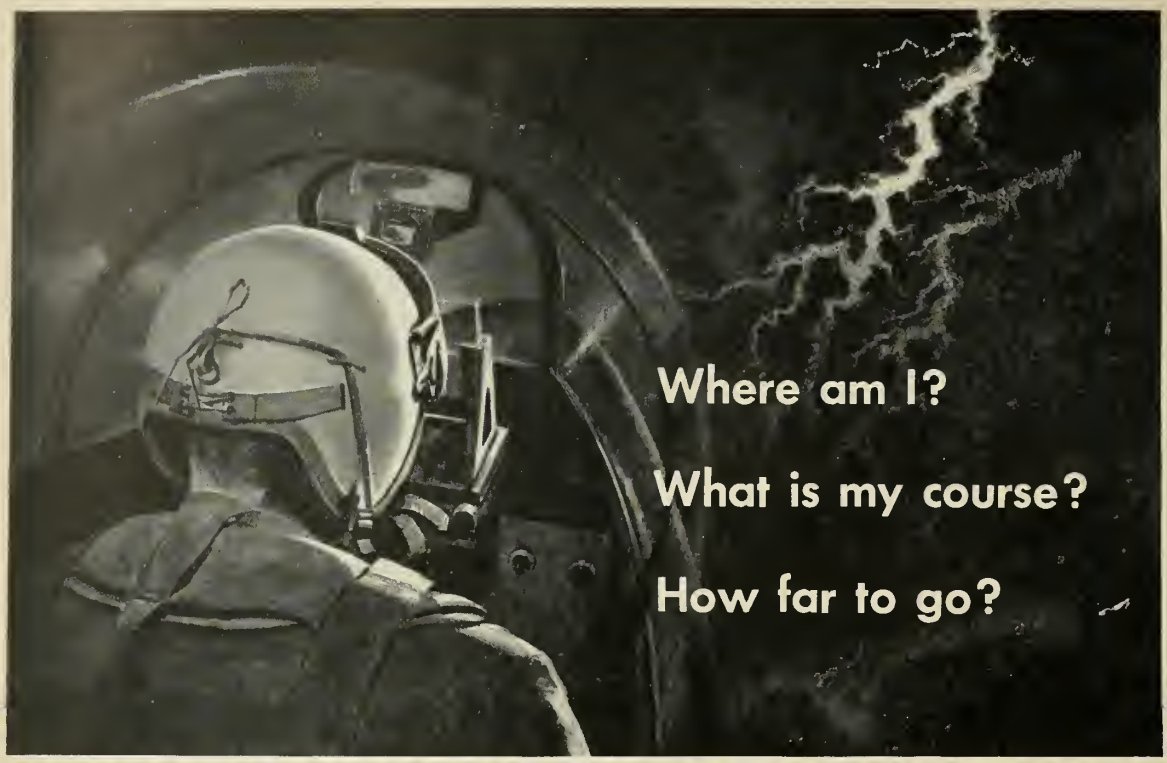
This is good. And for this purpose there is a primary need to lay more emphasis on the physical sciences as early as possible, especially in the upper high school grades. Fortunately this need is more and more recognized by educators and parent associations.

Also, the higher education at universities and colleges dealing with training of scientists and engineers must be broadened to avoid too narrow specialization. The modern history of aviation, especially the development of missiles and rockets, clearly shows that the engineer working in these fields needs education in more and more branches of the physical sciences. Aerodynamics became Aero-thermodynamics, then Aero-thermochemistry; for problems of guidance and command the aeronautical engineer must also be familiar with the broad field of electronics.

Essential is a constant awareness on the part of young people starting out that the world is complex and broadening—that all things in it are related.

This relates to a vital quality without which all the scientific ability imaginable would be to little avail. Instilling technological intuition—a working judgment of the physical sciences—into the business executive is tough enough. Even more difficult is the task of providing a broad base of *common sense* and evaluation for scientist and engineer whose whole educational and professional drive is high-lighted by specialization.

THEODORE VON KÁRMÁN.



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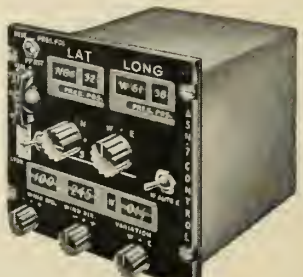
This FICo system can be installed in any aircraft—from jet fighters to tankers, bombers, transports and airliners. And it is in production now! It is smaller in size and lighter in weight than any comparable navigation system now in existence, and offers *extreme* accuracy. The ASN-7 features automatic variation and can be supplied with polar capabilities, automatic fix correction, and automatic drift and ground speed. For additional information, write to Airborne Equipment Department, Ford Instrument Co., on your letterhead.

FLIGHT INDICATOR of this system displays ground trock, required course, heoding error, and distance to the destinotion.



COMPUTER CONTROL feeds wind, variation, ond destination dato into the system. It displays present position, wind speed and direction, variation, ond destinotion coordinates.

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MISSILE SYSTEMS PROPULSION

Weapon systems management activities at Lockheed's Palo Alto, Sunnyvale and Van Nuys organizations call for significant achievement in propulsion. Areas include design analysis, evaluation of test information and technical management of propulsion subcontractors. Inquiries are invited from those possessing a high order of systems ability and strong familiarity with solid and liquid propellant rockets and ramjets. Please address the Research and Development Staff, Palo Alto 7, California.

Here Propulsion Staff members discuss problems relating to accurate positioning of a vehicle in the upper atmosphere. Left to right: J. F. Houle, propellant feed systems analysis; B. Ellis, Propulsion Department manager; J. J. Donhan, control force generators.

Lockheed

MISSILE SYSTEMS DIVISION

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features

Men for Missile Engineering
By Joseph G. Beerer 73
Space Travel and Our Technological Revolution
By Dr. Wernher von Braun 75
Propellant Progress 81
Progress in Air Force Rocketry
By Frederick I. Ordway III and Ronald C. Wakeford 83
Missile Progress by the Corps of Engineers
By Maj. Gen. David H. Tulley, USA 89
Progress in Army Missile Research and Development
By Maj. Gen. August Schomburg, USA 91
Navy Rockets and the Future of Man
By Rear Adm. Rawson Bennett, USN 97
Navy Missile Progress
By Rear Adm. John E. Clark, USN 101
Progress in Air Force Scientific Research
By Brig. Gen. Hollingsworth F. Gregory, AFOSR 105
X-1E Goes Aloft 114
Project *Vanguard* 117
Electronics Evolution 121
Missile Encyclopedia 123
U.S. ARMY: *Nike Ajax, Hawk, Nike Hercules, Dart, LaCrosse, Little John, Honest John, Corporal, Sergeant, Redstone, Jupiter* 124-136
U.S. NAVY: *Bullpup, Corvus, Diamondback, Sidewinder, Zuni, Sparrow, Torpedoes, Terrier-Tartar, Regulus I, Talos, Triton, Regulus II, Polaris* 137-150
U.S. AIR FORCE: *Mighty Mouse, Falcon, Bomarc, Rascal, Matador, Snark, Navaho, Thor, Atlas, Titan,* Miscellaneous Missiles 151-164
To Probe Tomorrow 170

news and trends

Army to Launch Second *Jupiter "C"* 44
Second *Atlas* Ready to go Next Month? 46
SAC Officers Briefed on SM-62 *Snark* 47
Army Building 2000-Mile Missile 48
Cislunar Aspects at ARS Meeting 50
Five-Stage Rocket Proposed by Truax 51
U.S. Army is Confident of Future ABMA Role 56
Floating Telemetry Bases for AF Test Range 59
New Way to Make Titanium Tetrachloride 60
Bloodhound Mainstay of British Defense 63
Sweden to Employ Anti-Tank Missile 65
Photon Propulsion Discussed by Reds 68

industry spotlight

Bell Aircraft Acquires Land for Research Center 202
Aluminum Co. of America Develops New Impellers 202
Industry Briefs 210

next issue:

PROGRESS IN HIGH-ENERGY SOLID PROPELLANTS

cover picture:

National Advisory Committee for Aeronautics has been instrumental in advancing manned rocket flight. For years NACA, in close cooperation with industry, has pushed research in this field. Obviously, this effort is undertaken with a complete understanding of the goal of manned flight—higher and faster, and finally toward the black yonder beyond our atmosphere. The cover picture, which was taken especially for m r, shows our most recent rocket plane, the X-1E. See story on page 114.

columns

Missile Business 41
World Astronautics 66
Behind the Curtain 67
Rocket Trends 69
Washington Spotlight 70
Astrionics 112
Space Medicine 167
West Coast Industry 205

departments

Editorial 11
When and Where 21
Letters to the Editor 27
International News 63
Propulsion Engineering .. 111
Missile Miscellany 168
New Products 175
Missile literature 211

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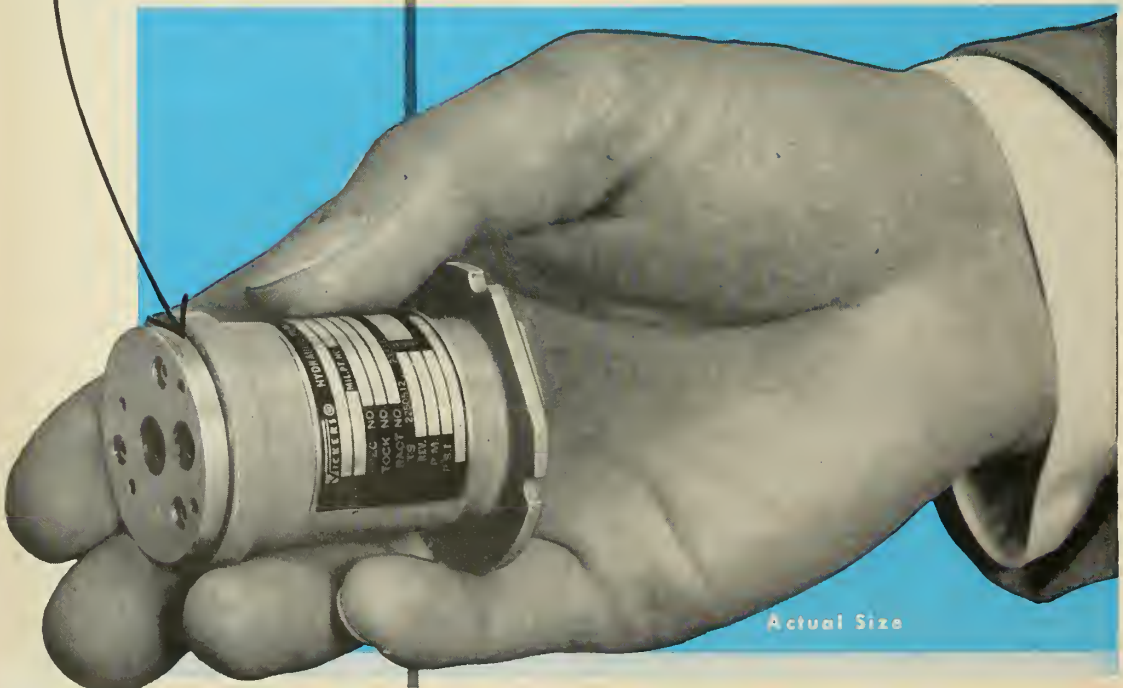

A large expansion program now in its early stages means large opportunities for additional engineers at Vickers. Write for information.

when and where

JULY

Royal Aeronautical Society and British Interplanetary Society, Symposium on High Altitude and Satellite Rockets, Cranfield, England, July 17-20. Air Force Assn. Convention, Washington, D. C. July 30-Aug. 4.

AUGUST

IAS Naval Aviation Mtg., U. S. Grant Hotel, San Diego, Calif., Aug. 6-10.

International Ignition Conference, Bendix Scintilla Div., Sidney, New York, Aug. 20-22.

Western Electronics Show & Convention, Cow Palace, San Francisco, Calif., Aug. 20-23.

SEPTEMBER

Royal Aeronautical Society & Institute of Aeronautical Sciences, sixth International aeronautical conference, Folkstone & London, England, Sept. 1-15.

General Assembly of the Intl. Union of Geodesy and Geophysics (IUGG), Toronto, Sept. 3-14.

ASME Fall Mtg., Hotel Statler, Hartford, Conn., Sept. 23-25.

SAE Aeronautic Meeting, Aircraft production forum and aircraft engineering display, Ambassador Hotel, Los Angeles, Calif., Sept. 30-Oct. 5.

OCTOBER

National Electronic Conference and forum on electrical research, development and application, Chicago, Ill., Oct. 7-9.

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

International Astronautical Federation, 8th Annual Congress, Barcelona, Spain, Oct. 7-12.

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

Canadian Institute of Radio Engineers, Convention-Exposition, Automotive Bldg., Exhibition Park, Toronto, Canada. Oct. 16-18.

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

ASME Conference on new developments in the field of power. Americus Hotel. Allentown, Pa. Oct. 21-23.

Computer Applications Symposium, sponsored by Armour Res. Foundation, Hotel Sherman, Chicago, Ill., Oct. 23-24.

Aircraft Electrical Soc. Annual aviation display, Pan Pacific Auditorium, Los Angeles, Calif., Oct. 24-25.

Baltimore Section IRE, and the Professional Group on Aeronautical and Navigational Electronics, Fourth Annual East Coast Conference on Aeronautical and Navigational Electronics, Fifth Regiment Armory, Baltimore, Md., Oct. 28-30.

NOVEMBER

IRE-PGCS Third Aeronautical-Communications Symposium, Utica, N. Y., Nov. 6-8.

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

National Defense Transportation Assn. National Convention, Shoreham Hotel, Wash. D. C., Nov. 18-21.

DECEMBER

ASME Annual Meeting, Hotel Statler, New York City, Dec. 1-6.

smallest connector

CEC's NEW LIGHTWEIGHT MINIATURE CONNECTOR FOR HIGH-ALTITUDE, HIGH-TEMPERATURE OPERATION

Consolidated's new series of miniature electrical connectors open new horizons for design engineers. Designed especially for the electronics, avionic, and instrumentation industries, these extremely reliable, multi-contact connectors meet or exceed MIL-E-5272A specifications. Recommended for all applications that require high-temperature characteristics, high breakdown voltage between pins and ground, low noise, and positive sealing against moisture and pressure leakage.

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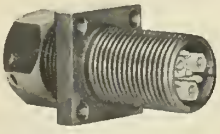
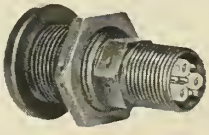
**DuPont registered trademark. See drawing for exclusive CEC design features.*



SQUARE-FLANGE RECEPTACLE
Series 100



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cec's new miniature connector

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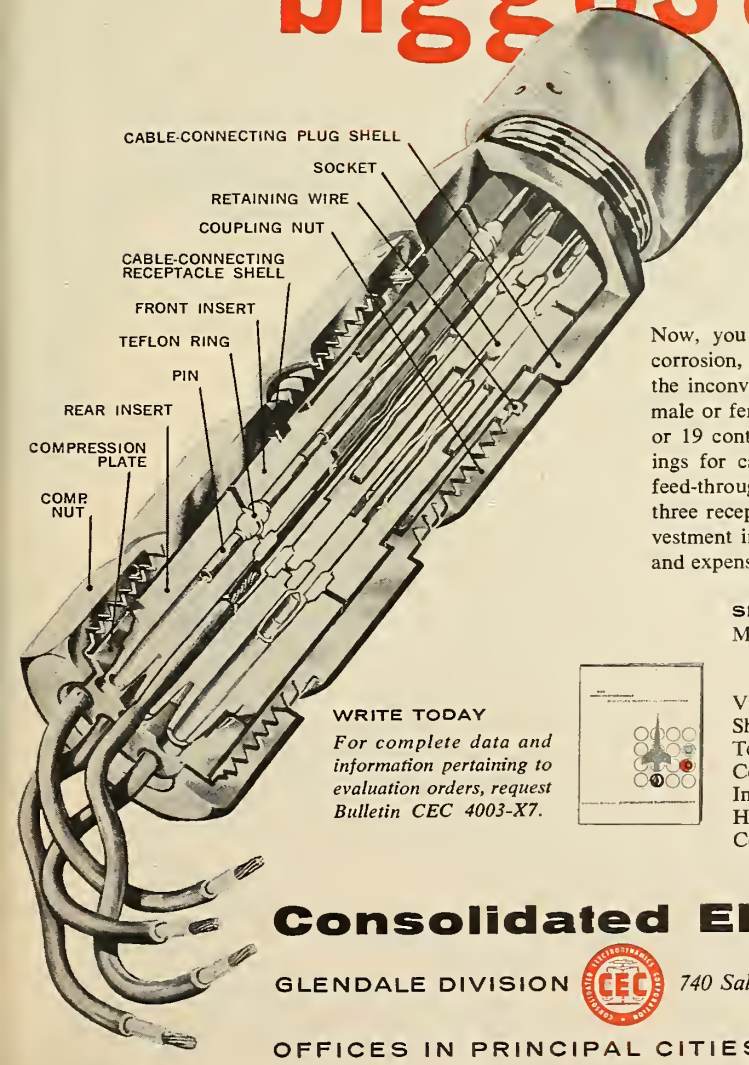

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Now, you can achieve positive sealing against moisture, corrosion, explosive vapors, and pressure leakage without the inconvenience and expense of potting. Interchangeably male or female, CEC Connectors are available with 1, 3, 7, or 19 contacts in three differently shaped receptacle housings for cable-to-cable, cable-to-equipment, and bulkhead feed-through. A standard plug connector mates with all three receptacles. Compare these specifications—a small investment in some evaluation units now may save you time and expense in the future.

SPECIFICATIONS

Max. Operating Voltage
1. Sea Level.....1800-v, a-c
2. 70,000 feet.....800-v, a-c

Vibration.....No resonances to 2000 cps
Shock.....>200 g's
Temperature.....−67° to + 400°F
Contact Voltage Drop...<25 mv at 5 amps
Insulation Resistance.....$>10^6$ megohms
Humidity.....160°F, 14 days, 95% RH
Corrosion.....Salt spray per QQ-M-151a

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For complete data and information pertaining to evaluation orders, request Bulletin CEC 4003-X7.

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★ Excellent long-time stability.

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For information about Edison precision Servos and Servo Components, write for Catalog No. 3044
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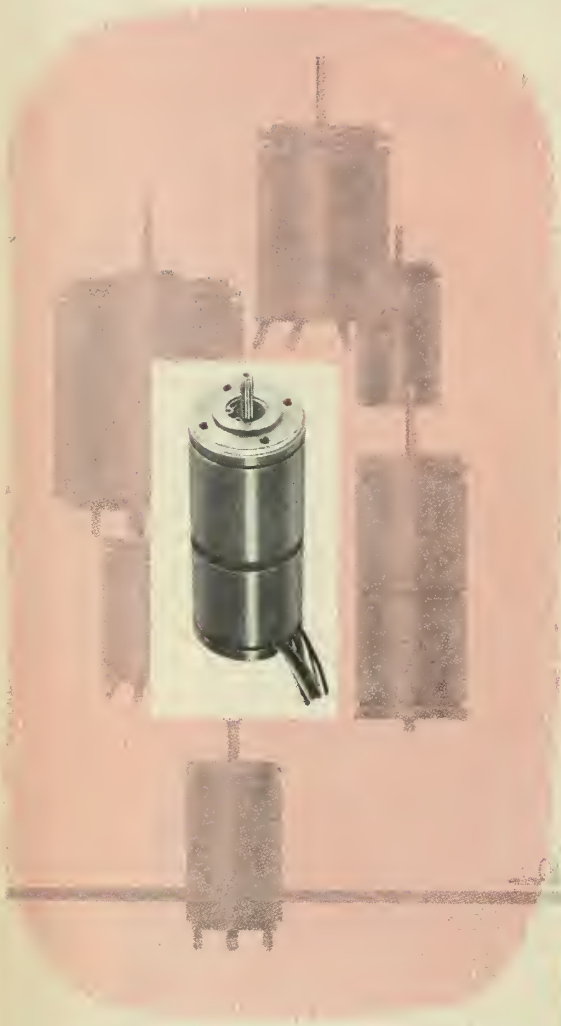

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TYPE OF MOTOR	TWO PHASE SERVO MOTOR-DAMPING GENERATOR
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STALLED TORQUE (MIN. OZ. IN.)	60
POWER INPUT TO MOTOR AT STALL (NOM. WATTS/PHASE)	3.5
SPEED AT MAX. POWER OUTPUT (RPM)	3300
TORQUE AT MAX. POWER OUTPUT (OZ. IN.)	.31
THEORETICAL ACCELERATION AT STALL	34,800 RADIANS/SEC ^{2}
TIME CONSTANT	.019 SEC.
POWER INPUT TO GENERATOR AT STALL (NOM. WATTS)	3.5
OUTPUT VOLTS AT 0 RPM (MAX. RMS)	.019
OUTPUT VOLTS PER 1000 RPM (MIN.)	5
PHASE SHIFT (MAX.)	10 DEGREES
DUTY	CONTINUOUS AT STALL

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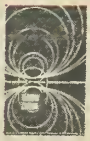
McGRAW EDISON



WRITE FOR SYSTEMS OF THE INSTRUMENT DIVISION

letters

Space Age Definitions Needed by Truckers

To the Editor:

This Bureau is one of eighteen in the larger cities of the U.S. to assist both carriers and shippers in the proper description and packaging of motor freight shipments. Our Bureau recently subscribed to your magazine to help us keep abreast of technical developments in the missiles and rockets field, as well as related developments in electronics.

The National Motor Freight Classification provides a description for "projectile or rocket parts." It is therefore necessary for us to have a few definitions to work from. We wondered if you might be kind enough to help us define and distinguish between the following terms as they are correctly used in the industry: projectile, jet engine, rocket engine, rocket, missile, rocket-missile.

At one time we decided that "projectile" was a general term applied to any article which is moved abruptly into or through the air by any force. This meaning would include a bullet, an arrow, a sone form, a slingshot, a rocket or a missile.

At various times we have considered a "rocket" defined as a projectile driven by a special type of motor called a "rocket engine;" and, in contrast, a missile was propellant without the use of a rocket engine.

However, it now appears, from usage in your magazine and in the industry, that a missile is much the same as a rocket, except that it is always "guided." So, at this point, we are simply confused.

Your help in defining these terms will be appreciated by the whole trucking industry.

C. F. Sullivan,
California Trucking
Associations, Inc.
3301 South Grand Avenue
Los Angeles 7, Calif.

Insofar as possible m/r feels that any definitions in any new field, missiles, rockets and astronautics included, should stick to traditional definitions. A projectile, therefore, is (according to Webster) "a body projected by exterior force, and continuing in motion by its own inertia; specifically, a missile for a firearm or cannon." That definition could also include hurled rocks, arrows, spears and the warhead of a ballistic missile. A jet engine is, in general, any engine based on the reaction principle. Specifically, however, usage restricts it to those engines which carry only fuel and rely on the atmosphere for oxident—axial and centrifugal flow turbojets, pulsejet, ramjet. Briefly, a rocket engine also relies on Newton's third law of motion, except that a rocket carries its own oxident. Missile includes projectile but is broader, including anything that can be "thrown, hurled or projected" whether guided or not—such as pilotless aircraft, for example. Rocket-missile seems to be a redundancy or terminology.—Ed.

Wants Missile Films, Books

To the Editor:

Our management Club, at Douglas Long Beach, is one of the groups needing more information about the missile program. We are starting on the *Thor* ground support equipment and do not have an adequate background in missile science.

In the April issue of m/r you referred to booklets and films by Martin & General Electric. Could you please forward the addresses of those companies so that we can make arrangements for copies of the booklets and renting of the films.

E. E. Brockmann
Douglas Aircraft Co.
Long Beach, Calif.

Contact Tom Irvine, Manager, News Bureau, General Electric Company, Schenectady, N.Y.; and Joe Rowland, Manager, Public Relations, The Martin Company, Baltimore 3, Md.—Ed.

Wants Cover Shot for Framing

To the Editor:

Your magazine has been a source of much pleasure and information to me. I have been receiving MISSILES AND ROCKETS for several months now.

The cover of the June issue, with the space ship heading toward a galaxy, is truly beautiful. Can you send me a photograph or reproduction suitable for framing? I will be glad to pay any charge for this.

Leonard Busbee
1841 New Tampa Highway
Lakeland, Fla.

It's in the works.—Ed.

Says They Come First

To the Editor:

With reference to p. 84, April m/r, while we thoroughly agree with author Fred S. Hunter that Systems Laboratories Corp. has many distinguishing features, one of them is not that it is the first corporate organization specializing in interplanetary flight. We understand SLC was incorporated in May, 1956. The General Astronautics Corp. was incorporated under the state laws of New Jersey in February 1956, three months earlier. The situation is somewhat similar to two rocket companies: New Jersey's Reaction Motors, Inc has a slight edge in age over California's Aerojet.

Ronald C. Wakeford
General Astronautics
Oyster Bay, N. Y.

Wants to Fire 30-Mile Rocket

To the Editor:

You and your staff are to be congratulated on the marvelous job you have done in the compilation of such a great amount of material during the relatively few months that m/r has been published.

I was particularly impressed with the issue featuring "Modern Torpedoes and Underwater Missiles." Back in 1943 thru 1945 I worked on one of the first guided missiles. It, too, was designed to be launched from the air and then to strike its target underwater.

The driving force was a rocket motor. Unfortunately, the project was not completed in time to be effective, and as far as I know has never been released from security.

The Rocket Research and Development Society of Houston, Tex. of which I am technical director, has a problem for which you may be able to give some advice.

This group is very active in the engineering of rockets and missiles and I

am sure that their efforts in the future will result in more rapid and efficient solutions to the problems that exist in this field.

However, we do not have an adequate firing range where we can accurately check performance. If at all possible, we would appreciate the opportunity of firing our 30-mile missile at some facility equipped for this type of work.

We have already contacted Lt. Col. James P. Hamill, Chief Ordnance Mission at the White Sands Proving Grounds but were informed that the Department of Defense regulations do not allow private groups to use that firing range.

If there is anything you can do to help us locate some facility where we would be permitted to fire our missile under controlled conditions, it would be deeply appreciated.

Ten or twelve boys would want to participate in this firing activity.

L. F. Megow
Rocket Research &
Development Society
3342 Arbor Ave.
Houston, Tex.

See Missile Miscellany, page 168, and write Mr. Foster Haley, Office of Public Information, Redstone Arsenal, Huntsville, Ala. He may be able to help. He'll try anyhow.—Ed.

Subject: Article entitled "Project Vogelhundt"

To: Missiles & Rockets Magazine

1. The attached material was submitted to this office for security review and clearance for public dissemination.

2. The statement in paragraph 1 of the article indicating that the project comes under the cognizance of the Naval Ordnance Test center appears to be in error. NOTC informs this office that while the project borders upon PROJECT SMISH, which, as you know, is highly classified, it in no way overlaps or invades that field.

3. Consequently, the Navy Department has no objection to publication on grounds of security. However, it is suggested that Missiles & Rockets Magazine, in keeping with its policy of obtaining official clearance for its material, submit article to the U.S. Army Canine Corps (QM) and/or the U.S. Air Force Strategic Air Command (Security Division).

4. For your information, it is believed that original research on olfactory processes and particularly on Bassett Male Aero Bark X3A was conducted by Army with technical assistance from the Seeing Eye Dog Foundation. Research on the Mark IV version was taken over by Air Force SAC in connection with its program of security for bases.

5. Early in 1956 it was determined that Bassett Female Yipe 6 and setter Female Yipe 8 appeared to be far more productive than the X3A and Mark IV versions of Bassett Aero Bark and that the end product was less subject to infestation by parasitic bosphoetai. Further and more detailed data on additional expermentation should be obtainable from the two services mentioned.

6. Regarding the alleged accidental firing of Project 73, which the article states, landed in the Panamint Range, it is suggested that this matter be referred to the Department of the Interior.

R. A. Barracks
Cmdr. USN
Chief, Navy Branch
Office of Security Review
Office of the Assistant
Secretary of Defense
Washington 25, D. C.

New readers see "letters" in m/r's May issue. Project Vogelhundt was submitted to Department of Defense Security Review, according to a long-standing m/r custom of never publishing any document that we have not cleared. After much serious consideration on the part of those charged with safe-guarding our security, m/r received this "official" clearance from a Navy Commander who (bless him) has a sense of humor.—Ed.

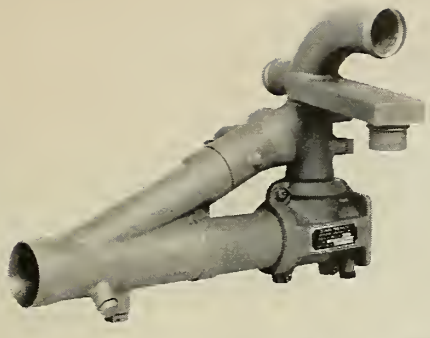
The Challenge of Gravity

To the Editor:

If it were possible to select a best issue from among the fine presentations which the m/r staff has put out every month, my vote would go to the recent June 1957 issue. The article entitled "Seven League Boots" by Seabrook Hull brings to the fore a subject which many have puzzled over but which relatively few have ever put any real effort into: gravity.

Please understand that aside from having the tools of an engineering degree and eight years experience in the consulting field my only familiarity with the subject comes from studying the works of others and a very slight amount of original thinking and calculation.

Being convinced, however, that the key to the great revolution in man's approach to his environment is hidden in the term gravity, it is my purpose to add



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letters

whatever meager help I can toward the solution of the mystery.

Not being one of the small group of particularly qualified men, I am interesting myself with the problem of stirring up interest among the larger group. Interest in any subject increases as one's knowledge of the subject increases. Obtaining knowledge on the history of research and development in the field of gravity is not impossible but is time consuming and sometimes rather discouraging. Except for a chapter in a physics text or a very involved mathematical treatise by Einstein most of the material is pretty well scattered.

There is no book available, according to the Massachusetts Institute Bookstore, devoted to the subject of gravity exclusively. I am therefore engaged in the compilation of such a book which I hope will serve as an introduction to the subject to many uninitiated but fertile minds.

The book will not be the presentation of original material but rather will be a review of the study of gravity from the earliest times to the present. It will include as complete a bibliography as possible of all articles and publications dealing with the subject. Excerpts or abstracts from these publications will be included (depending of course on the authors' and/or publishers' permission).

It is hoped that this book will excite the interest and imagination of at least a few capable young people to the point where they will take up the ball and devote their efforts to this problem.

I am fully aware that several well financed projects are currently under way and that they are manned by very capable men. It is my belief, however, that this small task force needs many new recruits to win the battle.

In order to make this book as valuable and complete as possible I earnestly solicit your comments and criticisms as to the undertaking itself and with reference to the type of material which you think should be included. I also request permission to reference your article (with proper credit).

Any information such as possible sources of information or parties who might be willing to assist this project in any way will be sincerely appreciated.

A "well done" to the entire staff of m/r. Keep up the good work.

William S. Alcott
49 Blackhawk Road
South Weymouth, Mass.

A letter follows. Good luck.—Ed.

Future Missileer

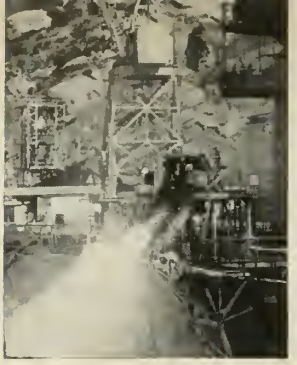
To the Editor:

I could point out more than one reason why I subscribe to your magazine, but they all would boil down to one: My great interest in the subject which is more than anything else symbolic of the world's progess and of the continuous effort to intensify the relations among peoples.

I am only a high school student but next year I will attend Rome University's Faculty of Aeronautical Engineering. I will thus be able to devote myself entirely to this subject.

It is my intention to take up a finishing course and work in the U. S. after acquiring my degree.

Albert Arcangioli
Viale Parioli, 81
Rome, Italy



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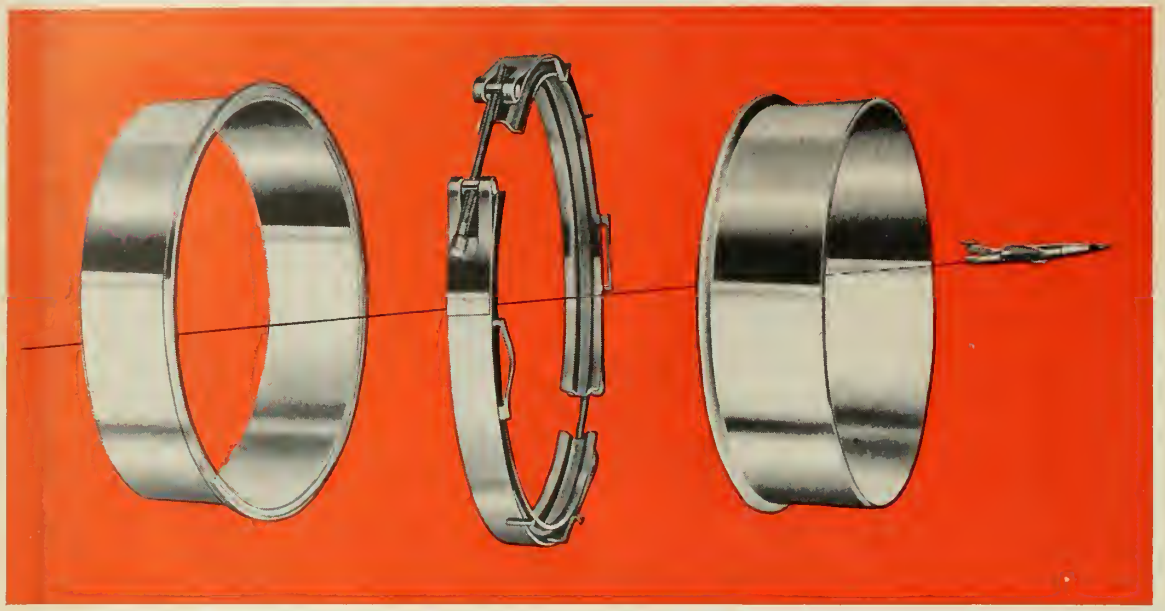

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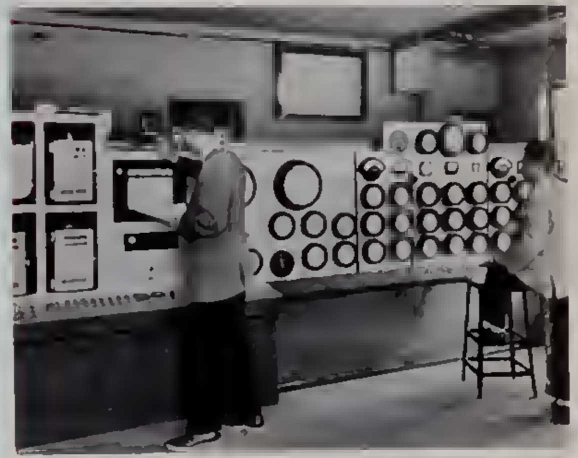
[illegible] of Liquid [illegible] Note [illegible] tank to [illegible]

View from south side showing Tank Farm

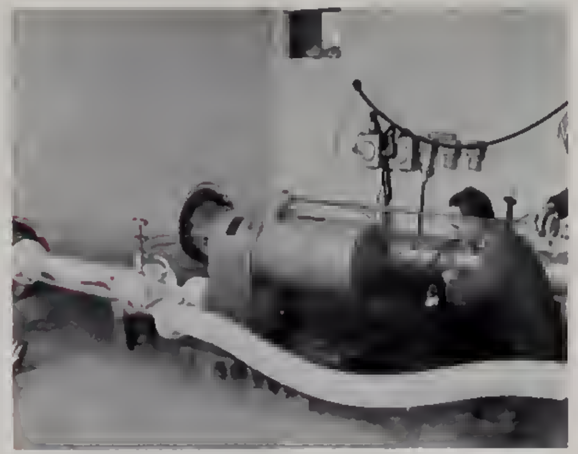
Instrumentation and [illegible] operating console [illegible] Liquid Oxygen Test Loop Blockhouse



View from east of full scale environmental qualification test of 1000 GPM RP Fuel Transfer System

Full scale cycling test of 1000 GPM remote Operating Liquid Oxygen Transfer System

Full scale life test on 250 GPM Topping Pump



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Pressure transfer evaluation using 300 PSI Liquid Oxygen Converter flowing into tower tank

Life test of remote operating Liquid Oxygen valve

Flow and pressure testing of high pressure vaporizer

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Control and sample panel of air separation column

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Open Letter to Industry

Subject: Project R-1
Project R-2

Gentlemen:

Some twenty months ago, our Company as a participating member of the industrial team involved in the Air Force Missile Program, was faced with the need for full scale cold flow testing of large missile oxygen prototype systems. At that time, we undertook an extensive survey to determine the available capabilities both at government and commercial installations for such testing. We found that tight schedules prohibited the possible use of government facilities and no commercial facilities existed. As a result, Cambridge Corporation inaugurated two projects directed toward achieving complete full scale testing capability for liquid oxygen and JP fuel support systems.

These facilities, as described in this folder, are now available to anyone active in the missile program or in the commercial oxygen industry.

Your interest is invited and can be expressed on the reader reply card attached. You may be assured of our whole hearted cooperation and assistance.

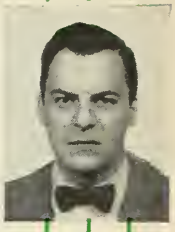
Very truly yours,

CAMBRIDGE CORPORATION

J. W. Logan
President

Missile Business

By Seabrook Hull



FOREIGN MARKET FOR U. S. MISSILES in next two years will total $300-to-$500 million. This is the missile build-up phase of the Mutual Defense Assistance Program. Once the pipeline is filled, the maintenance and modernization level-off rate will run about half that.

Nearly every type of U.S. missile is potentially involved. First interest, however, is in air-to-air, ground-to-air, tactical surface-to-surface and Intermediate Range Ballistic Missiles. Main markets are Western Europe, Australia and Japan. In the beginning, direct sales and grants to other countries will be minor.

Only real potential competitors U.S. missile-makers face at the moment are Britain and France, and even they won't build big missiles like IRBM's. At this writing, no U.S. missile company plans production abroad. Reason is severe initial capital cost. To a large extent, U.S. sales abroad will involve only the basic piece of hardware plus a minimum of spares. MDAP planners hope for local-country servicing, manning, maintenance and operation. U.S.-supplied nuclear warheads will remain U.S. property under the law but will be stored "just over the fence" from U.S.-made, foreign-owned missiles.

COMPETITION FROM BRITAIN will come primarily in air-to-air and surface-to-air missiles. Here, the British nearly match U.S. in some cases: are ahead in others. British appear particularly hot on terminal guidance, but lag in ground-control techniques. British hope their ability to produce less complex missiles at lower cost will be sales advantage. Foreign buyers are more price conscious than U.S.

AIR FORCE IS WORRIED ABOUT MISSILE COSTS. At recent briefing top AF officials told 100 representatives of 51 major contractors that future business would go where prices were lowest. Maj. Gen. David Baker, AMC Procurement Director, deplored current high costs.

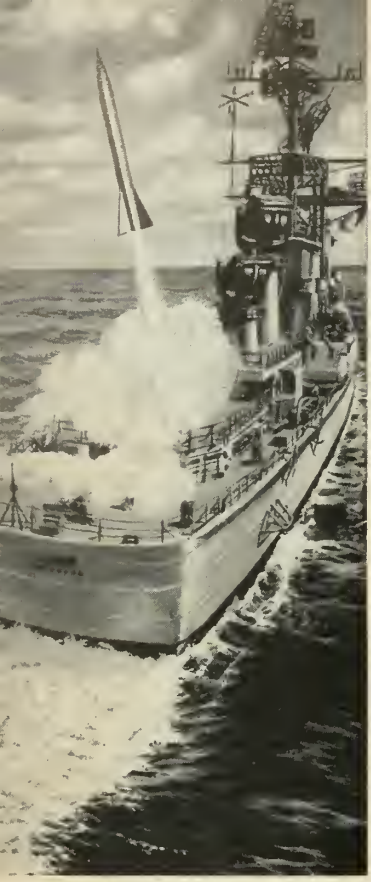
BIG MISSILE NEED IS PRODUCIBILITY. This means taking a tip from auto-makers and other mass production manufacturers. Tendency now of taking an R & D vehicle and ordering it into production substantially unchanged must stop. One answer is to put the manufacturing department on an equal footing with the designers. Another is to improve liaison between designer and producer. Designer's lack of knowledge of optimum production methods and producer's ignorance of design and operational requirements are, generally speaking, appalling.

DON'T WORRY about Defense Secretary Wilson's $38 billion ceiling on defense spending. Object's to avoid a deficit national budget. Treasury Secretaries traditionally over-estimate expenditures and under-estimate tax revenues—Humphrey more than most. The money's there and will be forthcoming if needed to keep missiles on schedule.

SOME MISSILE PROGRAMS WILL BE CHOPPED, however. White House has ordered end to missile bickering; claims it jeopardizes national security. Result: Wilson has ordered crash review of all missiles, particularly IRBM's *Jupiter* and *Thor*; wants action in 30 days.

SINGLE MISSILE R & D AND PROCUREMENT AGENCY may be result. This probably would mean wedding of AF Ballistic Missile Division and Army's ABMA into single-service R & D operation, not dissimilar to NACA—as suggested first by m/r in January. There are strong views that this should be non-service—neither AF nor Army.

VISIT OF 19 TOP AF BALLISTIC MISSILE EXPERTS TO REDSTONE, including Maj. Gen. Bernard S. Schriever, for complete exchange of technical information may mean IRBM nod for *Jupiter*.



MISSILE CRUISER—Problem: To launch a missile 1500 miles from target. An error of only 1 degree in launching information would cause a 25-mile target miss.

SUPERSONIC BOMBER—Problem: To navigate undetected for thousands of miles to exact position in space for release of bombs or missiles.

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U. S. strategy for maintaining peace by making aggression unprofitable is based on our ability to deliver a crushing retaliatory blow anywhere in the world. Accurate means of directing such blows at long range, high speeds and extreme altitudes make would-be aggressors wary of breaking the peace.

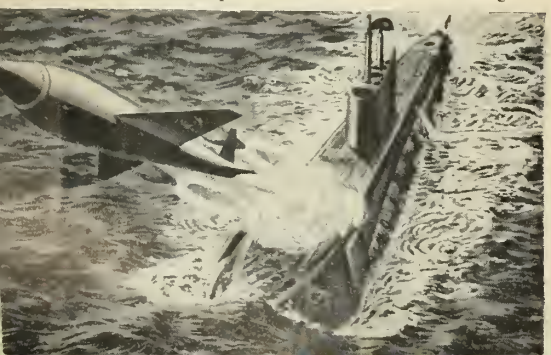
To be effective, weapon carriers must know at all times *exactly* where they are. For example, the long-range bomber with its pinpoint target or the pitching cruiser launching missiles far at sea must navigate with great accuracy.

Solving such problems is the task of Inertial Navigation systems which furnish all data required *automatically*. Completely self-contained within the bomber, ship, submarine or missile, these Inertial Navigation systems require no contact with ground stations. This is extremely important when military missions must be carried on without chance of detection.

To design and engineer Inertial Navigation systems involves a complex combination of engineering skills—gyroscopics, computation, electronics, servomechanics and more. Their production calls for laboratory precision at every stage. For example, the gyroscopes which form the heart of Inertial Navigation systems must be many times more accurate than those used in commercial navigation.

At Sperry, Inertial Navigation systems are being produced for a wide variety of military applications.

ATOMIC SUBMARINE—Problem: To travel submerged for days and know exact spot to surface for missile firing.



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Army to Launch Second Jupiter "C"

Army Satellite Tracking System Revealed

HUNTSVILLE, Ala.—An apparent speed-up of test firings at the nearby Redstone Arsenal and ABMA facilities in recent days has led to speculation that a second version of the *Jupiter "C"* is being rushed to completion.

The rumblings and subdued roars of tests from the huge stands at the arsenal have become longer and louder during the past few days, surpassing anything to which local citizens have become accustomed during the past five years. The tests can usually be heard in the city, several miles away, during mid-afternoon. Occasionally there is a second test in the late afternoon. They usually can be heard for about one minute.

In early June, one test began at about 4:30 P.M. but it ran more than twice the "normal" length of time. One citizen who timed it said the final cut-off occurred 162 seconds after the first sound was heard.

The first *Jupiter "C"*, an experimental stage-rocket device consisting of a *Redstone* booster and two stages of clustered solid-propellant rockets was fired last September from Patrick AFB, Florida. Reportedly the missile traveled 3,300 miles and reached a peak altitude of between 650 and 680 miles.

A small payload containing a radio transmitter and other instrumentation was supposed to have been tracked "all the way." Reliable sources say the first *Jupiter "C"* could have brought its payload into an orbit if the final stage trajectory had been preset accordingly. Apparently, the final stage of the *Jupiter "C"* brought the payload down in a powered trajectory rather than in a ballistic path.

The *Jupiter "C"* test vehicle was developed by the Army and Jet Propulion Laboratories to study missile staging and separation techniques as well as guidance, telemetering feedback and tracking.

Some sources have hinted that the second *Jupiter "C"* might put its payload into an orbit around the earth when it is fired shortly. The Army is interested in proving that they are capable of supporting any satellite experiment with current Army hardware. The first artificial satellite project undertaken in this country under the code name "Project Orbiter" was to have used the *Redstone* missile as a first-stage booster and a cluster of *Loki* solid-propellant rockets as the second stage. The project was cancelled when the Government announced Project *Vanguard*.

The Army's own satellite tracking system was put on display at the recent National Telemetering Conference in El Paso, Texas as the subject of a display sponsored by Jet Propulsion Laboratory.

Designed by JPL, the tracking system is known as Microlock. Main features claimed are ultra-high sensitivity, light weight and long life.

A transmitter for satellite use is contained in a small cylinder and will radiate a signal for three months and weighs 2 pounds. It provides two narrow band telemetering channels.

Tracking for a distance of 3000 miles using Microlock "at any azimuth or elevation angle" is claimed. Reportedly, JPL's satellite system was used in the altitude and distance record breaking flight of Army's first *Jupiter "C"*. Signals from JPL's electronics on board were received to point of impact.

Production of Microlock systems for Army use as beacons in missile testing is under way at Motorola, Inc.'s Military Electronics Division in Phoenix, Arizona.

USAF Assumes Responsibility For ABMA

HUNTSVILLE, Ala.—The Air Force and the Army may have buried the hatchet in their bitter *Thor-Jupiter* IRBM dispute as the result of the visit here June 19 and 20 of Maj. Gen. Bernard A. Schriever, commander of the USAF's Air Research and Development Command's Ballistic Missile Division.

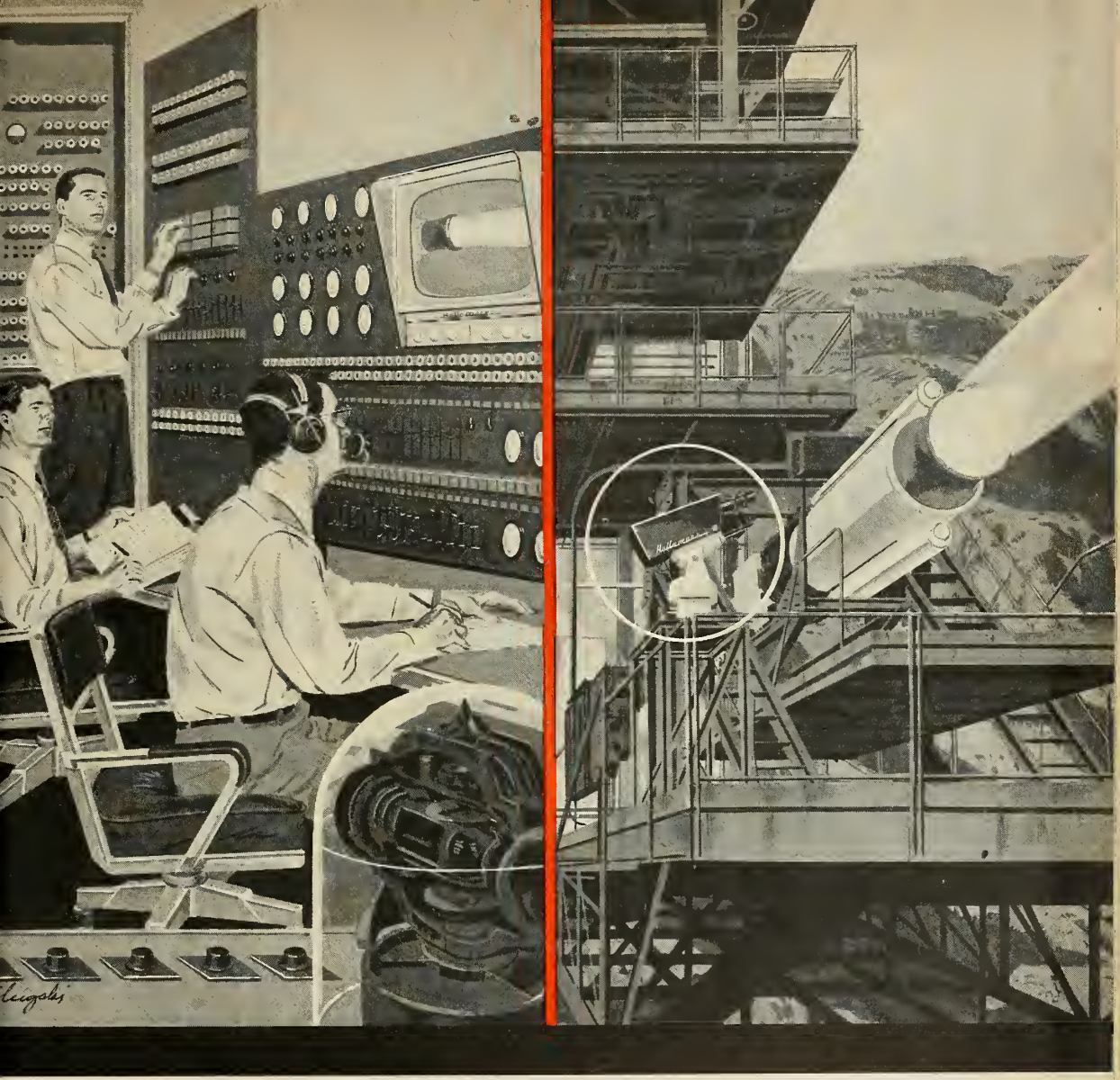
The Air Force assumes financial responsibility for IRBM work at the Army Ballistic Missile Agency as the government's fiscal year of 1958 begins on July 1st.

Schriever and a large staff of USAF missile officers visited with ABMA commander, Maj. Gen. John B. Medaris, toured the complete ABMA and Redstone Arsenal installation, watched the work on the Army's *Jupiter* IRBM and saw test firings. It was Schriever's first visit here.

There has been persistent rumors that USAF officers had previously been denied full briefings on the *Jupiter* by the Army, but this was denied by both services.

A brief communique issued by Schriever and Medaris said:

"There has been a complete interchange of technical information in the IRBM developments between the Army and Air Force commands responsible for them. The sole interest of both services is to provide the best IRBM at the earliest practicable date, in the urgent interest of national defense. It is to achieve this objective that we have committed all the resources in manpower, facilities and funds provided for the purpose. Out of this joint effort will emerge the weapons system determined essential to the security of our country."



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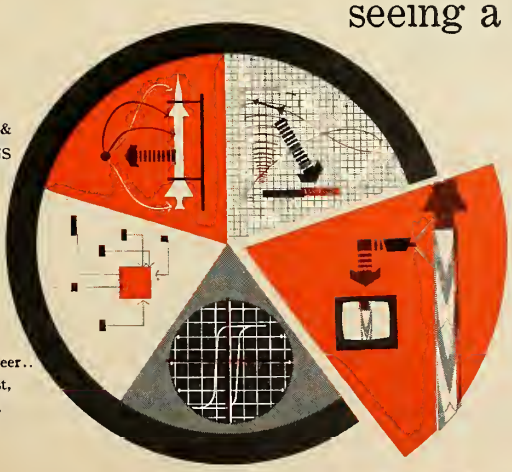

Far too hot, and positively too ear-splitting, for close, on-the-spot observati by human beings...when high thrust propulsion units are fired up for test, Hallamore closed-circuit television takes over the job. Throughout industry similar Hallamore systems are finding application...wherever the requireme is for remote observation or for fast transmission of visual impressions. Hallamore Electronics designs, develops and manufactures missile ground support and in-flight instrumentation systems, magnetic products, electroni components and audio visual communications systems. Current activity includes contracts for the United States armed forces and prime contractors of the aircraft and ordnance industries.

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Second Atlas Ready to Go Next Month?

M/R has learned reliably that the second *Atlas* ICBM is scheduled to be fired at Patrick Air Force Base next month. This is a positive indication that the present state of the *Atlas* development program is proceeding on or ahead of schedule.

Some sources felt that the recent firing was made under pressure in order to expediate the state of the art evaluation of the nation's top priority program. The recent highly publicized misfires of the *Thor* and *Jupiter* IRBMs has led the uninformed press and the public to the conclusion that our long-range missile program is in serious trouble. Scientists and engineers close to the U.S. missile program since its inception shortly after World War II are not alarmed.

Many of this country's missile projects have suffered from growing pains similar to those of the *Atlas*, *Jupiter*, and *Thor*. No informed citizen would have quibbled over the setbacks and costs of the atomic Manhatten Project. Yet, our position in developing the ICBM is the same as with the atom bomb: national survival is at stake. In the latest analysis the first *Atlas* launching was very productive, yielding a wealth of data invaluable to the follow-up flights.

Air Force officials have disclosed that the *Atlas* misfire was due to a malfunction of a propellant turbo-pump. The numerous pre-flight checks and static firings proceeded with only minor difficulties. Testing began the day before the firing and continued throughout the night. Faults in circuitry check out were corrected with minimum delay. Flight program called for test of the two 100,000 lb. thrust booster rocket engines with a calculated range of over 2,000 miles climbing to an altitude of approximately 400 miles.

Engine ignition functioned perfectly and the *Atlas* lifted in vertical ascent with the twin booster engines thrusting equally. At an altitude of approximately 8000 ft. the flow of propellants to one engine was disrupted. The unbalanced thrust resulting from the enequal burning threw the missile into a yaw with a resultant loop. Guidance control responded instantly and corrected the *Atlas* to its vertical attitude. This maneuver was repeated twice more before decision was reached to activate the destructor system. At the time of destruction the missile was earthward bound with a possible impact upon the launching site.

Convair, North American's Rocketdyne Division and General Motors AC spark Plug Division are to be commended for the smooth handling of the preparations and launch of the expediated *Atlas* firing. Investigation of the history of prototype liquid propellant rocket firings uncover a record which clearly pinpoints a high percentage of failures. The probability of failure increases when pressure is exerted upon designers, production and test personnel.

The Air Force has announced that large scale testing of the *Atlas* ICBM will get under way next fall indicating that the 100 ton missile will be rolling out of the Convair plant on a quantity production basis. Additional tests will probably be run on the booster configuration before a three-engined maximum range will undoubtedly be conducted during the tests this fall.

Air Research & Development Command revealed that six specially equipped tracking ships will be stationed in the South Atlantic to fill in gaps extending out along the planned 5000-mile range. The ships will be positioned over the ocean extending from the last Caribbean station on the island of St. Lucia to the station on Ascension Island.

The ARDC statement confirmed the reports that the *Atlas* firing program will proceed on schedule. The launching of the *Atlas* was notification to the world that the ICBM program has come a long way. The coordinated efforts of the Armed Forces and American industry has proved many times in the past that any technological challenge can be met.

AF Officials Check ICBM Engines

Brig. Gen. B. I. Funk, deputy director, Ballistic Missile Office, made his first inspection recently of the new North American Aviation rocket engine factory and test station at Neosho, Mo. He was accompanied by Col. Samuel Bishop, Col. Sherman Ellis and Col. Albert Shumsky, chiefs of procurement, production and logistics in the BMO at Inglewood, Calif. The Air Force officials were briefed on the progress of construction and production at the Missouri facility by C. W. Guy, assistant general manager of Rocketdyne; J. P. McNamara, Neosho plant manager, and E. A. Wright, factory manager.

SAC Officers Briefed On SM-62 *Snark*

A series of four special courses on the *Snark* SM-62 is being given to key officers and civilians from Strategic Air Command units across the country, including the headquarters at Moffett Air Force Base, by Northrop Aircraft's training services section at Hawthorne, Calif. Selected representatives from the Air Training and Air Materiel Commands also are taking the training.

Program is designed to familiarize the group on the overall weapon system, including the missile, ground support equipment, depot operations, field service, mission, planning, publications and training. Instruction is aimed to provide a knowledge of the *Snark* from an administrative standpoint.

Beech Unveils Reconnaissance Drone

Beech Aircraft has taken the lid off its Model 1013 combat reconnaissance drone which is adapted from the company's model 1001, Navy XKDB-1 target plane.

Designed for airplane or ship launch, Model 1013 is powered by a 110-hp McCulloch engine. It grosses 800 lbs, has an operational speed of 260 mph and a service ceiling of 22,-800 ft.

Beech said that first free flights of the XKDB-1 were made recently at the Navy Air Missile Test Center. It is currently undergoing contractor development testing to evaluate performance, radio guidance and recovery characteristics. It is propelled by a 120-hp McCulloch engine, has a speed of 320 mph, ceiling above 40,000 ft. and grosses 600 lbs.

Titanium Price Cut 10% by TMC

Titanium Metals Corp. has announced a 10% cut in the price of titanium products effective June 3 and applicable to a large backlog of orders of aircraft, jet engines, guided missiles, chemical process equipment, electronic and ordnance equipment.

The reduction is an across-the-board average, varying with the product. Commercially-pure sheet and strip are down $1.50 a pound; plate, 50¢ to $1.25 a pound; bar, 95¢ a pound; billets, 85¢ a pound; wire, $1 a pound.

Extrusions are down about 12% or $1.90 a pound. Titanium powder is reduced from $10 to about $8 a pound.

U.S. Army Building 2000-Mile Missile

The Army may not be allowed to use them, but nobody has said catagorically that they can't build them. So Army's going ahead researching and developing a whole family of solid and liquid propellant missiles, ranging from small tactical stuff like *Honest John, Little John* and *Lacrosse* to 300-mile *Redstones* 1650-mile *Jupiters* and 3300-mile *Jupiter-C* test vehicles.

In addition, however, the Army Ballistic Missile Agency at Redstone Arsenal, Huntsville, Ala., is filling some gaps. Reported to be among the gap-fillers are a 2000-mile range Thiokol solid propellant ballistic missile nick-named *Big "B"* (Bee?) and a 750-mile missile possibly called *Little "B"*.

This work is significant in more ways than one. First of all, it's good evidence that the Wernher von Braun team of Army missile-makers hasn't let the furor of the AF-Army missile squabble deter them from the primary task at hand—to make bigger and better missiles and to thus pave the way to space flight.

Secondly, the Army which has traditionally favored liquid propellants for long range missiles, is suddenly turning to solids. This is proof of Redstone Arsenal's acceptance of the progress made in this field in recent months. The advantage of solid propellants for service missiles is obvious. Support equipment required in the way of LOX generators, liquid fuel carriers, etc., is less. There is also possible a greater state of readiness with solid propellants. The problem, of course, is stable storage for long periods.

Both *Little "B"* and *Big "B"* are in the prototype hardware construction stage. All reports indicate they are being developed as weapons rather than as research or test vehicles. Though these programs were probably conceived, approved and given tentative funding prior to the issuance of Defense Secretary Wilson's famous November Memorandum, the fact that the Army is continuing their development implies: First a faith that Army will ultimately be given operational authority to use them; and second, that the Department of Defense is aware of the projects and has okayed them.

It is perhaps ironic that the Army should now be going ahead full blast with the development of solid-propellant long range missiles. It was the alleged Navy reason for withdrawing from the joint Navy-Army *Jupiter* project that the liquid propelled *Jupiter* just wasn't suitable for shipboard operations. A 2000-mile ballistic missile such as *Big "B"* would have greater range than the first-planned models of the Navy's Fleet Ballistic Missile, *Polaris*. First models of this are to have the conventional IRBM range of 1500 nautical miles.

It may well have been the engine for this that a Thiokol spokesman was referring to a short time back when he indicated that his company was working on a solid-propellant motor with a thrust of over 300,000 pounds.

One thing seems certain. If a solid-propellant missile of this nature is forthcoming within the next year it will certainly raise serious doubts as to the feasibility of going into heavy production on the operationally less flexible liquid-propelled *Jupiter* and *Thor*.

H. J. Strickel

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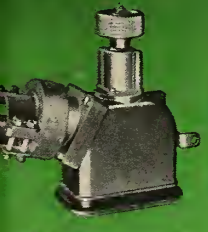

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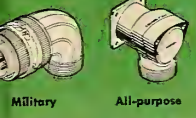

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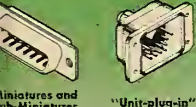

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Cislunar Aspects Checked at ARS Meeting

Utilities to be derived from cislunar operations were described by Krafft A. Ehricke, assistant to the technical director of Convair-Astronautics, in a space flight paper presented before the semi-annual meeting of the American Rocket Society in San Francisco.

These pertain to terrestrial observation, terrestrial communication, arrival from Venus or Mars, interplanetary communication and tracking by obtaining adequate baselines and to cislunar as well as lunar research. Even a vast television show—receivable on home sets—is a prospect.

The three-day gathering was held under the auspices of the northern California section of ARS in conjunction with the 1957 semi-annual meeting of the American Society of Mechanical Engineers, and the dual program attracted a large attendance. Feature events included a dinner at which Rear Adm. W. F. Raborn, director of the special projects office of the Bureau of Ordnance, was the speaker and a luncheon addressed by Dan A. Kimball, president of Aerojet-General Corp.

Missiles will continue to be a subordinate weapon for aircraft carrier task groups during the next 10 to 15 years, Adm. Raborn declared in his talk. Both air-breathing guided missiles and long-range ballistic missiles can play important supporting roles, he said. They can "shock" and largely neutralize the enemy air defenses in any kind of weather, and thus open the way for the attack by carrier-based manned aircraft, he declared.

Aerojet-General hopes to get underwater rockets up to speeds of 300 to 400 mph, with extended range, Kimball reported. He also assured his listeners that "real good progress" is being made on intercontinental missiles.

The effect of lunisolar perturbations on high observational and communications satellites, likely to be located from 3 to 10 Earth radii out, is very small and may be disregarded for most purposes. In the same region, terrestrial perturbation due to the Earth's asphericity is greatly reduced compared to the effect on low-altitude orbits. This transition zone, where the amount of perturbation from either source is particularly small, Ehricke calls a "zone of quiet." In this zone near-circulatory orbits are particularly stable.

If chemical space vehicles are to be used for manned interplanetary mis-

sions, Ehricke propounds the advantages of a captured satellite orbit at about 15 Earth radii out for the return trip from Venus or Mars. Less energy would be required than at closer distance from the Earth. The space craft would remain occupied only for a comparatively brief period of time.

As soon as their final orbit is accurately known on the ground, a relief vehicle would be sent up to transport the interplanetary crew down to earth. Ehricke points out that for vehicles with very high specific impulse, such as ion-powered vehicles and perhaps others, such complications would not be needed.

Farther out in cislunar space, lunisolar perturbation increases, but even at 20 Earth radii is not prohibitive for transponder satellites of what Ehricke calls a "terraluna antenna system" for interplanetary tracking and communication.

Thiokol's Utah Test Facilities Operating

Static test facilities at Thiokol Chemical Corp.'s new Utah Division are operating. Production facilities at the location are slated for completion in the fall.

Five-Stage Rocket Proposed By Truax

The increased use of rocket power plants with as many as five stages may require a look at some fields that were passed over.

Navy Commander Robert C. Truax, president of the American Rocket Society, and currently on special duty with the Ballistic Missile Division of ARDC, told members of the First Helium Symposium sponsored by the Aeronautical Division of Robertshaw-Fulton Controls Co., Anaheim, Calif., that "we cannot continue leaning blindly on tradition."

"We need a new kind of rocket for successful multi-stage rocket development, and we may be required to stop the chain of evolutionary development and take a different tangent," Truax declared.

Latter stages of a rocket power plant are subject to environmental conditions considerably different from those of the initial stages, such as a lack of back pressure, the direction of the gravity vector and the accompanying effect on performance. It was suggested that a re-examination and re-evaluation of optimum chamber philosophies may be the key to simpler and lighter latter stage design.

One suggested solution was a reduction of chamber pressures from what is currently considered optimum for overall rocket design. By reducing these pressures two major gains could be made: a savings in weight and a reduction in heat flux densities.

The reduction of heat flux density requires lighter and simpler construction, permitting use of thinner materials and the possibility of adapting modern welding techniques for ease of fabrication. It may also be possible to eliminate the turbo-pump entirely by using a pressure-fed system and chamber pressures on the order of two atmospheres absolute.

Lower feed pressures will reduce thrust and, as the flow rate decreases, the bulk coolant temperature will rise and tend to boil. Although this has been considered a somewhat undesirable condition, it may be allowable if chamber pressures go down.

"There is no data available to

show we can't, and some recent data shows we can," said Commander Truax.

Described as wet steam, the product of bulk boiling might be difficult to meter and may create a problem in control of mixture ratios, but as it may also flash into vapor during downstream flow, the possibility of utilizing atomization in place of impingement velocity should be considered.

The reduced thrust which would result in a latter stage rocket designed around the possibility of lower chamber pressures, plus the gravity loss increases, would become less important and might be resolved by extending the burning time. If the vehicle can be made smaller, the thrust/weight ratio may become unimportant.

In conclusion, Truax suggested that a program of research and development in boiling heat transfer is needed. He again stressed a scrutiny of optimum chamber pressure valves as an approach to the simplification and weight reduction of latter stage rockets.

Another speaker, William H. Lawrence, chief of the Mechanical Section at Edwards Rocket Base, Calif., told symposium members that "the rocket industry will grow to a large extent on the adequacy of gas component design."

Discussing the subject of "Operational Helium," Lawrence declared that a re-evaluation of philosophy of system operation is seriously needed.

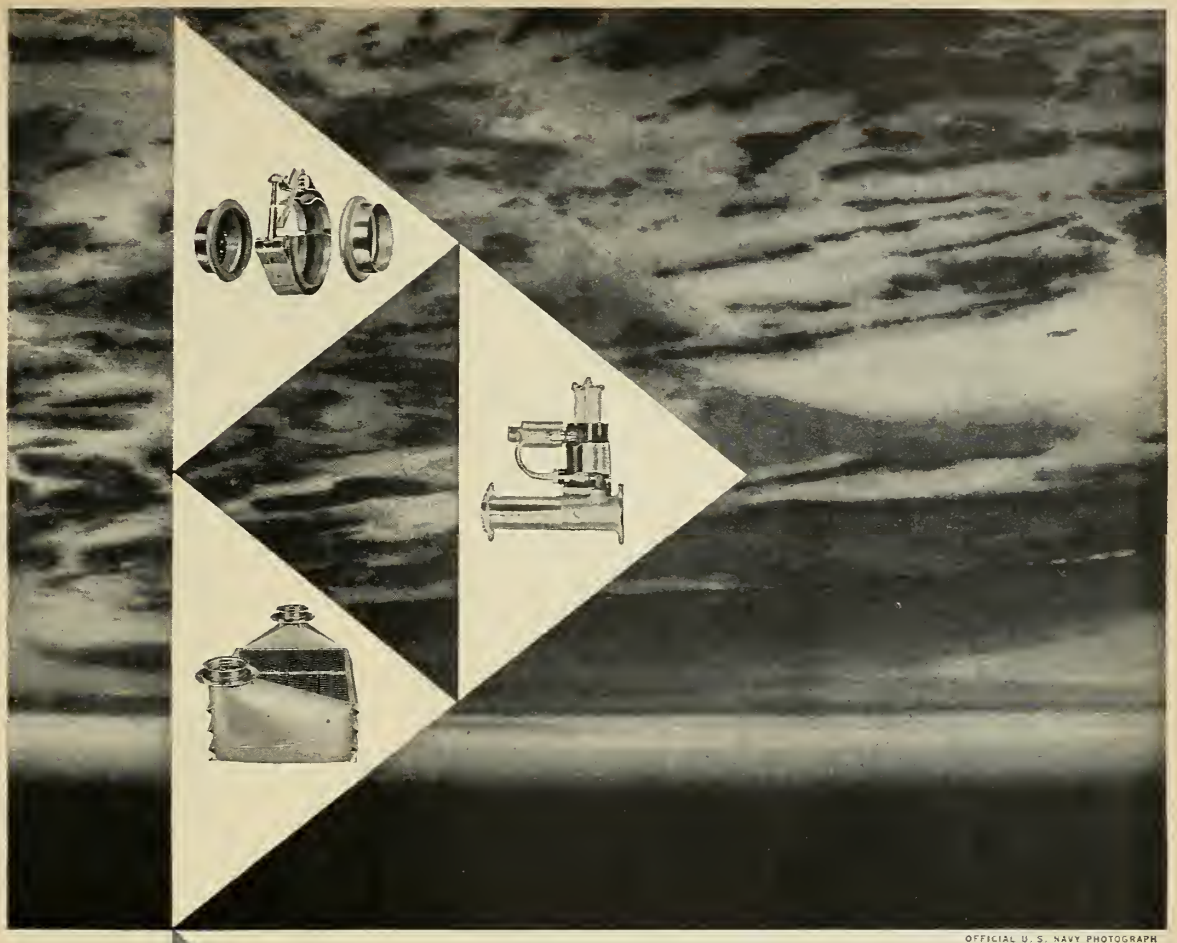
He pointed out an apparent lack of suitable high-pressure relief valves as existing components "either leak or start seeping several hundred pounds prior to relieving," and described the use of burst diaphragms at the Edwards Facility to prevent this.

Lawrence predicted an increase also in the use of liquid helium because of advantages in transporting, storing, and pumping which enable a large-scale user to handle a moderate quantity of the liquid and "do the same job which now requires an all-out effort with 'railcars' of K-bottles."

Firebee Achieves 14-Flight Record

Ryan *Firebee* "Drone 1518" has been parachute recovered 14 times in the desert at Holloman Air Development Center, N. Mex.

The drone, according to Holoman officers, has averaged more than 40 minutes per flight since it went into service Jan. 9, 1956, and has streaked at high subsonic speeds for more than an hour on three of its flights.



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New ICBM Data Telemetry Process

ICBM nose cone data acquired from flight tests are being fed back to General Electric Co.'s engineers 300 times faster than previously possible.

A unique automatic data processing facility installed at the GE Missile and Ordnance Systems department in Philadelphia has just been installed as an aid in the technological race to perfect the ICBM nose cone.

Harry Rosen, manager of the facility, said schedules calling for a maximum of 3-4 days to process 300 types of information telemetered back from a typical nose cone test could not be met by usual data handling methods.

An IBM 704 machine was chosen together with automatic analog and digital conversion machines and switching equipment to do the job. Many of the machines were designed by GE for the purpose.

Tapes containing information from nose cone tests run by various government and industrial organizations is sent to GE. Computations and graphical reports are then made up in record time for GE's 1100 engineers and scientists employed by the Missiles and Ordnance Department.

Autonetics Boosts Film Production

Autonetics division of North American has established a separate motion pictures unit and Jay E. Gordon, formerly supervisor of the motion pictures unit for both the Autonetics and Missile Development divisions has been named supervisor of the unit. He is assisted by Walter V. Hardy, in charge of professional and administrative services, and John D. Rogers, who heads the unit's production and technical services.

Autonetics has more than 30 motion pictures currently scheduled for production this year.

m/r Gets New Editor To Cover Red Missiles

Under its editorial expansion program, m/r is pleased to announce the addition of Dr. Albert Parry to its staff of contributing editors. Dr. Parry is Head of the Department of Russian Studies, Colgate University, Hamilton, N. Y. He will provide m/r readers with constant coverage of missile developments behind the Iron Curtain. Dr. Parry will have a regular column, Behind the Curtain (see page 67), as well as periodic feature and news stories.

U.S. Army is Confident of Future ABMA Role

HUNTSVILLE, Ala.—With the Air Force assuming financial responsibility on July 1st for a considerable part of work on the IRBM at the Army Ballistic Missile Agency here, the Army itself is smarting more from what it considers "blows to its prestige" than from fear of any appreciable cutback in funds or manpower for continued research and development of missiles and rockets of every variety and range.

Most of the top officials concerned, m/r found, were little disturbed by the furor that has resulted from the dispute over the Air Force *Thor* and the Army *Jupiter*, both IRBMs.

That battle is still on and now the Army has challenged the Navy over who can make and fire the best earth satellite. Published reports indicate that to date four *Jupiters* and three *Thors* have been launched. All the *Thors* are reported to have failed. Two of the *Jupiters* are said to have achieved remarkable results, one reaching a distance of 1,650 miles.

The Army has been extremely agile in announcing the results of the *Jupiter* tests. The Air Force has said little or nothing about the *Thor* except that the missile has a "production configuration," presumably with fins.

A fifth *Jupiter* may have been fired by the time this article is in print. The most successful Army missile to date is supposed to be the *Jupiter "C"*. This alphabetical designation, however, does not mean that it was the third to be launched, and this missile is actually a *Redstone* with two additional solid-propellant stage rockets.

If anything, the importance of the Army's role and mission has increased with the development of missiles. It is more powerful and more mobile than ever before in its history. Even with its operational control of missiles limited to those with ranges of 200 miles or less, its zone of operations on a battlefield has been greatly extended over the relatively narrow strips that were its responsibility as forward zones in World War II and Korea.

The *Jupiter* is only one of "between 30 and 50 projects" now under way at Redstone Arsenal and ABMA. These projects are being conducted for and in co-operation with the Army, Navy, Air Force and Marines. Many of them are already programmed for as long as 1962.

Informed estimates on the amount of money still available to Redstone and ABMA from the appropriations of recent years—funds authorized but not expended from as far back as fiscal 1950—are as much as $750 million.

Some of it would have been earmarked for work at other arsenals and by private industry, but the ultimate control would remain with Redstone and ABMA. This is in addition to the funds that Redstone and ABMA will receive for missile and rocket projects from the Army's fiscal 1958 appropriation of about nine billions.

On top of this is the obvious effect on the Army and its contractors of the recent decision to equip NATO allies with missiles. If the established pattern of military aid to Europe is followed, the Army will be asked first to train and equip NATO units with some of the earlier missiles such as the *Corporal, Honest John* and *Nike*, plus smaller ones such as the anti-tank *Dart*, a little five-footer.

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Now, you can provide positive protection and high-heat insulation for metal surfaces with FLAMEMASTIC. For four full years, FLAMEMASTIC has been used exclusively on one of the major production missiles. And it has been applied extensively in other experimental firings of rockets and missiles and on allied test and launching equipment.

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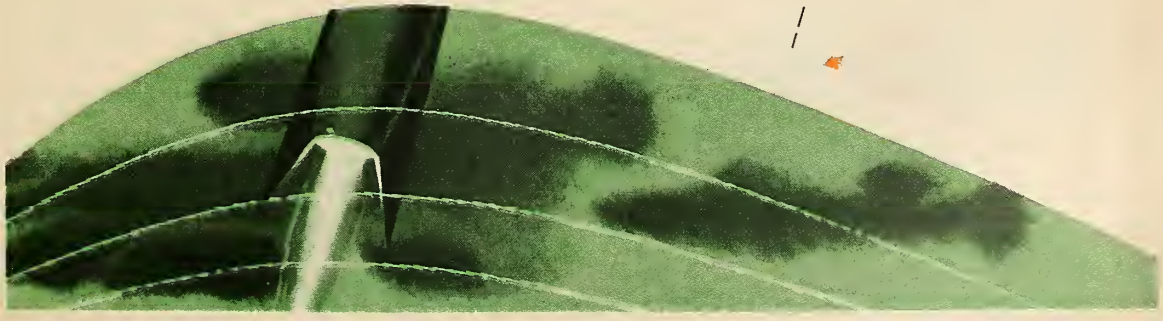

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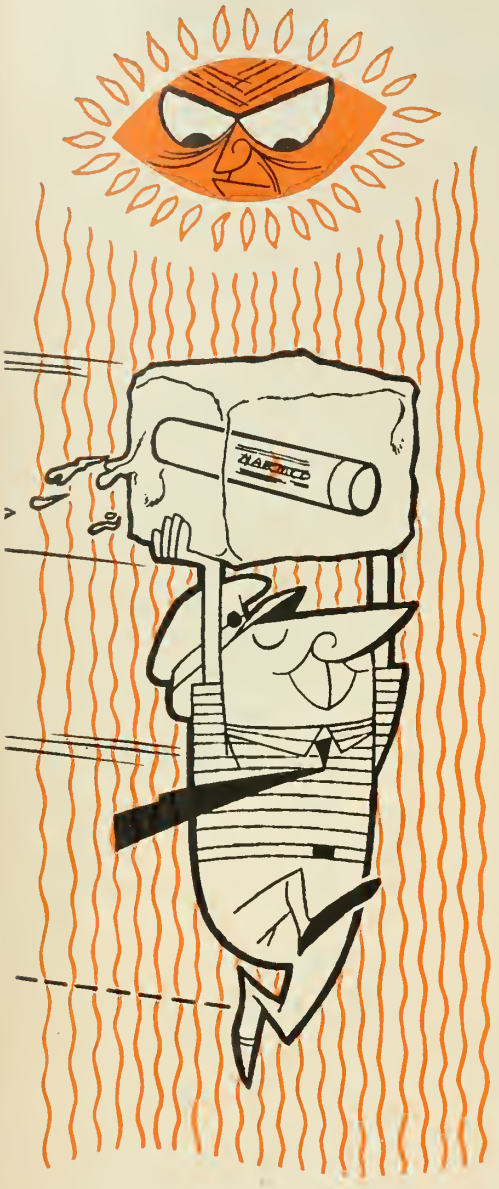

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Narmco's insistance on the ultimate in protective packaging, in controlled shipping conditions, and in informative marking and labeling, zeros in on one of the toughest problems faced by missile and airframe manufacturers... delivery of quality structures and assemblies under budget and on schedule! Receiving needed material on time and in top condition is of key importance in keeping production lines operating at profit-making efficiency. Assurance of consistently high quality after shipment is vital in terms of meeting production schedules. That is why Narmco strictly enforces protective packaging and controlled shipping requirements.

Attention to such "important trifles" is another reason for Narmco's leadership in structural adhesives and laminating materials... another reason why more and more Narmco products are being used by an ever greater number of airframe and missile manufacturers... *doing jobs every day that metals alone can't do!*

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Floating Telemetry Bases for AF Test Range

Floating telemetry bases will be used to fill the gap that now exists in the Air Force's missile test range between St. Lucia and Ascension.

Six Liberty ships have been demothballed at Oakland, Calif. and telemetering equipment has been installed by the Ralph M. Parsons Co., Pasadena, Calif. Operation of the fleet will be under direction of the Guided Missiles Range Division, Pan American World Airways. Operation will begin later this year.

Electronic equipment on board will be operated by the Radio Corporation of America, subcontractor to Pan American. A special area in the ships is designed to provide controlled ambient atmospheric conditions to insure accuracy of recorded data acquired by helical telemetry antennas mounted on the bridge of each ship. Data will be transmitted from the ships to Cape Canaveral, Fla. where the AF range control station is located.

The ships will be capable of operation for three week periods before returning to their bases in South America. The work of the "ocean range vessels," as they are called, will be supplemented in 1958 by five larger vessels that will be used to record missile impact data.

Temco Predicts Sales of $127 Million

Temco Aircraft Corp.'s president Robert McCullough has predicted that his company will do $127 million in business this year, compared to $90 million in 1956.

He said that the company's Garland plant will have 3,000 employees by early 1958. Its payroll will reach $7.5 million this year, compared to a little over $6 million last year. McCullough hinted that Temco's operation in Grand Prairie eventually may be moved to Garland where the company is building a $2 million engineering and office building on its 400-acre site.

The Garland plant is working on the Navy *Corvus* missile.

A. C. Sparkplug Gets Missile Facility Funds

A. C. Sparkplug Division of General Motors has received a $3,340,000 contract from Air Materiel Command for ballistic missile facilities. The company is working on guidance for *Thor* IRBM.

New Way to Make Titanium Tetrachloride

Scientists at Armour Research Foundation of Illinois Institute of Technology have developed a way to make titanium tetrachloride at temperatures much lower than required for the present method—with a higher purity and at less cost.

The compound is necessary in the manufacture of titanium.

The new process opens the way for use of low grade ores, such as ilmenite, in titanium manufacture, according to Clark E. Thorp, manager of the Foundation's chemistry and chemical engineering department.

The process starts with a "cold chlorination" of ilmenite ore at freezing temperatures, where the conventional process requires very high temperatures to chlorinate a high grade ore (rutile).

Key reaction is the precipitation of potassium chlorotitanate from ilmenite solution and the decomposition of the precipitate into titanium tetrachloride and potassium chloride at candle flame temperatures.

Thorp said it will take some time to develop the process fully. Patents have been applied for, and the Foundation is offering the process to industrial sponsors for further development.

Aerojet-General Has Private Stock Sale

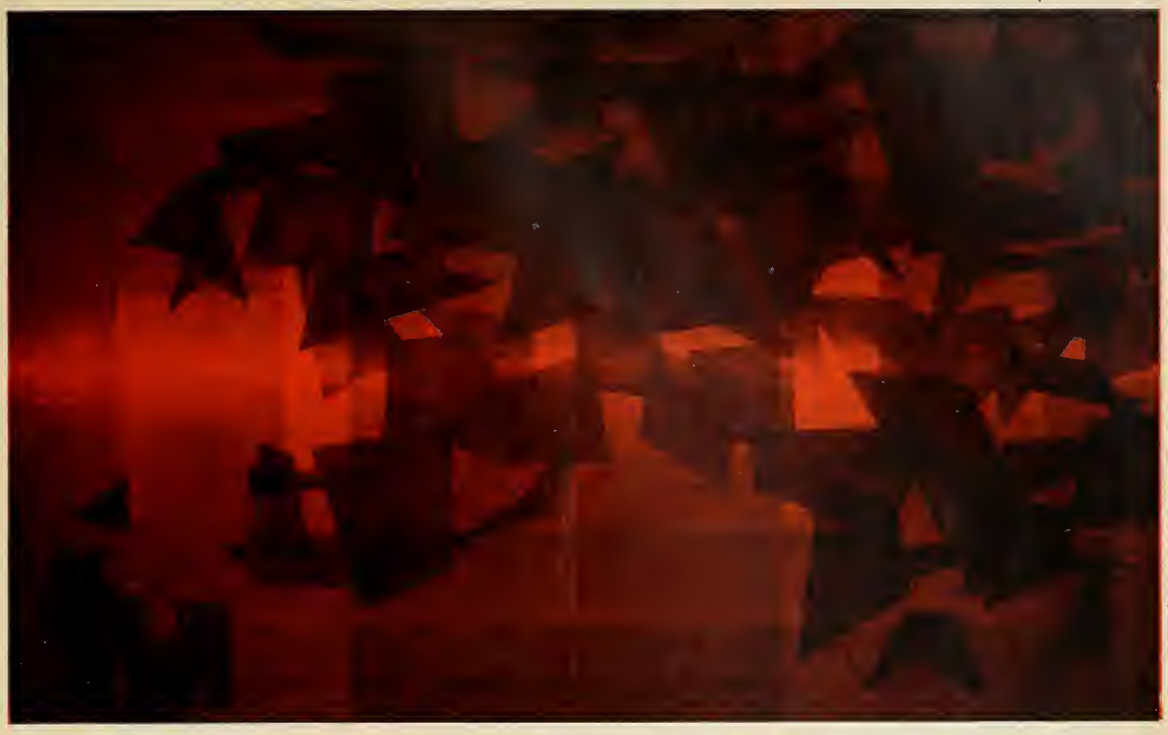
Private placement of 33,500 shares at $225 per share of common stock of Aerojet-General Corp. and promise of a 10-to-1 split before year's end has been announced by William O'Neil, president of General Tire & Rubber Co., chief stockholder.

The sale was negotiated by Kidder, Peabody & Co., Inc., and Auchincloss, Parker and Redpath, and leaves General Tire's ownership at 87.6%. Proceeds will be added to working capital.

O'Neil said the placement agreement included assurance that General Tire would not consent to conversion of outstanding Aerojet-General preferred into common stock and that General Tire would vote for a split in Aerojet-General's common on at least a 10-1 basis within a year.

Aerojet Gets Contract for Engines, JATO's

Aerojet-General has received a $1,948,924 contract for 1.8KS-7800 rocket engines and $723,232 for JATO's and igniters, according to the Department of Commerce.



"ECLIPSE" a recent painting by Simpson-Middleman, gifted artistic interpreters of the physical sciences. About this new expression they write: "'Eclipse' was painted as a result of watching an actual eclipse of the sun. We were particularly struck with the curious light that was both dim and glowing and the unusual pattern of the shadows on the leaves of the trees around us. We had never seen anything like it before." Painting courtesy of John Heller Gallery, Inc.

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Drop a note now to: John C. Sanders, Engineering Personnel Administrator, Boeing Airplane Company, Department R-65, Seattle 24, Washington.

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EEMCO AC and DC Motors

have been chosen for use in the majority of our latest aerial weapons.

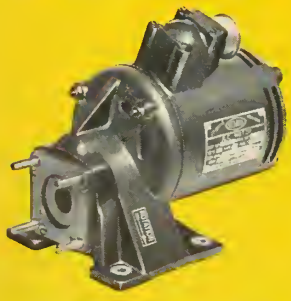
Type: C-1874 400 cycle 3 phase AC Motor and Clutch. **Weight:** 4.5 lbs. **Voltage:** 200 volts. **Output:** 650 watts. **Intermittent duty:** 12,000 rpm. **Meets Military Specification** MIL-M-7969A (ASG).

Type: D-638 400 cycle AC Motor. **Weight:** 17.5 lbs. **Voltage:** 200 AC, 20 amps at 6.5 hp. **Duty cycle:** 3.0 seconds at 6.5 hp, 15.0 seconds at 1.5 hp. **Maximum capacity:** 6.5 hp. **Continuous rating:** 5 hp at 2300 rpm, 15.8 amps, 200 volts. **Meets Military Spec.** MIL-M-7969A (ASG).

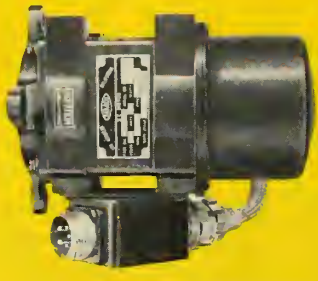
Over the years the precision, ruggedness and reliability of EEMCO products has been proven time and time again. The consistent, exceptional performance of these low-weight, high-output motors, a few of which are illustrated, has earned EEMCO industry-wide recognition. In this highly specialized field, where perfection is imperative, the widespread use of EEMCO motors and of EEMCO's equally reliable actuators is eloquent testimony.

Type: D-751 DC Motor. **Weight:** 20 lbs. **Duty Cycle:** 5.2 hp at 2100 rpm (intermittent) on 26 volts DC; 3.5 hp at 2200 rpm (continuous) on 26 volts DC. **Meets Military Specification** MIL-M-8609.

Type: D-800 400 cycle 3 phase AC Motor. **Weight:** 8.75 lbs. **Voltage:** 208 volts. **Horsepower:** 2.5 hp. **Continuous Duty:** 11,300 rpm; Equipped with thermal protector. **Meets Military Specification** MIL-M-7969A (ASG).



Type: D-899 400 cycle 3 phase AC Motor. **Weight:** 11.25 lbs. **Volts:** 200 volts. **Load:** 2.75 hp continuous output. **RPM:** 3140 rpm output at gear box. **Power factor:** 83%. **Overall efficiency:** 76% for entire unit. **Meets Military Specification** MIL-M-7969A (ASG).



Type: D-932 DC Motor. **Weight:** With radio noise filter—13 lbs., without same—12.4 lbs. **Terminal voltage:** 27.5 DC plus or minus 1.5 volts. **Load:** From .5 hp minimum to 2.6 hp maximum. **Speed:** Continuous at 12,000 rpm, plus or minus .005%. **Speed Control:** By frequency regulator supplying control field. **Meets Military Specification** MIL-M-8609 (ASG).

Type: D-927 DC Motor. **Weight:** 7.25 lbs. with 2-circuit noise filter for ungrounded systems. **Weight of filter:** 1 lb. **Terminal voltage:** 27 volts, 18 amps. **Load:** 0.5 hp. **Speed:** Continuous at 9900 rpm. **Meets Military Specification** MIL-8609.

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INTERNATIONAL NEWS

By Anthony Vandyk

Bloodhound is Mainstay of British Air Defense

New details have been released about the Bristol/Ferranti *Bloodhound* surface-to-air missile system. *Bloodhound* will be the mainstay of the automatic system which will progressively take over the defense of the UK from the manned fighters.

Bloodhound is a semi-active homing missile (guided by a radar beam projected at the target, and reflected back to receiving equipment in the missile itself). As a hostile aircraft approaches, its position is plotted and followed by radars. Coordinates of this position are fed automatically to a second ground radar unit and the missile launchers move automatically to bear on the target. As soon as the echo from the target indicates by its strength that the target is within range, a green light flashes in front of the launch controller who has only to press the firing button to send *Bloodhound* roaring into the sky. From that moment the hostile aircraft has failed in its mission—no amount of evasive action by the target can shake *Bloodhound* off the scent, Bristol states.

Reflections of the illuminating radar beam from the target are received by *Bloodhound*. In this way, the target illuminating beam enables the missile to "see" the target in much the same way as a searchlight would enable it to be seen by the eye. During flight, the missile senses the direction from which the illuminating beam is being reflected and automatically turns towards the position of the target. Any evasive action the target may make is automatically followed and appropriate signals from the guidance received to the missile control surfaces continuously correct the heading of *Bloodhound* relative to the target.

The *Seaslug*, the first guided surface-to-air missile for the Royal Navy, is a medium-range weapon, it has been officially announced in England. It is a rocket-propellant missile, with rectangular cruciform wings and tail guidance blades, launched by four wrap-around solid propellant boosters mounted on the forebody. Triple launching ramps, with automatic loading from magazines below decks, are used so that personnel are not exposed.

Targets are initially detected and tracked by long-range radar. Feed-in of target range, bearing, height and speed information is computed to position launching ramp and indicate firing time. The system is fully compensated for ship's roll. The missile apparently has fully active homing.

Firings of the *Seaslug* have taken place at Woomera, Australia and at Aberporth, Wales, from the Clausen rolling platform which simulates a ship's motion. Since July 1956 sea firing programs have been undertaken in HMS Girdle Ness, the Royal Navy's first all-missile ship.

While the missile designed was coordinated by Sir W. G. Armstrong Whitworth Aircraft, the launching ramp, magazine gear, radar and associated weapon direction and control equipment were developed by the Navy. Contractors "intimately connected" with the weapon system were: the General Electric Co. Ltd. (guidance), Sperry Gyroscope Co. Ltd. (autopilot), John Thompson Conveyor Co. Ltd., Sir George Godfrey and Partners, Vickers-Armstrongs Ltd., Metropolitan Vickers Ltd., McMichael Radio Ltd., E.M.I. Engineering Development Ltd., and Imperial Chemical Industries.

Japan Shows Interest in Satellite Tracking

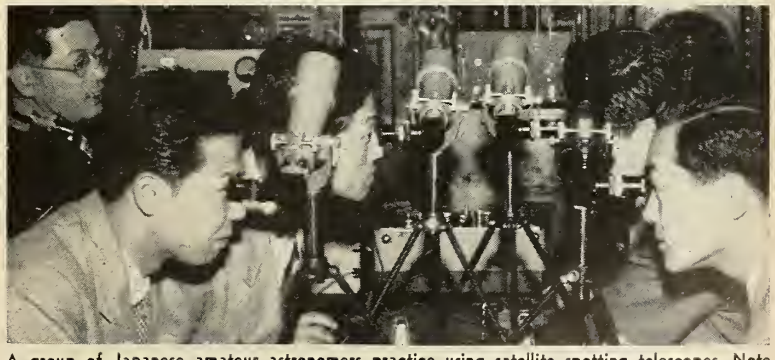
Japan seems more enthusiastic and excited by the forthcoming satellite launchings than any other nation, not excluding the U.S.

Japanese interest in rockets and astronautics was described in this magazine earlier (October and November, 1956). But the desire to participate in the U.S. satellite tracking program is greater than that shown by any other nations within the 40° North and South parallels. The extent of this popular interest is shown by the number of volunteer satellite observing teams.

Dr. Masai Miyadji, Director of the University of Tokyo Observatory, was picked by the Japanese National Committee, IGY, as coordinator for satellite tracking. This action was taken last October by the Japanese Science Council following the CSAGI meeting at Barcelona. Miyadji, an astronomer, is currently completing a six-week visit to the Smithsonian Astrophysical Observatory at Cambridge, Mass., center of optical tracking programs.

Dr. Miyadji's particular specialty is "time and space." While in the U.S. he will study optical and radio tracking.

A modified Schmidt camera, crys-



A group of Japanese amateur astronomers practice using satellite spotting telescopes. Note individual time signal keys, radio time signal receiver, and tape recorder. In background, not shown, is projection screen for use in simulating satellite motion of 1/5 to 1 degree per second. Students are members of Japanese Astronomical Study Association and are training for Japanese Moonwatch program. Photo was taken at the Science Museum in Tokyo.

Engineering representatives will be happy to discuss your design problems when you visit them at Booth 159, Air Power Panorama, Washington, D. C. July 31-Aug. 3; Booth 2412, WESCON Show, San Francisco, August 20-24.

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CABLE SPECIFICATIONS

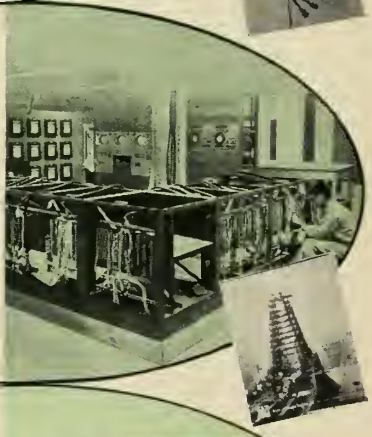
"Design Engineering Specification" Bulletin No. PAP-C-101. Comprehensive 19-page engineering manual describing materials, construction, design criteria, specification conformance, performance, identification, documentation and other important features determining correct cable for your specific application.

CABLE AS A COMPONENT

"Electronic Cable as a Systems Component" Bulletin No. 656. Generously illustrated pamphlet describes design and production of electronic cable in bulk and assemblies. Connectors and hardware; cable break-outs; environmental requirements; voltage rating, testing; cable procurement data – are some of the subjects covered in this bulletin.

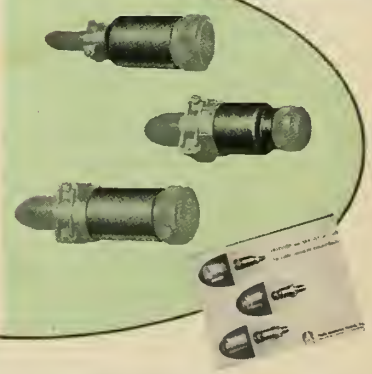
CABLE SYSTEMS

"Engineered Cable Systems" Bulletin 357. Illustrated brochure describing Pacific Automation Products' pioneering in the use of the Systems Concept to coordinate cable design with the development of complex electronic systems. Liaison engineering teams cooperating with systems design groups establish cable as integral part of system, supervising cable construction concurrently with development of other elements.



CABLE ACCESSORIES

"Extension and Adapter Sleeves for Cable/Connector Compatibility" Bulletin 257. Illustrated bulletin on aluminum adapters designed and manufactured by Pacific Automation Products, which for the first time provide a means of attaching any size AN connector to any size cable, with assured reliability.



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tal clock timer and associated equipment will be provided by the U.S., and installed at the Tokyo Observatory by January 1958. The station will be one of the 12 official U.S. stations. The Japanese Science Council and Tokyo University will cooperate in station management and operation.

In addition volunteer observing teams are being readied under the Moonwatch program. Twenty-five of these teams have already been officially approved and 5-10 more are in the process of organization. Dr. Miyadji is assisted by a committee of three: Professor Hirose, Mr. Torao, and Mr. Iijima, all of the Tokyo Observatory.

It was learned that the three major astronomical and two rocket societies have pledged support: Japanese Astronomical Society (Tokyo), Oriental Astronomical Society (Kyoto), Japan Astronomical Study Association (Yokahama), Japanese Astronautical Society (Tokyo) and the Japanese Rocket Society (Tokyo).

Total membership of these societies is about 3000.

Science departments of high schools are organizing observing teams under the leadership of Mitsuo Harada, science writer and president of the Japanese Astronautical Society. Whether or not these teams receive accreditation as official observers, they will be encouraged by the Science Council because of the scientific interest and training of students which will result. Each team is headed by a responsible accredited astronomer.

Three major newspaper chains, Yomiuri Press, Asahi Press and Mainichi Press, have agreed to pick up the tab for spotting equipment needs. A Japanese optical firm has designed high-quality monocular 'scopes at a cost of about $40 each.

Sweden to Employ Anti-Tank Missile

Sweden's Guided Weapons Bureau now has a staff of about 250, General C. A. Ehrensvard, Commanding General of the Swedish Army, has disclosed. Discussing details of the Army's guided weapons procurement program, he said that nuclear weapons supplement other weapons but do not replace them. The first missile to be introduced on a large scale among the Swedish defense forces will be an anti-tank missile.

This is likely to be the French wire-guided *Nord* missile in its improved SS-11 version. If tests with the missile are successful the Army will acquire the *Nord* SS-11 in sufficent quantities for its war organization.

World Astronautics

By Frederick C. Durant III

Arrangements may now be made for attendance at the Eighth Annual Congress of the International Astronautical Federation (IAF). The meetings will be held at Barcelona, Spain, October 7-12. The Spanish host society is the Agrupacion Astronautica Espanola.

The Thomas Cook & Sons tourist agency has been designated as official agent for hotel reservations for the congress. Block bookings in all classes of Barcelona hotels have been made. Check with the nearest office of Thomas Cook & Sons which has branches in all major U.S. cities, or with the Barcelona office, address:

Wagon Lits Cook, Paseo de Garcia, 8-10, Barcelona, Spain.

All meetings will be held at The National Center for Scientific Research, Barcelona, with one exception; the initial meeting of the IAF Council on Sunday, 6 October.

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A. V. Cleaver, British rocket expert of Rolls Royce, Ltd., has authored an interesting two-part article in "Flight" recently. Cleaver, a past chairman of The British Interplanetary Society, compares the predictions of early aircraft builders and scientists (circa 1900-1930) concerning future developments in aviation. They underestimated by a wide margin the rate of advance and extent of future aeronautical progress.

Cleaver draws an interesting parallel between the progress in rocket technology of today and realization of space flight tomorrow. One error made by the pundits of a few decades ago was in not recognizing the cumulative effect of many individual technical improvements upon future aircraft performance. It is possible that the same error in synergism may be made in today's predictions of the rate of achieveing manned space flight. Furthermore, the exponential rate of technological growth of the past decades may be expected to produce breakthroughs of completely new techniques and developments that are today unidentified. The import: astronautical developments possibly much sooner and on a greater scale than now anticipated.

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A symposium on "High Altitude and Satellite Rockets" to be held 18-20 July at Cranfield, England, is being organized jointly by The British Interplanetary Society, Royal Aeronautical Society and the College of Aeronautics. This top-level meeting and exhibition is the first such affair to be held in Great Britain. The program resembles the pattern of the week-long course, in "Orbital Vehicles and Satellite Flight" held at MIT last summer.

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Nearly 200,000 visitors were attracted to the U.S. rocket exhibition in Frankfurt recently. A similarly large attendance occurred at Stuttgart. Entitled "Space Unlimited" these shows stress the peaceful application of rocket power. Much good will has resulted. A film, titled "Adventure in Space Flight" has been produced by the U.S. Information Service. It features unclassified films of *Aerobee, Viking, Nike* and American V-2 research. There is strong interest in more of the same. The USSR Embassy at Bonn is countering with releases of information on Russian space medical research using dogs in sounding rocket flights.

Behind the Curtain

By Dr. Albert Parry

Soviet scientists plan to use rockets in their ambitious scheme to radically change the night lighting of Soviet cities. Clouds of luminous gas in the ionosphere are to be utilized for such lighting. The procedure will be as follows: As twilight falls, rockets will be employed to throw into the ionosphere a catalytic agent which will cause atoms of oxygen to form into molecules. It will be in the process of this formation that the needed light will be produced for Soviet streets.

Russian savants are not saying, however, just how soon this revolutionary change in their municipal mode of life will be brought about.

To the question, "When will the Soviets send up their first earth satellite?", Moscow replies rather vaguely: "In the next few months." But a much more exact date is the educated guess of an émigré Russian now living in the U.S. He is V. Nekrasov, an elderly artillery expert sent to this country by the tsarist government during World War I as a staff member of the tsar's commission to buy munitions for the Russian army. Interested in rocket propulsion since his young manhood, and well acquainted with the life and work of Constantin Tsiolkovsky, Russia's pioneer rocket theoretician and inventor, Nekrasov now says:

"September 17, 1957 will mark the one hundredth anniversary of Tsiolkovsky's birth. Quite some time ago the Soviet government announced that it would celebrate the date in a most fitting manner. But since that announcement not a further word has been said by Moscow's officials about the celebration. We can explain this silence by one reason only: the Soviet government is preparing to spring a surprise on the world—it will celebrate the Tsiolkovsky Centennial by firing the Soviets' artificial satellite into space on September 17 of this year."

Through its Czechoslovak Press Agency, the Prague government indignantly denies the recent reports appearing in West European newspapers, particularly those in Austria and West Germany, that the Soviet armed forces have established guided-missile launching sites on Czechoslovak territory. Declares the Czechoslovak government:

"No such bases exist in Czechoslovakia. It is obvious that the circulation of such false reports is a transparent propaganda maneuver intended to divert the attention of the public from the fact that the U.S. has for some time been equipping its military bases in the German Federal Republic with atomic weapons with the approval of the West German Government, and at the present time the Government of the German Federal Republic is rapidly moving towards the equipment of its forces with atomic weapons. Inventions of this type cannot, however, either hide the actual preparations for atomic war on the territory of West Germany or disperse the fears of the German people of the catastrophic results of such a policy, which were so emphatically expressed recently by leading West German atomic scientists."

The Red verbiage aside, this official Prague statement shows clearly that the Czech Communists and their Soviet Russian bosses are sufficiently worried by the reports of their East European guided-missile launching sites to take this trouble of denying the reports.

Photonic Propulsion Discussed By Reds

In *Komsomolskaya Pravda* for June 9, Moscow's Professor K. P. Stanyukovich discusses the "photonic rocket, the mightiest theoretically possible jet motor." He writes:

"You know that in most recent years scientists have discovered the existence of so-called anti-particles, that is to say 'matters in reverse.' They have succeeded in creating some of these artificially.

"Right after being 'born,' having existed but a most insignificant portion of a second, they immediately vanish. They vanish when they run into a particle analogous to themselves. But a tremendous amount of energy comes out of this, hundreds of times more than even at a hydrogen-helium nuclear reaction.

"It is quite possible to imagine that this emergence of energy would come not as an explosion but as a relatively stable process.

"It is probable that, as a basis of an interplanetary ship, man will then use one of the satellites of either Saturn or Jupiter, or perhaps some or other large asteroid. Man will bring to it the needed quantity of anti-matters, will install there a gigantic motor, and one beautiful day this celestial body will leave its age-old path in the solar system and will hurl itself into the black abyss of the Universe.

"Of course, both the 'combustion chambers' and the 'jet' of this motor will not at all resemble what we know today of motors. Most likely these will be annular magnetic fields which will organize streams of matter and of photons. The jet stream, or more exactly the jet ray of the interplanetary ship, will be of such intensity that even at a distance of millions of kilometers it will burn everything living—in case this ray falls upon the earth. Precisely for this reason, man will place the cosmodrome for this interplanetary flight so far away from the earth.

"Should it 'burn' in its motor 90 per cent of its mass, or the first stage of the rocket, so to say, our ship will fly from 250 to 280 thousand kilometers per second. Therefore, most likely, man on the earth will lose all touch with this interplanetary reconnoiterer.

"Some 10 or 15 years will pass, and then, in the black abysses of Cosmos, a star will emerge, coming toward us with a fantastic speed. It will shine forth with its ray of energetics, facing the solar system, as if it were the ray of a searchlight. The first navigators of stars will thus turn their photonic motor on, in order to brake their flight.

Professor Stanyukovich concludes by admitting that even the twenty-first century may not see this dream come true. But he insists that scientifically all this is quite plausible.

RCAF Orders *Firebees* For Training Troops

Ryan Aeronautical Co.'s *Firebee* jet target drone will be used by the Royal Canadian Air Force for anti-aircraft training of its defense forces. Canada ordered a number of the drones following a 10-day conference recently with Ryan officials.

What a wonderful location for a missile plant! This is Sud-Aviation's missile factory at La Bocca, on the shores of the blue Mediterranean near Cannes. The plant occupies an area of 15,600 sq. yds. and has a labor force of 380. Equipment includes 160 machine tools. Main activity of the French facility is the design and construction of missiles up to the pre-production stage.

Rocket Trends

by Erik Bergaust

AIR FORCE MISSILE MEN have discovered the solid propellant trend. Reportedly the Ramo-Wooldridge organization has presented a comprehensive report on solids to ARDC's Ballistic Missile Division. Some sources say the report indicates feasibility of solid-propellant ICBMs and that Gen. Ben Schriever is interested . . . Aerojet and Thiokol representatives have hinted it is possible to build a solid-propellant moon rocket. "If we can build a solid moon rocket, we can also build a solid ICBM," one industry spokesman said.

AIR FORCE AND CONVAIR were pleased with the first *Atlas* firing. The *Atlas* design concept proved to be sound. In particular, Convair *Atlas* designers were satisfied their thin-skinned pressurized hull proved satisfactory. First firing was perfect from first moment of ground check-out and countdown. Missile took off beautifully and a maze of information was telemetered back to Patrick. Fuel feed malfunction is considered minor problem, and stepped-up *Atlas* test program is underway.

AIR MATERIEL COMMAND's Maj. Gen. Baker sees a 500% increase in the next few years in missile spending; a 100% increase in military electronics and a 50% decline for manned aircraft; 40% down for turbojet engines. AF military hardware spending to hold at $7 billion with a $600 million per year R&D account. Missiles are to go from $500 million per year to $2.8 billion; aircraft to drop from $4 billion now to less than $2 billion. Electronics up from $750 million to $1.3 billion plus . . . "Money will be flowing to industry through a much more limited number of channels . . . neither R&D nor procurement can continue to support losers . . ."

AIR FORCE OFFICE OF SCIENTIFIC RESEARCH reports of high velocity and high temperature effects being investigated in a "variety of ways" under auspices of AFOSR's Physics Directorate. AFOSR's "Research Briefs" mentions some of the methods developed under AFOSR sponsorship, for example, light gas guns and electromagetic accelerators which drive pellets of 1 to 5 grams at velocities up to 33,000 feet per second. This work is being done at the University of Utah. Electronic accelerators being developed at Armour Research Foundation and at Utah should deliver even more reproducible results. These institutions are attempting to attain velocities approximating the cratering effects of meteoric dust particles hitting against metallic surfaces used for missiles and satellites, with velocities from 25,000 to 100,000 feet per second expected.

AIR FORCE AND ARMY MISSILE FEUD should possibly be considered in light of the fact that in Russia all medium-range and long-range missiles are under jurisdiction of the Red Army. Recently, several Soviet generals and marshals artillery have been permitted publicly to state that (in Col. Gen. Fomin's words in November, 1956) "long-range rocket weapons of intermediate and strategic types . . . constitute a form of artillery. Now artillery can be employed . . . also far beyond the limits of the tactical zone of operations of the ground forces." Col. Gen. Samsonov similarly spoke of long-range rockets as "a variant of rocket-firing guns. Thus we witness a new qualitative leap in the development of artillery."

LADIES ARE NOT PERMITTED to wear shorts in the Officers Club at Patrick AFB! Military personnel may wear civilian clothing off-duty at AFMTC installations, and although the Air Force admits "informality is the keynote to civilian clothing worn in Central Florida," ladies can't wear shorts in public places such as base exchange, commissary, bank, etc. "Base regulations should be consulted on civilian attire permitted for men and women at the Officers Club and other public places on the base," AF advices.

Washington Spotlight

By Henry T. Simmons

The U.S. will come under increasing pressure from its NATO allies during the next few years for shipments of guided missiles in addition to manned aircraft. A top Greek Air Force general told visiting U.S. newsmen in Athens last month: "Within the next five years, we must have some surface-to-surface and surface-to-air missiles. Without these new weapons we will not have the proper power to carry out our missions."

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So far, only England has officially requested U.S. missile assistance. Other NATO nations like Greece and Turkey apparently lack fundamental information on important categories of missiles, particularly air-to-air. Neither the Greeks nor the Turks have conducted a formal study of their own missile requirements, and it is doubtful whether they can take even this first step without substantial American help.

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Practice firings of the *Matador* surface-to-surface missile at the Air Force's 200-mile missile range in the Libyan Desert are a big event for several nomadic tribes of Arabs in the area. They are alerted when the weapons land, there is an immediate race by the tribesmen to capture the junk and sell it as scrap. For some years after World War II the export of shattered tanks and other equipment was a major industry for the Libyans.

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The Army is pondering the possible joint use of the USAF missile range in Libya for training exercises of its own units stationed in Europe. The Army now has *Honest John* and *Corporal* surface-to-surface weapons in the European theater and could profitably use the African firing range established by the Air Force. Its need for a long range will be particularly acute when *Redstone* units are assigned to Europe.

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The Air Force has revealed some surprising personnel figures for its first guided missile wing, the *Matador*-equipped 701st Tactical Missile Wing stationed in Europe. The wing has a grand total of 2,881 officers and men who operate or support 18 *Matador* missile launchers. This is almost the number of men required by a wing of strategic bombers; it suggests that the age of push-button warfare may not be as economical in manpower as initially presumed.

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Missile strength of the U.S. Navy's Sixth Fleet in the Mediterranean was at a low ebb in June, but will increase substantially when new fleet units arrive this month. Only missile deployed in the Fleet last month was the infra-red *Sidewinder* air-to-air missile, carried by McDonnell F3H-2N and North American FJ3-M fighters. This month the Fleet expects the carriers *Randolph* and *Franklin D. Roosevelt*, which should have all-weather F3H-2N *Demons* equipped with *Sparrow III* missiles. *Randolph* may also have a *Regulus* surface-to-surface missile capability. In addition, *Terrier* anti-aircraft missiles will return to the "Med" this month with the arrival of the cruiser *Canberra*.

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The Army will begin to ship *Nike Ajax* guided missiles to its units in Europe before the end of the year. First unit to get the weapons will be the 32nd Anti-Aircraft Artillery Brigade, transferred from England last month to positions west of the Rhine. The 32nd is now equipped with 75 mm Skysweeper and 90 mm cannons, but will be re-equipped with the *Nikes* for defense of the vast Army supply depots in the Kaiserslautern area. Later the 32nd will get the improved *Nike Hercules*, and its defense responsibility will be extended to include USAF airdromes in Europe and other key targets.

Don Walter, B.S. M.S., achieved an outstanding academic record at Cal Tech, Class of '40, while earning seven varsity letters. Today as Vice President in charge of Engineering and Van Nuys Operations, Don utilizes his technical and teamwork background to lead Marquardt's engineering and development manufacturing. He is an example and exponent of Marquardt's management philosophy.

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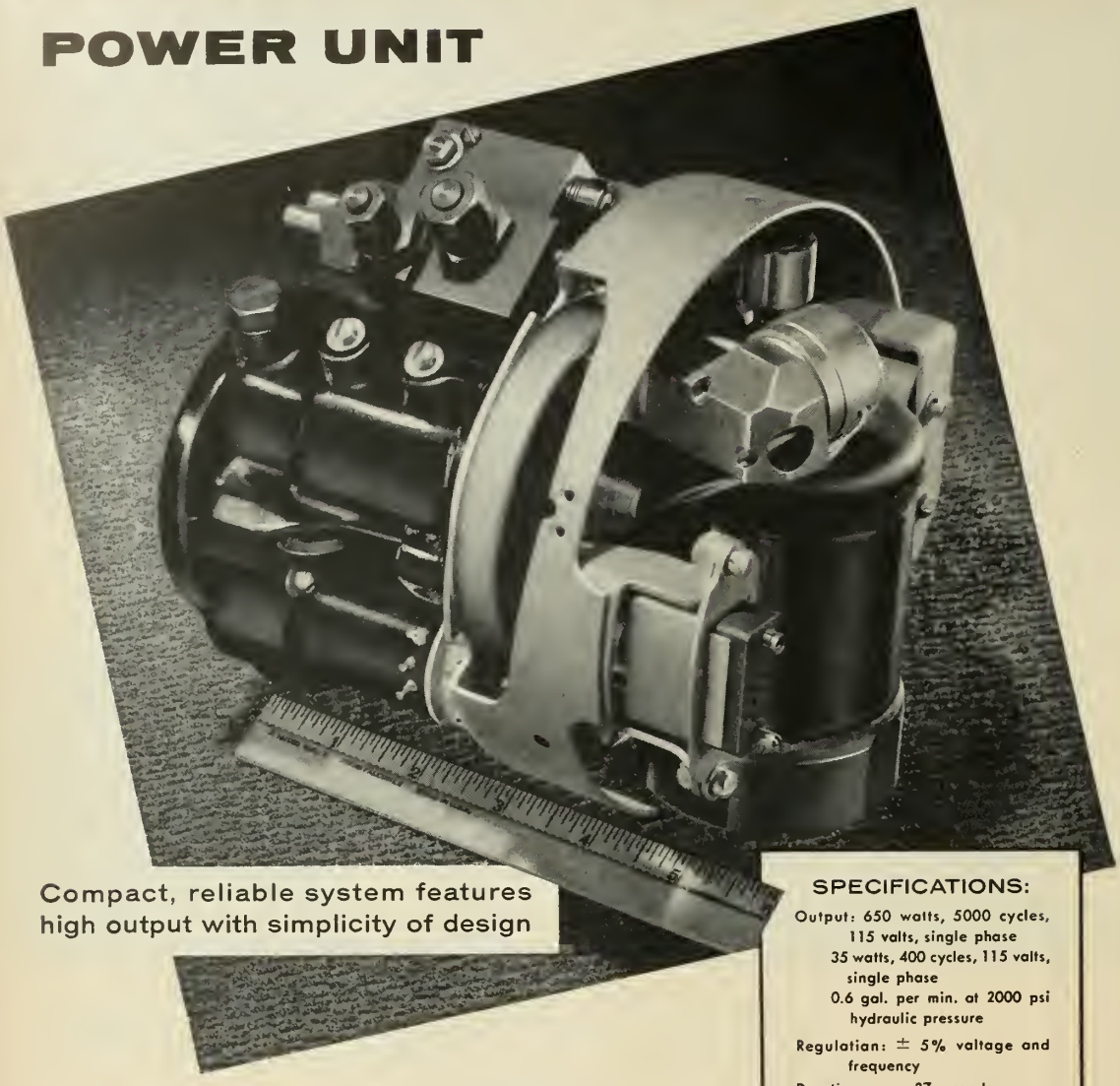

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35 watts, 400 cycles, 115 volts, single phase
0.6 gal. per min. at 2000 psi hydraulic pressure

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This AiResearch auxiliary power package operates the vital electrical and hydraulic systems in a missile.

Gases from a solid propellant spin the unit's turbine wheel at 50,000 rpm. The turbine's shaft drives the following: a 650 watt generator which supplies electrical power to run the missile's guidance system; a 35 watt generator which runs the missile's gyros; a hydraulic pump which in turn powers the servos that control the movable flight surfaces of the missile's airframe.

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missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS

Men for Missile Engineering

By J. B. Beerer

Missile Development Div., North American Aviation, Inc.

WHENEVER A NEW scientific or engineering breakthrough occurs there invariably follows a demand for new ingenuity and resourcefulness on the part of man. Thus, in the missile business today we find ourselves looking for new kinds of engineers, technicians and scientists—many of whom don't yet exist in full measure—to solve new kinds of problems.

This demand has been with us for quite some time now, particularly in the intercontinental missile field. No one will predict relief in the foreseeable future. Instead, as the state of missile art grows, so does our need for men of broader knowledge and abilities.

One program which has contributed greatly to the overall state of missile progress in this country is the advanced intercontinental missile, the SM-64 *Navaho*. Since its research inception more than 10 years ago, the *Navaho* project has brought forward major developments in basic missile systems.

The long-term development of large, liquid propellant rocket engines under *Navaho* enables a crash development to be initiated in recent years on the engines for the complimentary intercontinental ballistic missile. However, before any of these supersonic missiles are operational—developed to the point of military usefulness and operable by the military—a substantial amount of engineering and flight test remains ahead.

The *Navaho* is this country's only supersonic air-breathing guided missile project. It differs technically from the ballistic missiles in that it involves the solution of problems peculiar to airborne vehicles—an extension of the problems which the aircraft industry has been traditionally pursuing. The ballistic missiles present a unique set of developmental problems which become very severe at the extreme velocities required for long range.

The *Navaho* program was the first major USAF program established under the management system concept where the development of the complete weapons system — including power plants, guidance and composite design was to be achieved by a single company—North American. This management responsibility extends up to complete operational capability, including personnel training and logistics.

Total weapon system responsibility qualifies the *Navaho* program as a comprehensive, convenient pattern in studying today's missile projects and their attendant problems.

The problems cover practically the entire spectrum of both engineering and science. Fortunately, in *Navaho* we are beyond the research phase. We are largely beyond the basic engineering phase and into direct engineering, fabrication and flight test.

All missile programs face the very substantial task of achieving reliability. In completely automatic systems, the realization of reliability is extremely difficult but necessary before the military services can accept a weapon system for large scale stockpiling.

This brings us to the heart of our subject. We must have well trained, experienced personnel who can take the solutions of science and transform them into military hardware upon which the security of the U.S. rests.

The principle of jet power was clearly demonstrated in 100 B.C. by Hero of Alexandria. a Greek philosopher, with his rotating Eohlipile. But it has taken centuries before man was able to engineer this principle into the powerful and reliable jet engines which power our modern fighting airplanes. Today we are able to move from scientific principle through engineering to operating hardware in a relatively short time. This is to the credit of today's special types of engineer and the management groups in which he works.

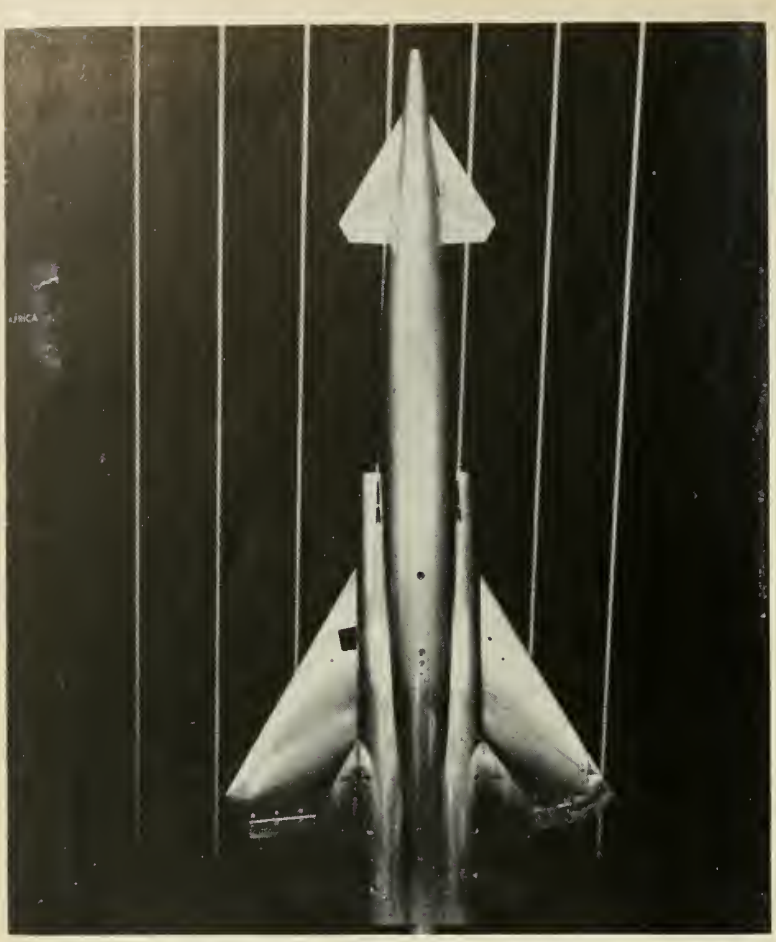
In North American's X-10, a test missile for the *Navaho*, we proved out supersonic aerodynamic design and automatic guidance and control in less time, with less effort and with fewer missiles, than we had dared hope. Thi reaffirms the fact that time needed to reach the hardware stage can be significantly shortened. This of course, requires vigorous and extensive system development prior to the welding together of the complete weapon system.

Engineers engaged in advanced guided missile work find that they must be closer to scientific principles than the engineer of yesterday. Looking into handbooks for approved solutions will no longer satisfy many of today's problems. The man must be capable of understanding the basic scientific principles and translating them, often directly, into drawings.

Since the systems including those pieces of equipment which we normally call "hardware" have to be designed and developed by people, people become the most important factor.

The people involved, as well as the product, are getting to be more complicated—or rather what they have to know is more complicated.

For example, we have long had an engineer we called an aerodynamicist and another we call a thermodynam-



The fine detail of this large-scale wind-tunnel model of North American Aviation's NAVAHO test vehicle, the X-10, is a good example of the knowhow needed for missiles.

icist. Now we find that at the supersonic flight speeds we are working with today sciences of aero-and-thermodynamics merge into one—and so we have the aerothermodynamics engineer.

Much has been written and spoken about the so called heat barrier—the problem of aircraft heating up to very high temperatures as they pass through the earth's atmosphere at high speeds. When we begin trying to solve these problems we find that the shape of aircraft becomes vitally important. So the thermodynamicist becomes the aerodynamicist and vice versa.

Now there is another kind of engineer who has come into being in the missile business—and I might add, also in the aircraft business. We call him a systems engineer. Our personnel people sometimes refer to him as the general practitioner of missile engineers as compared to the specialist. Perhaps it would be better to call him a multiple specialist or a man who is a specialist in several, rather than one field.

There aren't many systems engineers today. After a solid base of academic training, the systems engineer must build himself a superstructure of broad experience in the missile industry. And so we really find him pioneering a relatively new field of engineering.

However, the systems engineer must be backed up by specialists in aerodynamics, thermodynamics, hydraulics, electronics, structures, propulsion and many other interrelated specialties.

Not so many years ago, a man in aeroelasticity and flutter, for example, also had to be an expert in dynamics. Today he must spread himself into another field—electronics—for modern electronic flight simulators and computers are the tools with which he works today.

An engineer in design of automatic checkout equipment also requires quite a unique background. He devises complicated instrumentation tailored to make thousands of checks on specific missile types in preflight countdowns. To do all this he needs to know avionics, hydraulics, pneumatics and related special fields.

From every point of observation, we find the engineers and scientists growing as the horizons of the industry expand. Those who make the most significant contributions are almost always the ones who are a combination student and practical engineer.

Both industry and our schools are rising to this new engineering challenge. I know of no major aircraft manufacturer who is not spending considerable money and time for on-the-job training. These same industries are contributing to colleges to help them set up courses in such new fields—often at a graduate level—as ceramics, electronics, rocket propulsion, etc.

While our total effort in missiles today is directed toward defense and military application, the general body of scientific and engineering knowledge being accumulated will certainly find application in non-military technology.

First will come uses of new techniques and materials developed in missile research. These will include utilization of new heat-resistant materials, new methods of metal working such as chemical etching, new techniques in heat-treating, adhesive bonding and welding.

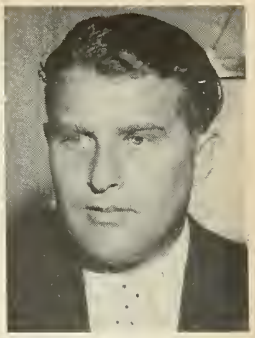
Gains in electronic growth and expansion already show themselves in computers that multiply man's computing ability a million-fold—in automation systems that operate oil wells, man machine shops and printing presses like human experts.

Sub-miniaturization shows its new importance in Tom Thumb size transistorized radio and TV sets, to name only two broad commercial applications. The field of instrumentation is rich in the applications to consumer products.

Out of the development of powerful liquid propellant rocket engines has come high speed pumps and turbines for which I'm sure many future commercial applications will be found in addition to ones we already know.

It is also significant to note that tomorrow's pilot is finding that he needs a sound engineering background if he is to meet flight challenges of the almost immediate future. While we have been designing pilotless missiles we have also been designing manned vehicles that called for new approaches. These will allow a pilot to function at new extreme altitudes and speeds. This leads us to the study of aero-medicine and human factors research.

We find ourselves faced with the need to extend the operating limitations of both men and machines. Out of this may well come new combinations of technical and engineering skills the scope of which we have only a bare indication. ★



Progress Toward Space Flight:

Space Travel and Our Technological Revolution

By Dr. Wernher von Braun

Army Ballistic Missiles Agency

DURING THE FIRST three months of this year hardly a week has passed when the newspapers did not report on some gathering of scientists and engineers who were discussing space rockets and astronautics. A few years ago that very word—astronautics—was virtually unknown, and most people bothering to stop and reflect about its meaning would at best have taken it as a mild joke.

Today one of the largest and best reputed aircraft companies in the United States has its $40-Million Astronautics Division with thousands of employees. In those astronautical meetings of scientists and engineers arguments no longer rage about the feasibility of this or that paper proposal, but about test programs, schedules, budgets, tracking organizations and rocket hardware. There can no longer be any doubt about the fact that Astronautics has reached the stage of practical engineering.

What causes this sudden interest of man in the conquest of outer space and the exploration of worlds beyond our own? As it behooves a group of astronautical hopefuls let us for a moment assume the point of view of those little green men who allegedly have been observing us for centuries from their flying saucers.

Let us see what has befallen the inhabitants of this planet earth, who after several hundred thousand years of quiet, self-sufficient earthbound existence, suddenly have learned to fly and who now, a mere 50 years later, are making visible preparations for ventures outside of the atmosphere and even beyond the gravitational field of their abode.

From their all-encompassing orbiting vantage point our little green friends would have noticed that from the beginning of the 19th Century on, strange activities set in on this planet the like of which had never before been seen. They observed how iron tracks were laid across the land.

Soon a string of coaches, pulled by a smoking and puffing something, was seen moving along the rails. Carriages, hitherto horsedrawn, were seen speeding along without the benefit of horses and humble dirt roads gave way to broad cross-country avenues which soon filled with dense traffic.

Artificial lakes appeared on the face of the earth. Wire lines supported by filigree steel towers were strung from these lakes to neighboring cities. And while these cities stayed ablaze with light after sunset, a forest of smokestacks soon began to hide them in a veil of smog.

As experienced, cosmopolitan-minded travelers through the galaxies, our visiting astronauts would have concluded that the inhabitants of this planet earth were beginning to learn how to harness the forces of nature. From their experience with other inhabited worlds, they would have known that man and his earth were in the midst of that most crucial and painful period of their existence, the transition from the pre-technological to the golden technological age.

Proud as we may be of our steady advances in the natural sciences and engineering, of all the little daily improvements here and there that we are wont to wrap up in that little word

"Technology and ethics are sisters. While technology controls the forces of nature around us, ethics controls the forces of nature within us."

It is with pride and humility that m/r reprints herewith the deliberations of a thinking man. Major General John B. Medaris, Chief, Army Ballistic Missile Agency, has described Dr. Wernher von Braun as one of the most intensely patriotic Americans alive today. He also possesses a mind that is insatiably curious, penetrating and probing. He can discuss with clarity and intelligence space flight, rockets for peace or war, the world's great religions, Europe's first industrial revolution or the motives of Tamerlane. With the new weapons described as "ultimate" and with man about to break loose from his confining earthly sphere and extend his environment to infinity, the interrelationship between God and science is no longer a subject merely for theoretical discussion but is a matter of vital practicality—a prime consideration in the struggle for survival of the species. Dr. von Braun's profound presentation was originally heard by a scant two or three hundred people at the Annual Spring Meeting of the American Rocket Society in Washington, D.C. It should be brought to the attention of everyone concerned with the affairs of mankind. Special reprints are obtainable from MISSILES AND ROCKETS *magazine.*

The Editors

"progress", we seldom stop to think how deep-reaching the effects of this technological revolution have been on virtually everything that has happened on this planet during the last 150 years.

Perhaps the fact that man's occupation with the natural sciences can be dated back many centuries, that names such as Aristotle, Copernicus and Newton are generally accepted landmarks of man's growing scientific enlightment, has somewhat obscured the picture. We should not lose sight of the fact, however, that while these and other great men searched for knowledge and truth about God's world, they did not concern themselves in the least with the application of their scientific knowledge to the plight of man.

It is an undeniable fact that only since the beginning of the 19th Century something absolutely new and unprecedented has entered human history: the determined attempt to liberate the human race from the yoke of heavy physical labor through the harnessing and utilization of the forces of nature.

All the great civilizations of the past were based on some form of human bondage. The ancient had outright slavery. In the Middle Ages it was called serfdom, but for all the fine distinctions historians have tried to make between these terms the basic idea was always the same: In pre-technological times a civilization was looked upon as an organism, like a flower. And for a flower to bloom and to turn its blossom toward the light, its roots, which give it the strength, must dig in the dirt.

For humanity's survival a certain amount of unpleasant, heavy labor had to be performed. Mechanical means for doing that dirty work were unknown. Therefore human bondage for all but a happy few appeared to be a God-given necessity, and a logical and even vital institution in the pattern of the creation.

This simple logic seemed so obvious that even the great thinkers of antiquity—and among them were the originators of many of the most fundamental ideas of the Western World—found nothing offensive in it.

Technology, the submission of the forces of nature, is man's first and only chance to abolish effectively the curse of slavery, whatever its name. Only with the help of technology can we hope to build a cultural organism in which not just a favored few, standing on the shoulders of the multitude, may blossom, but one in which everybody has an equal chance to deploy his capabilities in the light of universal freedom.

We are on our way to this lofty goal, but we have not yet attained it. In fact, in its first phase the technological revolution probably created more new problems than it solved. It speeded up the growth of the large cities where many a farm boy traded the freedom and beauty of life on the farm for the ugliness of a crowded existence in a smokefilled industrial city. It created great riches on the one side and inadequate benefits for the workers on the other, with resulting unrest.

It created a new representative of human bondage—the proletarian, a slave who was no longer for sale but for rent. Theoretically of course, the proletarian was a free man, but the penalty for his deserting the job was still the same as that for the slave of ancient days—death by starvation.

We are still surrounded by sad remains and reminders of this early phase of the technological revolution. The lot of many miners is still reminiscent of that of the Biblical Hebrew slaves who built the pyramids, and the monotonous job of an assembly-line worker still has a conspicuous resemblance to that of an ancient galley-slave.

But the new paradise which the technological revolution promises is no longer a mere silver lining on the horizon. We have unmistakable signs of its imminence. Our highways are no longer built by road gangs toiling with pick and shovel but by cigarette-smoking operators sitting on heavy road-building machines. Assembly line workers are rapidly being replaced by electronically controlled automation of manufacturing processes.

The stoker of an electric power plant who, half a century ago, half-naked and sweating had to shovel coal into blazing fires, now sits in a tile-covered control room clad in a white gown and monitors the instruments of the automatic fuel controls. No longer does he live in a cold water city flat. He has his own little suburban home and drives his own car.

The technological revolution has brought about an entirely new set of unprecedented problems for the organization of human existence on this planet. In fact, most of today's political problems are a direct consequence of the technological revolution. Capitalism, socialism and communism were unknown words before the invention of the steam engine. So were terms such as trade unions, raw material bases, transoceanic supply lines and oil concessions.

One of the most crucial problems of our times lies in the fact that the very nature of technology is dynamic, while the forms of political law and order which mankind needs for peaceful co-existence are fundamentally static.

The contradistinction between the static forms of political order and the rapidly changing technological conditions is likely to create in the future, as it has in the past, a continuous source of conflict. For every major invention changes the basis of human existence far more profoundly than a treaty between nations or an agreement between statesmen.

The overshadowing prominence of the technological revolution is impressively manifested by the fact that it knows no national boundaries. Its unmistakable signs—smokestacks, roads, railroads, power lines and industrial cities—can be found on both sides of the Iron Curtain, in America and Europe, the birthlands of modern industry, as well as in historically agricultural Russia and China.

It has spread like wildfire to South America and Australia and is establishing ever firmer footholds in the darkest parts of Africa. Even spiritual India—where since time immemorial men had held that the only road to human happiness was abstention from worldly ambitions, goods and riches—is now competing with the rest of the world in the construction of hydro-electric power plants and the operation of transcontinental airlines.

But while the enthusiasm for the technological revolution may be the same on both sides of the Iron Curtain, there are truly fateful differences in its implementation.

We in the West take account of the fact that the prime mover of technological progress is man himself; man, with his hopes, dreams and imaginations; man, with his enthusiasm and pride of accomplishment; but man also with all his foolishness and weaknesses, with his personal ambition, greediness and thirst for pleasure. We believe in a free society where man can pursue his own dreams, follow his own ambitions and form his own life.

We believe in limiting his activities only to the extent as they might harm his fellow citizens, and we are entirely ready to accept even his weaknesses such as egotism and search for easy profit as natural and human and smilingly put them to work.

We subscribe to the belief that the rich man's luxury of today is the average person's consumer goods of tomorrow. The result of this general attitude is an economy governed by an all-out effort by everybody to be more effective than his competitior.

We must push the spokes of the wheels of progress in order not to be run over ourselves. But while we are throwing everything we have into the fight, we must concede that we are using some of our strength, not against the forces of nature which we set out to harness, but against our business rivals.

On the other side of the Iron Curtain this free-wheeling way of going about the business of progress is considered wasteful. In accordance with the basic communist creed that there should be no private ownership of means of production, the State took over the management of the factories and laboratories.

Not man himself, as a warm-blooded individual, was to be the hub of progress but an all-embracing and all-controlling master plan. Whole series of consecutive Five-Year Plans were thus enacted which, on paper at least, provided an admirably dovetailing set of schedules for the organization of industrial development and progress. The gear box of this gigantic machinery, the purpose of which was to convey the driving power to its many outlets, was grandiose, but soon it became apparent that what had failed was the motor itself: man.

At first, communist revolutionary enthusiasm was supposed to step in and provide the driving energy which had taken a nose-dive when, because of lack of incentive, the personal interest of the individual had faded.

After the storm of enthusiasm had blown itself out, an appeal to proletarian solidarity was called upon to replace it. And after this had failed, too, naked terror was tried as the last resort.

While it succeeded in keeping the wheels of the machinery from grinding to a complete stop, the results were so disappointing that the Soviet leaders themselves realized that the re-introduction of incentives—which, of course. was tantamount to a differentiation in the standard of living—was an absolute must if their great Soviet economical experiment was to be saved from monumental failure.

The Soviet leaders were confronted with yet another problem which compelled them to return to an effective incentive system. While their Communist Revolution could be run and was run by political amateurs, the technological revolution can only be run by professional scientists and engineers.

Without an adequate educational system capable of producing a steady supply of scientists and engineers to direct the work in their factories and laboratories, they could not hope to catch up with the Western World's advances in technology. And without continued progress in the realm of the technological revolution, their political revolution would have been doomed. For it would have been demonstrated for all the world to see that communism was not capable of industrially organizing a backward country.

We know how frighteningly successful the Soviets have been during the past decade in producing ever-increasing numbers of scientists and engineers. But while this development—and its consequences on the future economic and military position of the West—should be given all the serious consideration it deserves, we should not lose sight of the fact that it contains a very strong element of truly bright hope. For there can be no scientific education without encouragement of a critical attitude on the part of the student.

Dr. Wernher von Braun with a model of his famous "pioneer model" manned space rocket.

There can be no scientific progress without a healthy disregard for the printed word and for dogmatic truths established by authorities or famous predecessors. And no man can be a true engineer unless—like a medical man—he looks upon his job as a calling, as an opportunity to make a contribution to the technological progress for the betterment of man's life on this earth.

I am convinced that the education of those hundreds of thousands of scientists and engineers in the Soviet orbit will have its lasting effects on the Soviet system itself. It will make it more and more difficult for the few to impose their will unchallenged upon the many. Those hundreds of thousands of critically and scientifically trained minds will cause more discussion, criticism and "feed-back from the bottom". They will, in general, mellow the Soviet system's monolithic structure. But most important, they will, in the long run at least, enhance the role of ethics in the Soviet system and will reduce the role of momentary expediency.

It is my firm belief in the ennobling effect which this mass-education program will have on the Soviet system, that affords me my optimistic outlook on the future of mankind.

Our present, sometimes seemingly hopeless, political impasse with the governments behind the Iron Curtain shows us with a frightening clarity that all of man's scientific and engineering efforts are in vain unless they are performed and utilized within a framework of ethical standards commensuate with the magnitude of the scope of the technological revolution. The more technology advances, the more fateful will be its impact on humanity.

If the world's ethical standards fail to rise with the advances of our Technological Revolution, we shall all perish. Let us remember that in the horse-and-buggy days nobody got hurt if the coachman had a drink too many. In our times of high-powered automobiles, however, that same drink may be fatal!

The successful release of atomic energy presented mankind, in one neat package, a simple choice between hundreds of cheap electrical slaves for everybody—and universal destruction. With the rocket, the technical differences involved are even less. Any ballistic missile capable of carrying a nuclear bomb over an intercontinental range can be modified to carry a few instruments to the moon. In both cases the question of which of the two loads will ultimately be placed into the nose of such a missile is not in the hands of the scientist or engineer who builds the rocket. It is solely dependent on what

ethical standards will prevail in the world in times of crises.

Technology and ethics are sisters. While technology controls the forces of nature around us, ethics controls the forces of nature within us. But while technology is a mere 150 years old, the problems of ethics have occupied the minds of the greatest thingers on this planet for several thousands years.

I think it is a fair assumption that the Ten Commandments are entirely adequate, without amendments, to cope with all the problems the technological revolution not only has brought up, but will bring up in the future. The real problem is not a lack in ethical legislation, but a lack in day-to-day ethical guidance and control.

Prior to the Renaissance the church applied this tight individual guidance to emperor and beggar alike. But when science freed itself from the bonds of religious dogma, thus opening the way for the technological revolution, the church also lost much of its influence on the ethical conduct of man.

It has been frequently stated that scientific enlightenment and religious belief are incompatible. I consider it one of the greatest tragedies of our times that this equally stupid and dangerous error is so widely believed. But it is easy to see why so many people fall for it. We instill in our children a tremendous amount of what we call factual knowledge, but we deny them knowledge of what we do *not* know: "You can't teach what you don't know yourself," is the cheap excuse. But by not telling the children about nature's mysteries, its infinite number of unexplained and unexplainable miracles, we deny them that most important dowry for their future life, humility.

Nothing has probably retarded human progress more than idolatry of our own achievements. By adoring our own scientific achievements we kill humility, the mother of any true scientific progress. By adoring our own technological advancement we kill the urge to come up with a better product.

Nature around us still harbors many thousands times more unsolved than solved mysteries and for all our scientific enlightenment we know more mysteries today than when the technological revolution began. So there is no reason why God cannot retain the same position in our modern world that He held before the natural sciences began to pierce through the walls of dogma erected by the church.

Science and scientists should put this simple but widely unknown truth across to people everywhere. With all the modern means at our disposal, with schools, churches, educational institutions, press, radio and television, we should tell the world that religion and science are not incompatible; that, on the contrary, they belong together. For only with God reinstated in the heart of the world, will He furnish mankind and its leaders the ethical guidance through the dangers and pitfalls of the technological revolution.

The fear of the nuclear bomb, the restlessness of modern city life, the standardization of many consumer goods with its resulting levelling effects on tastes, fashions and even opinions—in short the unpleasant aspects of our technological age—have caused many people to decry technology as a whole and to preach return to the simple life. But for any civilization that has entered the road of technology, and there is hardly any civilization on this planet left that hasn't, there can be no return. For it is in the nature of the technological revolution that it first destroys the existing economic pattern before it can effectively replace it by a superior one. Thus for a country dedicated to industrial development to return to the simple life would mean complete economic ruin. There is only one way to overcome our present difficulties, namely to pursue the technological revolution with even greater zeal and determination.

But in order to keep the technological revolution alive, it must be continuously incited by research. Only by feeding it with new discoveries and new inventions will it continue to roar along the road of progress.

One of the main ingredients of any research or exploratory work is just plain curiosity. It is as unwise as it is unrealistic to insist on justifications for new research projects on the basis of their immediate purpose and their potential practical application. Technological history abounds with examples proving that it is simply beyond the capability of man to predict what will follow in the wake of a major discovery.

I do not know of an example which could illustrate this simple truth more strikingly than that grandiose project so dear to the heart of every true rocket man: flight into outer space. How often have we heard questions such as "Why should we try to establish artificial satellites?" or "Why do you want to go to the moon?", questions hopelessly ignoring the mainspring of human existence. The simple fact is that we have the technical means at our disposal to go about these challenging tasks; therefore, the only really justified question should be: "Why should we *not* do it?"

Space flight is not just one of a great number of technological projects of the near future. It is in a class all by itself because it means, in the broadest sense of the word, an extension of man's activities beyond the realm of his home planet. Today when we talk about space flight we think mainly of rocket ships and their engines, of guidance and navigation methods and of the technical means for controlling the environmental conditions aboard a space ship.

These engineering problems are really only part of the broad aspects of space flight. They are a very important part to be sure, because it is still the lack of adequate transportation equipment that prevents us from traveling to the moon and to Mars. But once these means of transportation are available, research activities beyond our own planet are bound to fan out tremendously.

We can get an inkling of what we may expect in this regard from the rush of research institutions on the rather modest payload accommodations for scientific instrumentation on the *Vanguard* satellite rockets. Thus we may safely assume that once laboratory space in manned space stations is for rent, we shall run into all kinds of professions up there which have very little concern with the engineering aspects of rocket ships.

Of course, we shall find astronomers and astrophysicists, radiation experts and medical researchers, meteorologists and reconnaissance men up there. But commercial interest will have entered the field, too, and we should not be surprised to find a sign at some door indicating a maintenance headquarters for an orbital ultra high-frequency message relay center for a television relay station.

But once man sets foot on the moon and the first voyages to our nearer planets are in preparation, new professions will join the cause of space flight. Botanists and zoologists, geologists and archeologists, mapping experts and may be even interplanetary mining prospectors will be represented in man's first interplanetary expeditions.

It is difficult to think of a field of human endeavor that will not be involved in man's greatest venture. Thus it is only natural that space flight has moved to the forefront of scientific research.

It is the ultimate objective of our great technological revolution to free man from the slavery of heavy physical labor, to elevate mankind from its historical bondage to a race of masters, in whose service toils an army of mechanical and electrical slaves.

This liberation through technology will enable man to devote more time to think and to dream. It will raise all our civilizations to levels never before attained in human history. Space flight will free man from his remaining chains, the chains of gravity which still tie him to this planet. It will open to him the gates of heaven.★

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PROPULSION PROGRESS

Some twenty years ago, a backyard static test of a new chemical propellant combination was likely to add some 25 seconds to the increasing specific impulse climb at a cost of a few dollars. Today we are groping for increases of only a few seconds at costs of from four to six orders of magnitude greater. And, our propellant future, limited by known compounds and problems of stability, seem to be headed to a maximum level plateau of about 300-350 seconds for working systems. It is expected that it will take us some ten years to reach this ultimate in chemical propulsion.

Despite this now very gradual climb, there is a vast technology and a new industry being forged to support the progress that already has been made. Here then is where the real progress is being made—concerned with production, stability, logistics, economics, and the expanding market of applications.

Biggest propulsion advance lies in the field of "exotic" fuels. Since we had only a handful of good oxidants to play with, it seemed logical to look for improvements—particularly heat content—in our fuels. The light metals and the various hydrides all offered higher heats of combustion per unit volume than conventional hydrocarbons. These exotics are now getting into production. Known under the name of "Zip" or "Hi-Cal," the exotics apparently are hydrides of boron which can be used directly or as a "Mickey" for common hydrocarbons. Presumably the exotics will be slated for use in jets, ramjets, or in rocket systems.

Although details of the exotics are just starting to trickle out, it is probably safe to say that the laboratory phase has been completed and that the main effort is now centered in building production plants. Within the next two years, the production of exotics will have assumed the tonnage scale. Only then will a true balancing out take place. This balancing out will weigh the actual operational advantages against such powerful factors as handling and logistics, demand versus production and overall cost. Commercial applications of the exotics hang on the comparison of laboratory expectations and actual practices.

Right now, straight LOX seems to be the choice of all large missile systems. However, the days of LOX for some applications are already numbered. Several years of work have gone into the preparation of pure ozone and, as the exotics are used to "spike" the hydrocarbons, ozone will probably be used for increasing the oxidizing power of LOX. As yet, however, straight ozone is a bit difficult to handle and ozone technology has not yet operated on any scale but laboratory operations.

Liquid fluorine (or fluorine compounds) is closest to displacing LOX. Nearly everyone agrees that fluorine offers a good balance between high flame temperature and low molecular weight. Since fluorine will probably offer the ultimate in oxidizing potential and give nearly the theoretical limit for chemical systems, the path for fluorine is well marked. And fluorine, unlike ozone, has well established handling techniques and is now being produced on a tonnage basis.

For smaller systems, nitric acid will continue to be a popular propellant. Other propellants such as hydrogen peroxide, ethylene oxide, the alkyl nitrates are already being relegated to auxiliary propulsion systems. Research, however, has failed to turn up stable liquid monopropellants in the 200-250 sec range.

In order to come up with high energy monopropellants, two "dirty" systems are under investigation. One employs what might be called a composite liquid propellant, premixed amounts of oxidizer (such as nitric acid) and fuel. Stability is the big problem here. The ten foot pole is gradually getting shorter as the "gunk" liquids are appearing more attractive to the engineer who formerly would only consider pure or "clean" liquids.

The gunk propellants—gels, slurries, pastes, suspensions, etc.—are being considered for new systems—particularly where high heats of combustion and high volumetric loading are essential.

In between the liquid and solids are the hybrid systems. Two systems have been evaluated in hybrid rockets. One used liquid oxygen which burned a solid polysulfide rubber while the other used hydrogen peroxide and a polyethylene plastic fuel. Neither systems have shown great advantages over either the true liquid or solid system.

This does not necessarily hold for the reverse case where conventional or exotic fuels are used in combination with pure solid oxidants. Work in this latter system, however, has been very sparse. The effort going into the solid fuel ramjet is not as sparse. Several groups have been engaged in development and several systems employing solid fuel ramjets are in the works.

The biggest single important solid propellant development has been concerned with scale-up for producing really large single grains. Both composites and double base castable propellants have evolved which now permit grains of almost any size. However, just how large are current big grains is difficult to ascertain because of security reasons.

It is probable that present solid propellant technology can give grains of about 1 million lb-sec and that within 2 years we will have solid rockets as large as the V-2 (ca 4 million lb-sec) and that in 5 years an operational solid propellant IRBM will have been developed.

At the other end of the solid propellant scale, ammonium nitrate is ushering in the era of low cost, medium energy sources. It is already being used in the area of RATO and boosters. Biggest area for these propellants are APU's and a host of industrial and commercial applications.

Newest entry into the propulsion field was the continuous detonation engine. Although thrusts are yet small, the specific impulses are quite good. Since this work is yet in the laboratory stage, extrapolation to large-scale hardware is difficult.

The next propulsion plateau above chemical propellants will probably be the use of nuclear energy. In the atomic rocket, propulsion progress is of a mixed nature. The stretching out of our aircraft nuclear propulsion program has been blamed on excessive weight and a high level of radiation. In the power reactor field, however, progress is being made in increasing heat transfer by increasing pile temperatures. Developments now taking place in other realms, however, may never make the thermonuclear rocket practical.

There is a great deal of interest in non-heat engines. Two entries for study of ion propulsion have been let and there are a host of researchers working on electrical and magnetic particle acceleration. Fusion energy for rockets is a hope, although distant. And the ultimate of all propulsion schemes—the utilization of photons—still awaits a laboratory foundation.

Engineering Progress in Air Force Rocketry

By Frederick I. Ordway III and Ronald C. Wakeford

RECENT TEST FIRINGS of nuclear armed air-to-air rockets spotlight the progress made in aerial warfare. Although overshadowed by the more spectacular developments of IRBMs and ICBMs, new advances in aerial rocketry have caused revolutionary changes in the tactics of plane-to-plane combat.

The design and development of a successful air-to-air missile is a complex proposition with enough variables to keep teams of engineers and scientists busy for months and years. Not only must the missile operate in harmony with the aircraft that carries it, but all internal mechanisms must be carefully mated with the missile itself.

The *Firebird* represents a relatively early attempt by the Air Force to provide an accurate liquid-propelled air-to-air missile for operational units. It was developed in about two years by the Ryan Aeronautical Co., and carried the official designation XAAM-A-1. It was first tested in 1949, was carried on external launching racks.

Firebird incorporated a semi-active radar homing system and a proximity fuze. Control surfaces were located on the wings and fins. The carrying airplane housed the search radar.

The 7½-foot missile (10 feet with booster) had two sets of cruciform plastic wings with control and stabilization surfaces. The basic structure was conventional aluminum alloy sheet. Such aircraft as the B-26 and *Twin-Mustang* F-82 generally carried four of the 600 pound Firebirds, which could be fired alone, or in groups of two or four. The overall development program cost about $2 million.

Mighty Mouse

For years America's only operational air-to-air rocket was the reliable 2.75 inch, folding fin unguided *Mighty Mouse*. If hostilities were to break out today it would continue to be a standard defensive weapon. *Mighty Mouse* was a Naval Ordnance development of the successful German R-4M rocket of World War II, and has been fired not only from such Navy aircraft as the *AD Skyraider*, but flown many Air Force fighters. The *Aeromite* is much like the *Mighty Mouse*, using a somewhat different propellant.

The rocket uses a proximity fuze, and has fins that fold out at launch. Some airplanes, for example the F-89 and -04C, carry them in wing tip pods to improve dispersion, firing about twelve in a quarter of a second. Other planes, such as the F-86, fire them in single volleys of 24, leaving the aircraft at 200 miles per hour.

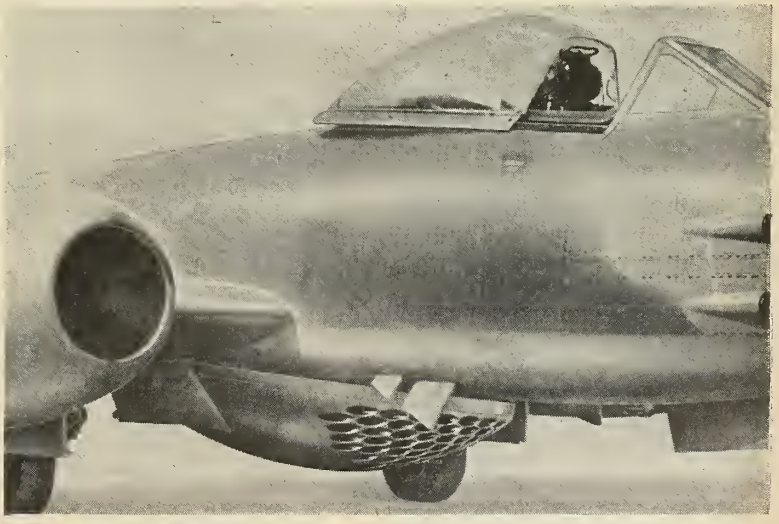
The F-89D can carry 104 of these 2.75 inch rockets and fire them electronically. A T-110 rocket gun has been developed to fire the *Mighty Mouse*.

Mighty Mouse has been in production for years and is used throughout the squadron service. It is used in practice shoots against aerial towed targets like the radar-reflecting nylon marquisette units currently in vogue. B-45 and B-57 aircraft generally tow the targets for practice shooting with the *Mighty Mouse*.

There is considerable pilot disagreement about the relative effectiveness of launching salvos from trays under the nose and from wing-tip pods. While accuracy from the former position may be high, pilots point out that by loosing your rockets from wing positions you can get more rounds on a target per pass, better dispersion characteristics, and hence a greater chance of destroying it.* In the case of the *Mighty Mouse*, cost is not an important factor which helps make it an attractive defense item.

Eglin Air Force Base is supposed to have a fully developed two-inch replacement of the *Mighty Mouse*, which was shelved because of long-term *Mighty Mouse* commitments, and

* A dispersion of 20 miles means a deviation of 20 feet for 1000 feet of travel. Unguided rockets are normally spinstabilized, though longitudinal fins often provide prime stability. The higher the number of rpms, the more dispersion is reduced.



Swiss Oerlikon's bid in the small air-to-air folding fin rocket field. This launcher for 76 of the five centimeter diameter projectiles is mounted on a British Gloster Meteor twin jet fighter. Some pilots perfer the straight ahead firing of this center mount to the converging pattern obtained when the rockets are fired from wing-tip pods.

because of current emphasis on air-to-aid guided weapons.

Zuni

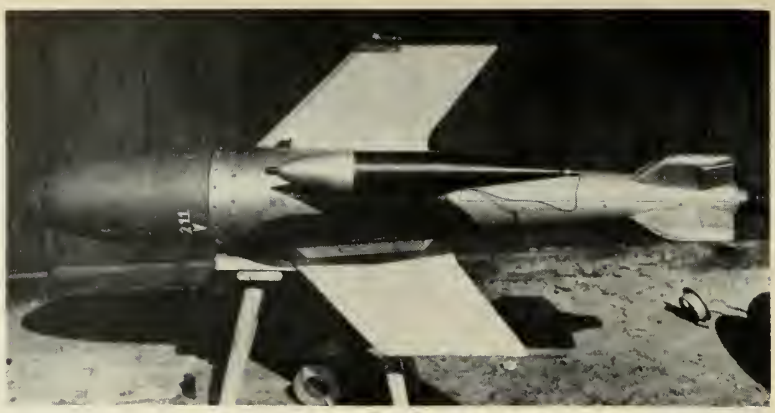
Named for the Pueblo Indian Tribe, the new Navy *Zuni* air-to-air 5 inch high velocity aircraft rocket was developed by the Ordnance Test Station, China Lake, Calif. This folding fin, solid propelled weapon has been extensively tested by both BuOrd and the Fleet Operational Development Board, and is now approved for operational use. It has twice the velocity of the HVAR of World War II fame.

The *Zuni* launcher can accommodate four rounds and not only launches the rocket but is also the storage case. It is jettisoned after use. The elimination of the normal packing case is expected to result in considerable time savings. *Zuni* is also designed for air-to-surface applications.

The unguided rocket generally has good static stability and reports indicate that *Zuni* is no exception. Detailed performance figures, however, are not yet available. In guided rockets, on the other hand, one must allow for a large displacement of controls to maintain a given flight path or to change direction. With relatively low static stability, they enjoy a high maneuverability rate.

Sparrow

There are three *Sparrow* missiles now in existence: *Sparrow I* (AAM-N-2), *Sparrow II* (AAM-N-3) and *Sparrow III* (AAM-N-6), developed respectively by Sperry-Rand, Douglas and Raytheon. *Sparrow IV* is apparently still under the cognizance of Navy BuAer, and as far as is known no contractor has been designated to build it.



German X-4 was developed as a wire controlled, rocket propelled, gyro stabilized missile. It employed a proximity fuse. By the time World War II ended it was almost ready to use.

Sparrow I, first produced in 1951, is manufactured by the Sperry-Farragut plant in Bristol, Tenn. and at the Douglas Aircraft Co. in Calif. A beam-rider, it has a semi-active terminal homing device developed by Sperry and Raytheon. It is considered very accurate up to five miles.

Sparrow II, with an active homing system is to be used by the Royal Canadian Air Force to replace its abandoned Velvet Glove development. It has a rounded nose, trapezoidal form, and shortened fins.

Raytheon will build *Sparrow IIIs* at Sperry's Bristol plant when *Sparrow I* phases out. This new missile has been mounted on McDonnell F3H Demons.

It is radar guided, has a blunt nose and tail surfaces similar to *Sparrow I* with a smaller degree of sweepback. Raytheon has a $60-million Navy contract for its air-to-air work. *Sparrow I* has seen wide operational use on McDonnell F3H2N *Demons*, Chance-Vought F7U3M *Cutlass*, and other aircraft.

An approach to bomber defense this Cornell Aeronautical Laboratory missile design looks like but actually preceded that of the HAWK.

Falcon

Under development since 1947, the GAR-98 *Falcon* is a product of the Hughes Aircraft Co. and Philco. The three-to-five mile missile has been carried by a wide variety of aircraft including the F-86, -89, -94, -100, -102 and CF-100, and was first tested in 1950. The F-89H was the first operational aircraft to carry *Falcon*, which has been mounted on both wing pods and pylons.

In the pod mounting layout, three *Falcons* are often carried on the periphery. The pod itself contains three 7-battery 2.75 inch rocket panels. An interesting feature of the *Falcon* is its temperature sensitivity. For this reason special heaters are used to maintain the firing temperature. In solid rockets this temperature sensitivity is expressed as the percentage change of thrust for each unit of temperature change and generally runs from 0.0025 to 0.014 additional pounds of thrust per degree. On hot days you get a higher thrust while lower than rated thrust may occur on cold days if no heating blanket is used.

GAR-1 (Model 1) is six feet long and six inches in diameter, weighing 112 pounds. Newer models are longer and heavier, and have a greater range. Four have been placed in production since the inception of the program. The latest is the GAR-1D, featuring major control changes. Since atomic explosives reportedly can now fit into four-to-five inch diameter projectiles, *Falcons* with atomic warheads may be approaching.

Falcon may eventually be made in an infra-red version using a beam rider guidance system with semi-active homing. Whether Models 2 or 3 will have it is not known. The missiles can be fired from any positions including underneath and in salvos beyond the defensive range of a bomber.

As production goes up, costs go down. A few years ago figures of $25,000 to $50,000 were quoted for *Falcon* Model I. Now it costs about $10,000. Rumor is production runs over 100 a month.

Sidewinder

Infra-red guided *Sidewinder* (AAM-N-7) is one of the Navy's latest aerial weapons and is operationally installed on jet airplanes operating from both land and sea bases. Seen mounted on pylons under the wings, the missile is reported to be one of the most accurate in the business, having successfully knocked flares off the wing tips of an F6F drone without causing sufficient damage or de-

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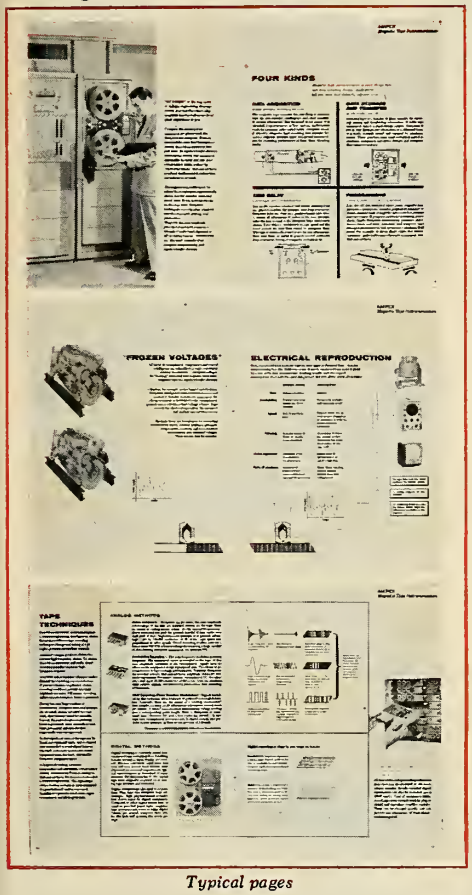
Tape is the stuff of which memories are made – the versatile data memories for a jet propelled age of electronic miracles. If you are one who keeps up with times and techniques, it is a field well worth knowing. This new brochure gives a wide-angle view of the whole subject.



Typical pages

What kinds of applications do you think of when magnetic tape recording is mentioned? Sound recording, of course, and telemetering, if you are in that business. But what about simulating a rough road to test truck axles, controlling a milling machine to cut an aircraft wing section out of a solid billet, monitoring for a sudden occurrence that may happen only once in a year or two, recording data that can be reduced to graphs and tabulations without ever being touched by human hands? These and many more are described.

How significant is the fact that magnetic tape recording reproduces data in the same electrical form in which it was recorded? Enormously important, when you realize all the things the reproduced data can do that couldn't be done with the original signals or with the common forms of visual recording. For example the data can be slowed down to look at fast transients. It can be speeded up for wave analysis. It can be read out in any form. A tabular comparison between original signals and taped signals gives the full story. And a step-by-step pictorial demonstration of magnetic tape recording and reproduction puts the electrical-data idea into tangible, easily visualized form.

What does the data on magnetic tape look like? You can't see it, but the brochure will give you an idea of what it would be like if you could. And incidentally this may help to clarify the differences between various magnetic-tape-recording techniques.

Do you talk in tape's language? When is a tape recorder not a recorder? What is the difference between a channel and a track? What is a servo speed control? A much needed glossary gives the consensus of our views on terms.

For whom did we write this booklet . . . the expert, or the man for whom the whole subject is new? Both. It is written and illustrated so that any engineer or technically trained person can readily grasp the concepts and gain a broad understanding of the subject. If you are one of those who has already worked extensively with tape, you will find some new twists in the way the subject is explained, and perhaps ideas on new areas you hadn't explored. And incidentally, a copy of this brochure in some handy file will give you a good start in indoctrinating that new man in the department.

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July, 1957

Circle No. 3 on Subscriber Service Card.

The Fairey Fireflash, first British air-to-air guided weapon to destroy radio drone. Two external boost sockets accelerate missile to supersonic speeds. It is a beam rider.

flection to the vehicle to prevent its later recovery.

The infra-red guidance package producing such pin-point accuracy is the first of its type to reach operational status. *Sidewinder* is operational on F9F, F3H-2N and FJ3 aircraft, and sees service with Attack Squadron 46 on the *U.S.S. Randolf* and Fighter Squadron 211 on the *U.S.S. Bonhomme Richard.* It is effective up to 50,000 feet and has an accurate range of about 3500 yards. Contact and ambient fuzes are provided.

Some Navy fighter airplanes carry both radar guided *Sparrows* and infra-red guided *Sidewinders* at the same time. Since infra-red is ineffective in rain or heavy clouds, radar is handy under these conditions. Infra-red is rather difficult to fool, but it can be done.

Bombers, however, can generate powerful interference for radar signals flowing from the intereepter to the missile. Since neither radar nor infra-red is perfect we expect that unguided barrage rockets will form a secondary defense for some time.

Sidewinder is stabilized by attaching small bucket wheels to control surfaces and rotating them at high speed. Performance of *Sidewinder* has attracted the attention of the Air Force which it may mate with the F-104 Lockheed fighter.

The missile is currently delivered by Philco which originally assisted the Naval Ordnance Test Station, China Lake, Calif., in its development. *Sidewinder* is characterized by a blunt nose, four triangular forward fins and four rectangular surfaces aft.

It has been reported that the *Diamond Back* will succeed the *Sidewinder,* and that it, too, will be infra-red guided.

Ding-Dong (MB-1)

Little information has been released on this new, atomic-tipped, liquid propellant, air-to-air missile. Although 1956 is considered the year of its conception, warhead tests were made in the spring of 1955 at the AEC's Nevada test areas to provide basic information on the missile's requirements.

The missile was reportedly flight tested with its A-warhead during the May 1957 AEC atomic firings in Nevada. Developed for the Air Force by Douglas Aircraft Co., it is the first nuclear warhead rocket in the U.S. for air-to-air operations. A solid propellant version is currently reported under development.

Ding-Dong MB-1 (the name *High Card* may once have been used) is to be tested on F-89J, F-102 and F-106 airplanes. The Hughes Aircraft Co. is presumably handling the control problem. Air Force says that it will stock A-warheads for the missile at various points around the country.

The *Tingaling* is a training version of the *Ding-Dong,* with a spotting charge only. Air Defense Command uses it.

A number of air-to-air missile programs were cancelled before they were through the development stage. Navy BuOrd's *Meteor* project, handled by the Massachusetts Institute of Technology, was one of these. Active until 1951, the missile weighed 500 pounds, carried a 25 pound warhead, and was to have flown at Mach 3. Some work on it was reportedly done by the Bell Telephone Laboratories.

The Martin *Oriole* XAAM-N-4 BuAer-sponsored missile program was cancelled in 1954. Little is known about it except that it was to have a range in the neighborhood of ten miles, and was to fly in the Mach 2 region. It may have been ramjet powered.

Among the active programs in the U.S. about which no details are currently available is an air-to-air missile under development by Republic's Guided Missile Division.

Bomber defense missiles are currently receiving considerable attention. It has been widely circulated that Cornell Aeronautical Lab's BDM is merely a modification of the *Hawk* surface-to-air missile. CAL insists, however, that such is not the case, that their missile is a test vehicle specifically designed for bomber defense, and that not only is it completely independent but preceded the *Hawk* design.

The Air Force has long kept an eye on the missile as a possible defen-

Ryan Aeronautical Co. FIREBIRD used radar homing and proximity fuse; was one of first guided air-to-air missiles in U.S. Bottom shot shows MIGHTY MOUSE package on F-86D.

sive weapon for bombers and B-52's may soon be carrying them. This interest probably dated from the time German jet-powered intercepters began to invade American bomber formations in World War II, attacking with 50mm cannon from the rear.

Some investigations were made to adapt 2.25 inch and 5 inch spin-stabilized rockets for such use. To launch rockets from the rear of modern, high speed jet bombers present a series of complex problems including aerodynamics, guidance and control.

One project under study was the 1½ inch caliber *Nasty*, which was given spin stabilization by canted rocket nozzles and canted fins. Its high velocity kept it from weather-vaning when fired sidewise to the rear of bombers. Initial boost was provided by rocket guns, presumably the T-132 known to fire short, 1.5 inch rockets. This North American Aviation development has been cancelled by the Air Force.

Both the *Duck* and *Goose* have been mentioned as missile weapons to be carried by the *Hustler* B-58. Whether either or both have a BDM application is not known.

Air-to-Air Warfare

Air-to-air rocketry requires much in the way of pioneering to develop and maintain invulnerability and accuracy. Weapon and counterweapon have been the order of the day since the earliest battles, and counterweapons from shields and armor to antimissile missiles have always been available to plague the tactician.

The guided air-to-air missile has not yet been tested under real combat conditions. The air-to-air missile is a formidable weapon if only from the viewpoint of the tremendous closure rates to be anticipated from interceptor and attacking intruder, both travelling in the supersonic speed range.

Presumably an optimum air-to-air weapon system must prevail over a maneuvering target and decoys and electronic countermeasures, to say nothing of terrain and weather conditions. The latter are particularly important when the opposing force attacks at low levels.

Prior to combat and without a completely automatic fire-control system, an intercepter has to go through several maneuvers, each susceptible to error. Upon being vectored into position by ground radar through possible cloud cover and chaff countermeasures, the fighter will have to assume the correct heading or collision course, determine the range, speed and maneuverability of the target and get close enough to bring the air-to-air missile into action.

Once launched the missile must follow the path of the attacker and detonate upon or within a lethal distance of the target. This was the picture of events prior to the introduction of a completely automatic fire control system such as that developed by Hughes Aircraft for use with the *Falcon* missile.

Panel removed shows BMD test bomber defense missile's circuitry for control and guidance.

Ideally, ground radar picks up enemy intruders at maximum range and tracks them. Intercepters are sent aloft and homed upon the attacking force by a control system inter-related with the ground radar, a lead collision course being automatically set and flown.

At a pre-set distance the intercepting aircraft's control system takes over, locks on to the attacking force, corrects for intercept and launches the air-to-air missile. The pilot has very little to do with the whole operation.

Countermeasures would appear to be governed by the following factors: Being warned immediately that ground radar is in contact with his aircraft, the attacking pilot will know that defensive intercepters with air-to-air missiles are to be expected within a short while. His immediate reaction might be evasive action such as dispensing chaff and possibly low level operations.

Presumably he would also make preparations to neutralize the anticipated missiles. Such devices as decoys and standard disruption of radar procedures might be used. In the case of the infra-red type guidance, advanced methods of diffusing heat could be used to deflect the missile from the target. A more expensive and complicated device would be the anti-missile missile which is currently being considered for the *Hustler* (B-58) intruder.

Air-to-air missiles are equipped with a variety of warheads each designed for a different purpose. The isotropic warhead or unoriented charge fragments in all directions while the non-isotropic or directional warhead concentrates its power into a single direction. This latter procedure involves a delicate fuze design to determine the whereabouts of the target.

The blast type warhead was conceived as a high pressure device and has an effect similar to that of a depth charge upon a submarine.

There has been some conjecture as to what effect radiation would have on the delivering agent as well as the target.

In defensive action this weapon presumably would be used only over the sea, large open friendly areas or in enemy territory. The thermal warhead, a fire raiser which can be chemical or nuclear or the environmental warhead, designed to put either the crew or propulsion system out of action by a chemical agent of some kind, can be equally lethal.

The selection of a suitable fuze presents quite a problem to the systems engineer as well as the designer. There are many types although the missile and warhead tend to dictate the design of this extremely important component. The timed, proximity and impact fuzes are commonly used.

Since the destruction of a target is intimately coupled with the detonation of the warhead at exactly the right moment, the correct selection of a fuze will be decisive in any attempt to abort an enemy air attack.

Despite the difficulties inherent in the nature of aerial warfare and accentuated in the air-to-air missile system, new and advanced techniques are continually being developed to make the vehicle more efficient and deadly.★

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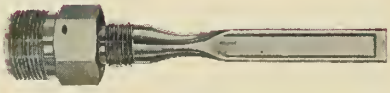

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Basic resistance at 0°C = 120 ohms.

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Missile Progress by the Corps of Engineers

By Maj. Gen. David H. Tulley, U.S. Army

Commander, U.S. Army Engineer Center

TECHNOLOGICAL and engineering achievement in the missile field has made possible weapon systems of of such potential as to revolutionize our defense organization, tactics and techniques. We find ourselves egging industry on to new accomplishments while scrambling to keep abreast of advances already made.

Pressed by time and the technological advances of others, the Army's Corps of Engineers has been engaged in providing engineering support to the development and testing of the Army guided missile program and the packaged nuclear reactor power program.

Engineering progress in this field is indicated by successful development of such support equipment as the *Nike* ground installation elevator, electrically controlled and hydraulically operated. The elevator brings the missiles from underground storage boxes to above-ground firing positions.

The present *Nike Ajax* elevators are 52 feet long and 9 feet wide; they weigh approximately 12½ tons; the vertical travel is 18 feet. These elevators are being modified to accommodate the larger *Nike Hercules*.

Construction of *Nike* sites is an established mission of the Corps of Engineers. Because of distances imposed by safety regulations, a below-ground site requires only 25 per cent of the real estate area required for above-ground installations.

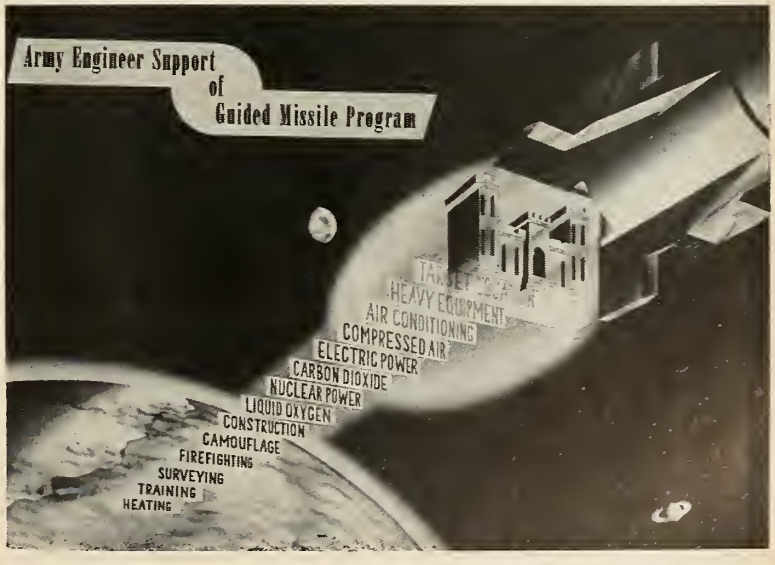
This advantage represents significant economy in expensive metropolitan real estate. Such construction also necessitates installation and control of heating and air conditioning units.

These units are required in radar control vans to assure greater accuracy and lower maintenance. In addition, it is necessary to provide the missile with a positive fuel feed and high control surface reaction against supersonic pressures. Therefore, high pressure air is required.

This high pressure air must be moisture and dirt free. It is supplied by gasoline-engine powered, multiple stage, 3500 psi air compressors. Another part of the Corps of Engineers' share in ground support equipment is the exacting demand for electrical power for the acquisition radars and guidance systems. These systems require both 60-cycle and a 400-cycle electric power.

In the continental U.S. the Corps of Engineers provides frequency converters to change commercial 60-cycle power to 400-cycle power required by the radar vans; 30, 45, 60, and 150 KW generators for standby and for field use are also provided.

The equipment found at *Nike* sites is maintained by engineer-trained anti-aircraft artillery specialists, backed by engineer field maintenance and depot organizations. The engineer-trained anti-aircraft artillery specialists number 1,200 trained each year at the Engineer School. On completion of training, the soldier specialists report to one of the many *Nike* sites.



Army's Corps of Engineers support of the Army's guided missile program is illustrated in this artist's drawing, showing areas of back-up programs conducted by Belvoir engineers.

Progress to date has been significant. Missile ground support has come a long way and we have learned to establish specifications and design criteria for ground equipment in a short time.

Most significant effort of the Corps of Engineers may well be support of the *Redstone* missile. This support is in the field of liquid oxygen. It is rather difficult to handle under field conditions, is vulnerable to enemy action and boil off losses are high.

The LOX units must be air transportable. Working with other military and civilian agencies, the Corps of Engineers has designed and has in production 5-ton per day, 20-ton per day, and 50-ton per day air-transportable LOX plants.

Firing sites require construction effort on access roads and bridges; thus the need for construction equipment in this ground support phase. In non-tactical areas our military construction program meets the demand for testing installations, laboratories and other missile support activities.

We now provide a 25-ton truck-mounted crane with a 90-foot boom to assemble and raise the missile to the firing attitude from transport position.

Solidified CO_2 is the next item. This generated product is used to cool the *Redstone* guidance mechanism. It is necessary to generate the CO_2 in one plant, solidify it in the other and then saw it into "cocktail" cubes for ease in handling and packing aboard the missile. Anticipated development of better heat-resistant electronic components will make this equipment obsolete. However, its retention with our missile fire fighting equipment is assured.

One of the most challenging problems faced by the Corps of Engineers is target location. The system for locating the target must be compatible with the guidance system for the missile.

Map making has been refined and improved but still requires air or ground control of the area being mapped. After survey, data is compiled and the printing done—two tons of 1/50,000 scale maps or 42,000 sheets will be required to cover the trajectory of one missile.

Actually only two sheets are needed, one for the firing site, the other for the target area. Topographic details between these two are of no consequence but the accurate extension of direction (azimuth), elevation and range from the launching sheet is critically important and is a big problem.

Much effort is presently underway in this problem area and considerable progress has been made. Electronic digital computers have reduced by years the time required for geodetic control adjustment. Theodolites accelerate field survey. Geodimeters and tellurometers measure distances electronically. Radarscope photography maps the ground through clouds and darkness. The earth satellite will help too.

The Corps of Engineers is working on electronic systems to locate photographing aircraft with respect to known terrestrial reference points. Perhaps the answer lies in establishing electronic targets in the sky.

If we can establish such a target and hit it, the ballistic trajectory will take care of the rest. We would then be using an electronic cantilever instead of tons of maps for the preplotted trajectory.

Another subject of interest to the Corps of Engineers because of its association with missile programs, is the subject of nuclear power.

The primary military advantage of nuclear power and heating plants is the potential logistic savings in transporting conventional fuel. As a consequence of this reduced logistic load, military operations are less dependent on long lines of supply and, therefore, less vulnerable to enemy action.

Operations can be more flexible since increases in power may be obtained without too significant increases in logistic effort. More electric power from such sources than heretofore available will substantially affect future planning where large quantities of relatively fuel-free heat are desired. The use of small portable reactors in a given situation could make feasible an operation which might otherwise be marginal.

Recognizing the military advantages of nuclear power plants, the Secretary of Defense assigned to the Army the responsibility for representing the military services in carrying out a research and development program with the Atomic Energy Commission. This responsibility within the Army has been placed on the Chief of Engineers.

At the present time, a joint Army-AEC program has been established to develop a family of nuclear power plants to meet the requirements of the three services. The plants are to provide power and/or heat in remote inaccessible locations, devastated areas, combat zones and CONUS disaster areas. The large plants will be capable of use in areas where logistical support is difficult, costly, or vulnerable to interruption by enemy action.

Smaller plants could be developed as mobile or semi-mobile compact power plants for support of military operations in theaters of operation and for emergency power requirements. It is contemplated that the mobile plants will be mounted on trailers or barges and that the larger semi-mobile plants will be in the form of air-transportable modules that can be coupled together rapidly in the field of operation and that can readily be moved after operations. Considerable progress has been made in this field. (See article in June 1957 M/R p. 66) ★

Corps of Engineers Support

It takes research scientists and development engineers to design a missile that works on the test range. But it takes the Corps of Engineers to turn it into an operational weapon.

Nearly every phase of missile field support is the responsibility of the Army Engineer. His duties involve use of such things as missile carrying vehicles, fire fighting apparatus, high pressure air compressors, liquid oxygen generation equipment, fuel and liquid oxygen transport trailers and storage containers, camouflage equipment, electric power generators, cranes and other erector equipment.

He is a cornerstone in the ABMA structure.

Out of the cooperatives effort with ABMA has grown a vast research, production and testing network—a far cry from the inadequate facilities that housed ABMA two years ago. Additional facilities are being added as needed.

While he is mainly concerned with this construction program, the Army Engineer's job periphery stretches over a wide area and includes problems of missile logistics, mapping and geodesy, troop support, equipment and supplies, chemical, electrical and mechanical engineering.

A typical day might find him making decisions involving the preparation of plans for new buildings, roads or power plants to giving advice on employment and technical problems or on a new mobile LOX plant.

In addition to its support of ABMA, the Corps of Engineers has also been busy at Redstone Arsenal and White Sands Proving Grounds. It is closely tied to technical services activities. The Corps has assigned representatives to these agencies for consultation and to act as liaison.

Progress in Army Missile Research and Development

By Maj. Gen. August Schomburg, U.S. Army

Assistant Chief of Ordnance for

Research and Development

THE EXTREME requirements for accuracy demand the ultimate from the missile guidance and control engineer. Guidance and control systems present problems which probably surpass any others in the history of military research and development. The guidance and control problem encompasses all items necessary in predicting the missile's flight path, sensing deviations from this path, calculating the kind and amount of corrections needed to return to a new predicted path, translating the corrections into commands, transmitting the commands to the control equipment, translating the commands into necessary control forces, and continuously monitoring the overall functioning.

The problem areas encountered in the design and development of accurate guidance systems for Army missiles are further complicated by tactical requirements.

In the field of surface-to-surface missiles, the Army has a need for a family of field artillery missiles to provide all-weather direct and general support for land, airborne, and amphibious operations. These missiles, carrying appropriate warheads, must accurately extend beyond conventional artillery coverage.

They must also supplement and extend the capabilities of support aircraft. They should provide high accuracy and destructive effectiveness on such targets as tanks and fortifications and furnish supporting fire of required accuracy for combat troops making deep penetrations such as airborne assaults or armored breakthroughs.

The characteristics of enemy weapon systems, missiles as well as aircraft, determine the guidance requirements for anti-air missiles. To be of full value in this atomic age an anti-air missile must have the guidance capability to inactivate a hostile warhead. This puts increasing demands on guidance system designers for greater accuracy capability.

Countermeasure invulnerability is a prime requirement of any effective weapon. The counter-countermeasures design objectives may be stated as designing equipment so that successful countermeasures are technically impossible, tactically not feasible or economically unprofitable.

The design of counter-countermeasures features of Army equipment is undertaken at the very earliest date in the initiation of any new missile project. In order to build a system which will most likely be used five to fifteen years in the future, the designer must consider not only existing and proven countermeasures but must ask himself what can be expected in new countermeasure designs during this period.

It is important to allow for future system improvements as new components become available. These enable us to produce an effective system on a tight schedule and still take advantage of new techniques at the earliest possible date.

The design must be confirmed after it is established and tested by the designer. Normally, other agencies are engaged to study the design both from theoretical and practical aspects. These studies, which extend to actual and simulated missile flights where countermeasures are used, lead to many design improvements.

While capture is an extreme case, security leaks can be almost as damaging and planning ahead in design can reduce and eliminate the possibility that a system may have to be abandoned because of a counter-measure compromise.

The Army has and will continue to meet and exceed the countermeasure threat by following this procedure: appraising the counter-measure environment, designing accordingly, critically evaluating the design.

Another formidable problem which the weapon system developer must meet is that raised by propulsion. In the early days of missile development liquid rocket propulsion was the only way to obtain the high thrust and the long burning time necessary to meet the high performance requirements of the system. Liquid propulsion motors were used in such successful developments as *Corporal, Nike-Ajax* and *Redstone* missiles.

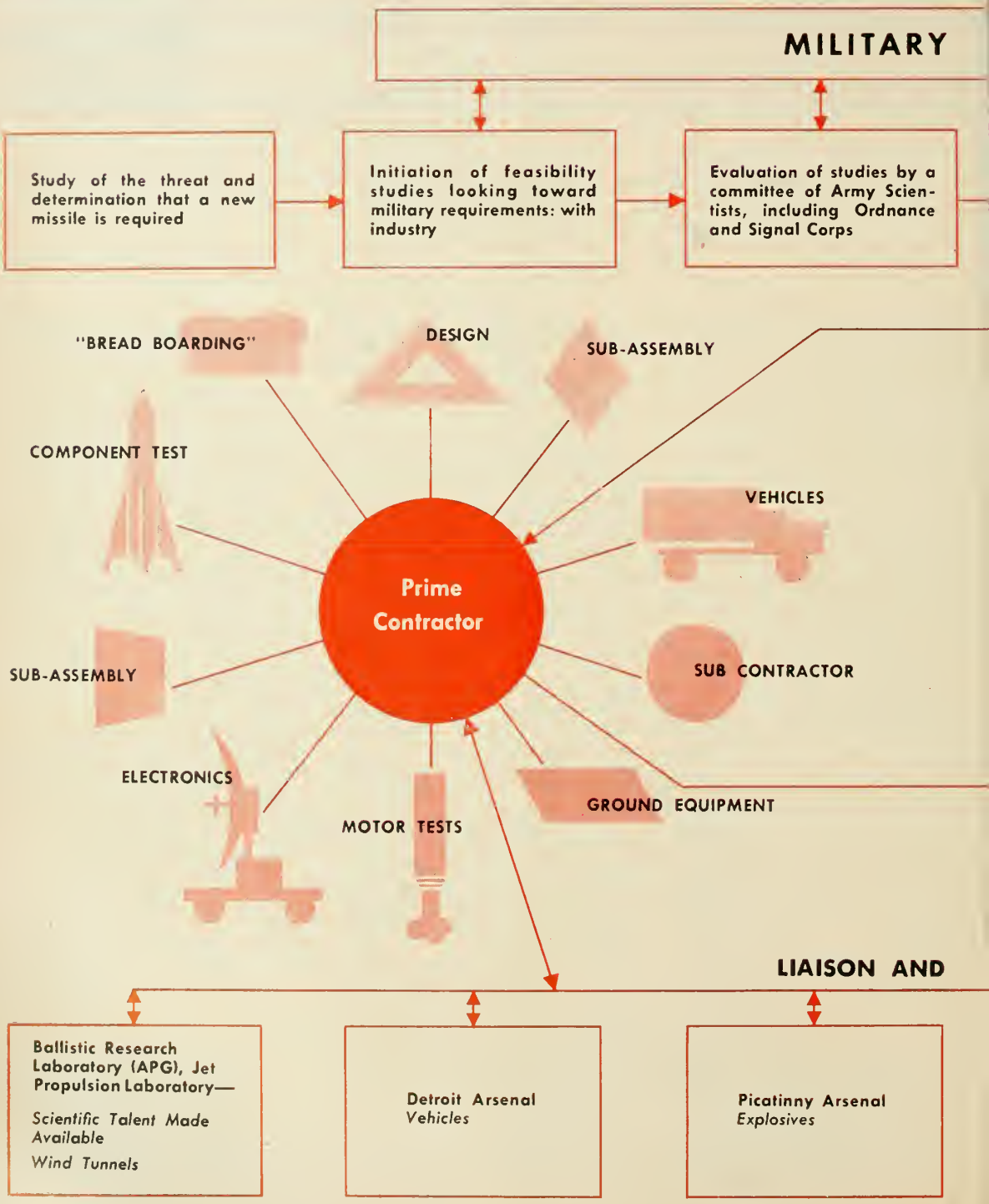
As time went on research and development agencies of the Army Ordnance Corps established the feasibility of adapting solid propellants to the propulsion problem, based on prior successful experience with free rockets using double base propellants.

At the same time, the agencies indicated that ceilings existed for this type propellant. These ceilings limited performance to such a degree that for certain propulsive requirements, other methods would have to be devised.

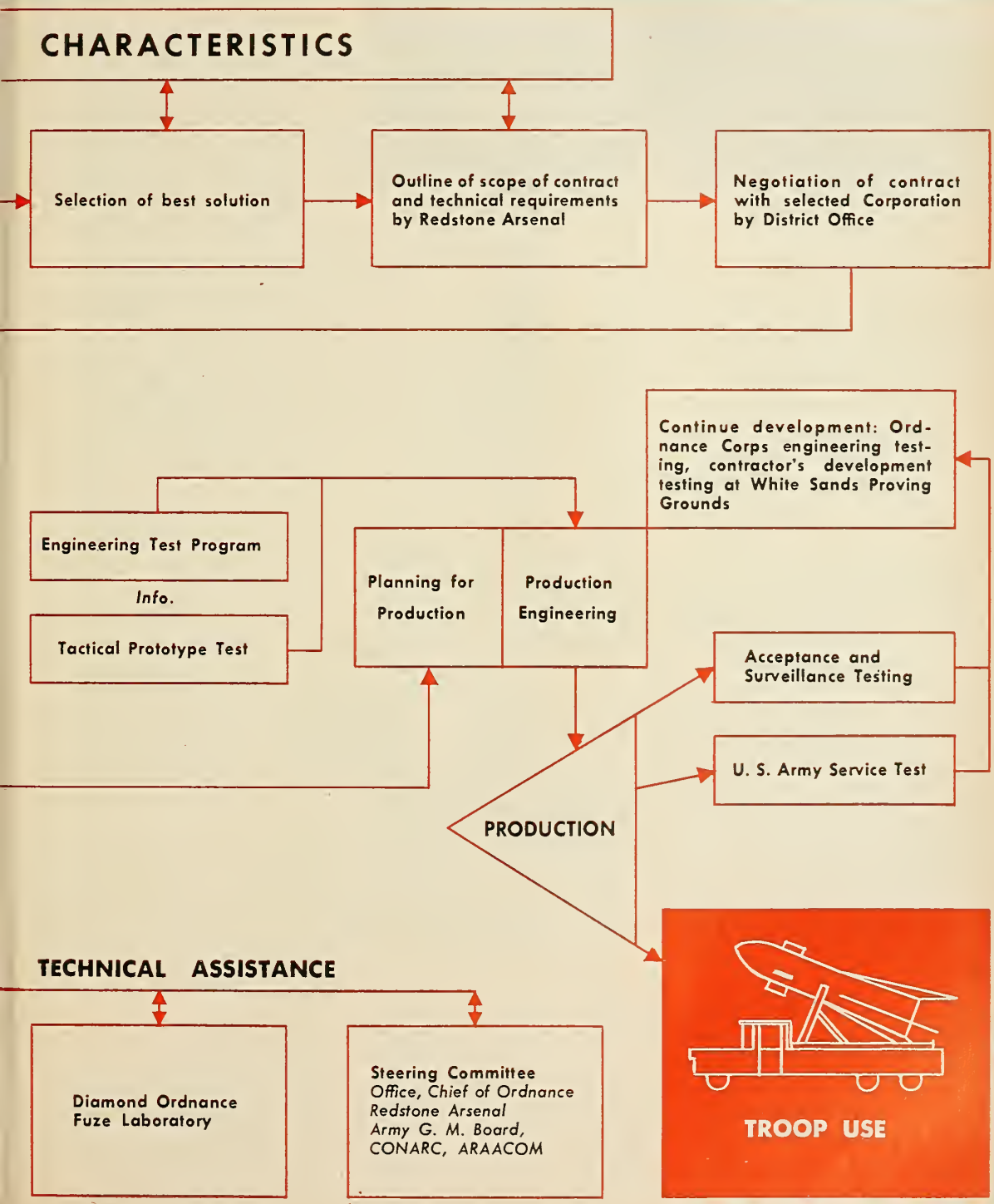
The restrictions, however, were not sufficiently stringent to void application to such systems as *Honest John,* the *Nike-Ajax* booster and the currently developmental *Little John.*

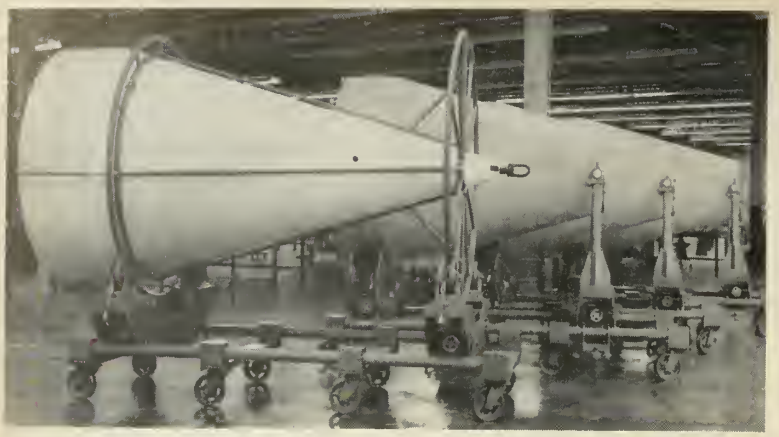
Anticipating more demanding applications, the Ordnance Corps research agencies devised a new approach to solid propellant development culminating in the composite family. This major breakthrough opened new opportunities of meeting tactical problems previously

PROVIDING AN ARMY



MISSILE | From Basic Conception to Production, One Program Would Follow This Pattern:





Army missile policy: research and development by a coordinated Army agency, production by the American industry. In this case: Redstone nose cones by Chrysler Corporation, Detroit.

considered beyond solution.

With the use of this tool, systems such as *Lacrosse* and *Dart* have been developed as practical front line weapons able to destroy the enemy's defense network while maintaining a high degree of safety for friendly troops.

New vistas of air defense have also been opened by current developments using these propellants in high performance surface-to-air missiles. Continuous evaluation of enemy attack capabilities and persistent research effort in the field of composite propellants, has made defense against the possible ballistic missile threat a reality from the propulsion viewpoint.

While major advances have been made in the fields of accuracy, countercountermeasures and propulsion, technological advances in aerodynamics, mechanics and aircraft design have followed a parallel course.

Current development programs are using data from the still expanding library of aerodynamic and structural information. Transonic, supersonic, and hypersonic aerodynamic study programs are furnishing data on platform, surface cross-section, over-all configuration, boundary layer conditions and aeroelasticity.

Current research programs in the field of aerodynamic heating at high Mach numbers and controlled motion in rarified air and under vacuum conditions are showing the way to meeting future threats.

It should be emphasized that although the missile itself is a spectacular instrument of destruction, it cannot function alone. Even after guidance, propulsion and ballistics and structures have been perfected, the missile is inert and unless the without the equipment for transporting, preparing, testing and launching. The same painstaking design, testing, redesign, manufacture, and inspection required for an effective weapon must go into every item of ground equipment. Accomplishments are illustrated by the following examples:

Vehicles. In one system now in an advanced stage of development, the number of vehicles required to launch a missile has been reduced by 60%, as compared with the system it supersedes. The corresponding weight reduction is even greater. An even more important result is the reduction of approximately 60% in trained manpower requirements.

Propellant Handling. In several of the older systems, highly corrosive, toxic and inflammable propellants constituted a major problem. In many instances these have been replaced by solid type propellants which require little special equipment and fewer men for handling. This, of course, makes possible a faster rate of assembly and handling, with a corresponding improvement in firing rate.

Launchers. The complexity and reloading time of launching equipment is being reduced. In some instances automatic control is replacing manual operations. Extensive investigations of blast effects and launcher tie-down requirements have been made. These have included tests to determine the most effective deflector configurations and the optimum deflection angle.

Some of the more recent designs of blast deflectors use aluminum to reduce weight. In order to reduce launcher tie-down problems, the reactive forces of the exhaust gases have been employed for launcher stabilization. As a result these problems have been reduced in newer type launchers. Mobility and the time required for placement of some launchers have been improved.

Pre-flight Checkout Equipment. Methods and equipment for pre-flight checkout have also undergone striking improvements. An early missile system required four manhours for missile checkout and many of the checks required a high degree of judgment.

A later system reduced this to three manhours. Another system has reduced this to two-thirds of a manhour and the checks are all of a go, no-go type which require no interpretation by the operator. One recent guided missile only requires one-twentieth of a manhour for checkout.

Target Simulators. Another important achievement in testing equipment is the newer type programmed target simulator. This is a most imporant accomplishment from the standpoint of economy and reliability. With this type tester a series of commands selected to test the missile's performance capabilities can be recorded on a magnetic tape.

These are fed to the missile control system and the responses are recorded. This type of testing can be used to replace much of that formerly done with target drones. In addition to the money saved by eliminating the need for expensive drones and the trained men involved, other very important advantages result.

Drone tests are not repeatable. When a malfunction occurs in a missile flight against a drone, an attempt to duplicate the test may not result in the same malfunction even though the same defect is present. In the tape-controlled test, the commands can be duplicated any number of times.

The testing of missile capabilities must obviously be limited to the ability of existing drones to execute the required maneuvers. Guided missiles must be designed to meet the threat from planes and missiles now under development which will be in the air from four to seven years hence.

The target simulator is the only device available for this type of tests. Also, since the time and money required for this type of test are much less, faster and more complete performance evaluation is possible.

It must be stressed that problems continue to exist and that obsolescence is an ever prevailing specter. But each day under the guidance of the Army weapon systems development agency, the coordinated effort to provide the Army's arsenal with adequate missiles for both offensive and defensive action is continuing apace.

We have made significant progress. The proof is in *Nike-Ajax, Corporal, Honest John*—already in the hands of troops—and in *Nike-Hercules, Hawk, Dart, Lacrosse, Sergeant,* and *Jupiter*—soon to be released. Ground-to-ground, air-to-air, ground-to-air, we have made them all. And they work.★

Rocket Logic in Retrospect

...t the Deacon finished the one-hoss shay.

Now in building of chaises, I tell you what,
There is always *somewhere* a weakest spot,—
In hub, tire, felloe, in spring or thill,
In panel, or crossbar, or floor, or sill,
In screw, bolt, thoroughbrace,—lurking still,
Find it somewhere you must and will,—
Above or below, or within or without,—
And that 's the reason, beyond a doubt,
That a chaise *breaks down*, but does n't *wear out*.

But the Deacon swore (as Deacons do,
With an " I dew vum," or an " I tell *yeou* ")
He would build one shay to beat the taown
'N' the keounty 'n' all the kentry raoun';
It should be so built that it *could n'* break daown:
"Fur," said the Deacon, " 't 's mighty plain
Thut the weakes' place mus' stan' the strain;
'N' the way t' fix it, uz I maintain,
Is only jest
T' make that place uz strong uz the rest."

So the Deacon inquir... the village folk
Where he could find... oak,
That could n't be sp...

Oliver Wendell Holmes never dreamed of intercontinental missiles or thermal thickets when he penned "The Wonderful One-Hoss Shay". Yet, a hundred years later, no sounder logic exists for the designer of rocket cases. In the ideal rocket design, where a pound less weight can mean miles more distance, all sections should be exactly of identical strength. No part should be one iota stronger or weaker than the rest.

Fulfilling Dr. Holmes' "picture of the impossible" to the ultimate degree has been M. W. Kellogg's aim from the time it began designing and fabricating rocket cases for the Navy Department in 1951. Since then the company has continued to participate in the research, development, and production of a wide range of missile and rocket propulsion systems.

Organizations interested in putting the Kellogg team to work on their specific rocket problems are invited to write.

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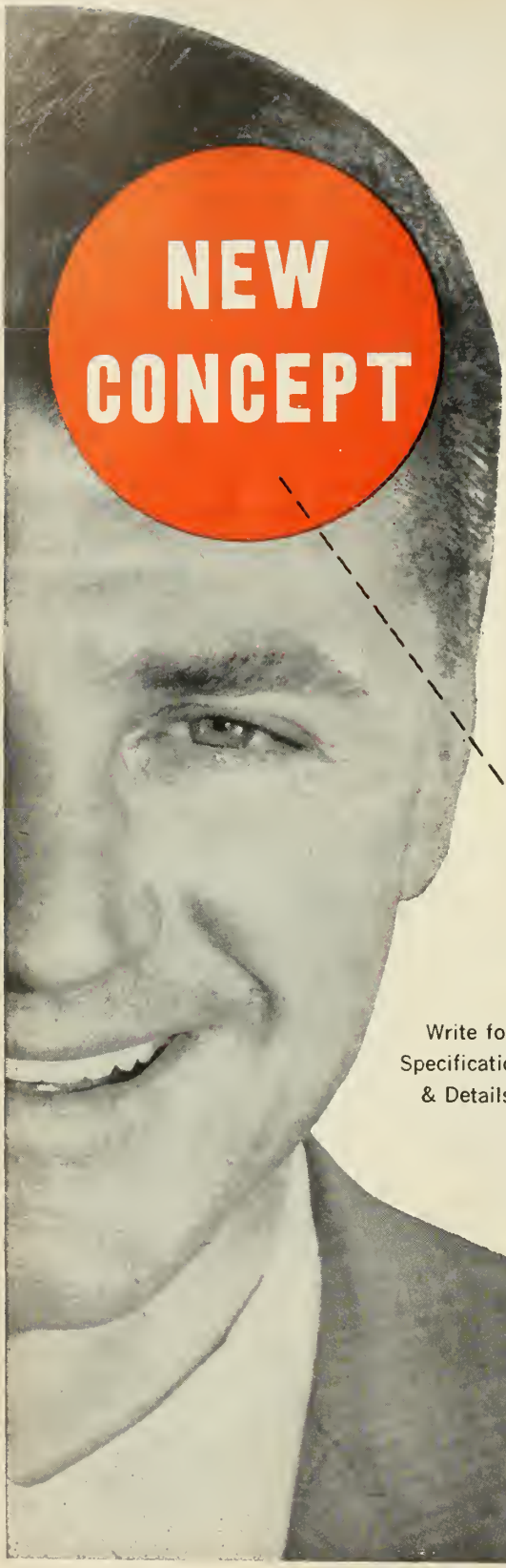

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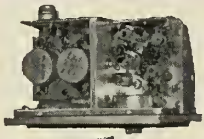

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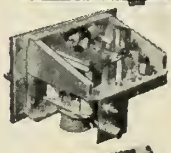

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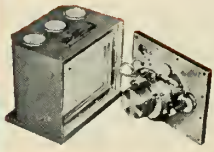

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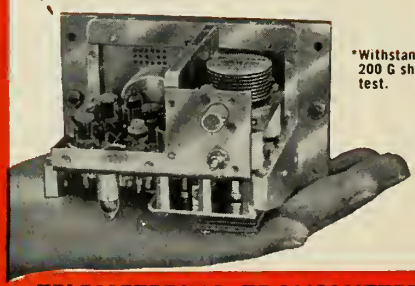

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Upper Air Research Progress . . .

Navy Rockets and the Future of Man

By Rear Admiral Rawson Bennett
Chief of Naval Research

THERE IS ONE unknown that has always been mankind's greatest challenge, and that is the heavens above. Today we simply call it space. We have constantly sought to solve the enigma of heavenly phenomena particularly our own moon, the planet and the stars. And deep within us there has always been the urge to soar through the skies and reach those other worlds.

Soon man will take the first step toward achieving that goal. A man-made sphere will be rocketed 300 miles into the upper atmosphere at a speed of 18,000 miles per hour or nearly five miles per second. This sphere, only 20 inches in diameter, will then circle the earth like a tiny moon while it automatically sends back information to us.

This project is the next logical step forward. The earth satellite heralds a new era in what might be called space research, presaging the day when man himself will venture into outer space.

In 1923, the Naval Research Laboratory was established to carry out broad research in the physical sciences. It is this laboratory, now under ONR management, that is chiefly involved in the development of the earth satellite and launching it into space.

The Office of Naval Research was itself a pioneer organization when it was established in 1946. It was the first military agency specifically designed to support research on a large-scale basis. ONR's chief mission is to finance and promote research by academic and commercial laboratories in virtually every field of science.

Since 1946, ONR's program in upper atmosphere research has been accumulating important scientific data that is achieving both these ends. The knowledge that is being gathered has enabled scientists to gain a better understanding of cosmic-ray activity and very high altitude weather conditions.

If our aircraft are to navigate at heights approaching 100,000 feet at speeds of Mach 5 or more we must have far more accurate information on air density, pressures, and temperatures as well as cosmic radiation at those heights. If we are to achieve any considerable improvement in radio and television communications and long-range electronic detection devices, we must know a great deal more about the ionosphere and magnetic field above the earth which have a controlling effect on radio signals.

The ionosphere is a region of rarified, ionized gas which exists at levels between 50 and 250 miles above the surface of the earth, and our means of studying it from the ground are extremely limited. This complex region of the atmosphere is interrelated with solar activity, geomagnetic disturbances, the aurora, and cosmic rays which are very high-energy-charged particles that come from somewhere in outer space and bombard the earth in all directions.

Each of these phenomena must be studied in relation to the others. For example, magnetic storms that frequently are associated with radio blackouts are connected with sunspots which in some way affect the energy distribution and total flux of cosmic rays.

More precise measurements of the fluctuations in cosmic-ray activity may permit a correlation of these two phenomena. This may ultimately give us the ability to predict periods of poor communication due to solar storms much as weather is predicted today.

The upper atmosphere holds the keys to many of the basic secrets of the universe, yet until the advent of the high-altitude sounding rocket it was like a rolled up scroll that gave us only intriguing peeks and glimpses of its contents.

The first rockets used in upper atmosphere research by the Navy and others were the German V-2's, of which more than a hundred were available after World War II. Most of the V-2's hit altitudes of about 100 miles with one reaching 117 miles.

Convinced by the experience with the V-2 that there were immense possibilities in the use of research rockets, the Navy in 1946 became the first to order rockets specifically designed for upper atmosphere research. That year the Office of Naval Research in close cooperation with the Navy's Bureau of Ordinance ordered the *Aerobee*, which was designed and developed by the Applied Research Laboratory of Johns Hopkins University and the Aerojet-General Corp.

The first full firing was made in November, 1947. Later it was somewhat modified to become the *Aerobee-Hi*. It has been in continuous use longer than any other research rocket and will be one of the chief rockets used in the upper atmosphere experiments of the International Geophysical Year.

Both the *Aerobee* and the *Aerobee-Hi* are much smaller than the V-2 —about 23 and a half feet long and 15 inches in diameter, with the *Aerobee-Hi* generating a thrust of 4,000 pounds. Yet this Navy rocket has been able to travel considerably higher and faster than the V-2, recently reaching a record altitude of higher than 180 miles (possibly 190 miles).

In 1946 ONR's Naval Research Laboratory ordered the large *Viking* research rockets which would be able to carry payloads approaching the 1,000 pounds of the V-2. Developed by The Martin Co., the *Viking* was 48 feet long but reduced to 42 feet in later models. The 14th and last of these rockets was recently fired.

The diameter of the first series was two feet, eight inches. later in-

creased to four feet for the second series. The 8,000 pound fuel load consisted of liquid oxygen and ethyl alcohol, generating a thrust of about 20,000 pounds, far less than the V-2, but the weight of the *Viking* was also considerably under the V-2, ranging from 10,000 to about 16,000 pounds.

The *Viking* rockets, carrying payloads some of which were only 100 or 200 pounds less than the V-2, consistently reached far higher altitudes than the V-2 and in 1954 established the record for single-stage rockets with a height of 158 miles. Although this record has been recently broken by the *Aerobee-Hi,* the payload of the latter rocket is only a few hundred pounds as compared to 825 pounds for the record-breaking *Viking.*

Both the *Aerobee* and the *Aerobee-Hi,* which was first fired in 1952, are "boosted" rockets, in which a JATO-type solid-propellant booster assists the rocket at the start of its flight and then falls away after about three seconds. The fuel is alcohol-aniline and nitric acid which sends the rocket at speed faster than 4,000 mph.

Some of the instruments carried in its nose cone measure the rocket's performance, particularly propulsion, aerodynamics and structure. In recent flights the instruments planned for use in the earth satellite have been carried in a section just below the nose cone.

In one recent flight, instrumentation roughly equivalent to the weight of the satellite included two thermistors for measuring temperatures within the instrument section, a differential pressure gage for comparing internal and external temperatures, three micrometeorite microphones, a solar aspect cell, a Lyman-alpha ion chamber, a satellite Minitrack telemetering transmitter, and the necessary power for the transmitter.

A photoelectric cell was mounted on the side of the rocket to determine the aspect or vertical position of the rocket with respect to the horizon. A solar battery, which weighs considerably less than the mercury-cell battery that will power the transmitter in the first satellites, was also flown to determine its suitability as a power source for the satellite.

Scientific data obtained by the satellite package were telemetered back to earth during the flight via the Minitrack system, while rocket performance data were telemetered by the more conventional *Aerobee* system. The micrometeorite microphones, just as they will on the satellite, detected the sounds of micrometeors or "meteor dust" hitting the skin of the rocket.

One of the phases of the Naval Research Laboratory's rocket research program is high-altitude photography. The first reasonably good high altitude photographs were obtained on a V-2 rocket flight in April, 1947. Little improvement in definition or altitude was achieved until the 1954 record-breaking flight of the eleventh *Viking* previously mentioned.

The 158 miles reached by this rocket is the greatest height from which photographs of the earth have ever been taken. The pictures were made with a 4 x 5-inch K-25 aircraft camera. Sheet-metal housings for the camera were used in the earlier flights but these frequently opened on impact and the film was exposed. Recovery became satisfactory when it was decided to wind the film into a steel casette.

One of the basic problems in rocket research in the upper atmosphere is the expense. The *Aerobee-Hi* rockets, which cost less than the *Viking,* run between $30,000 and $40,000 per rocket. Partly for this reason the Navy has sponsored the development of smaller rockets that are launched from balloons or aircraft.

The balloon-rocket method, known as the *Rockoon,* was developed by Iowa State University. This method combines the 12-foot solid-propellant *Deacon* rocket produced by the Allegheny Ballistics Laboratory with the high-altitude plastic *Skyhook* balloon, which lifts the rocket at a speed of about 800 feet per minute to altitudes generally ranging from 50,000 to 70,000 feet.

At a fixed altitude a pressure switch in the firing gondola closes, setting off the igniter inside the rocket and firing it in an almost vertical direction. The rocket burns for approximately two seconds, but with the aerodynamic drag of the lower altitudes eliminated this is sufficient to send the rocket to altitudes of 50 miles or more.

Another method known as *Rockair* uses aircraft which are sent up to altitudes of 40,000 to 50,000 feet, at which point rockets capable of reaching heights of about 100 miles can be launched.

The nose cone of the *Deacon* rocket contains a small FM transmitter, which telemeters signals from a geiger counter, ionization chamber or pressure and temperature instruments.

The radio signal is received on the ground station where the detector signal is unscrambled from the FM carrier. This signal is then amplified and recorded by a Brush recorder on a moving strip of paper. This makes it possible to determine the cosmic-ray intensity or temperature, pressure and density at any time during the flight.

During the IGY the Navy will play a prominent role in gathering information on the upper atmosphere both through the earth satellite program and through exploration with a number of *Aerobee-Hi* and *Rockoon* and *Rockair* rockets. Most of the *Aerobee-Hi* rockets will be launched from Fort Churchill, Canada, which is on the edge of the northern auroral zone.

This research will be directed especially to the aurora and to the ionosphere and solar radiations in the auroral zone. The *Rockoon* combinations, to be launched from ships in the Pacific, will be used in getting data on solar ultra-violet and X-ray emissions during solar flares.

There are many unknowns that must be known before we can seriously consider space travel. If the duration of the flight is long, the effects of cosmic and solar radiations on humans must be determined, and we are only beginning to study their effect on living cells. Another risk difficult to assess at present is the probability of meteor collisions.

Although this hazard has been estimated and various schemes proposed for eliminating it, none have ever been tested. In a long flight elaborate equipment requiring a continuous power source will be necessary to provide the human passengers with the necessities of life. This equipment, along with that needed for the navigation of the vehicle, will have to be completely automatic and reliable because the long flight would probably impose terrific physical and psychological strains on the passenger.

These and other serious obstacles can be overcome only by a relentless program of basic research. We have yet to fully understand the theory of combustion in a rocket motor. We need more research on fuels, on high-temperature metals and ceramics and on new methods for cooling the inner walls of rocket motors and the outer skins of high speed airframes.

The most direct way to attack such problems is through the development of more and better sounding rockets that can ascend far above the altitudes thus far reached. The achievement of practical, reliable, unmanned satellites is also essential.

Rockets and satellites are our best laboratories for space flight research. They are undoubtedly the predecessors of future space ships.

Although space may eventually be a future field of battle, it is a narrow view to consider rocket research as largely military in nature. It would be equally shortsighted to dwell primarily on the material benefits that might be derived from exploring other planets. The one product that makes the entire program justifiable and undeniably worthwhile is knowledge. It is the same product that characterizes all basic research.★

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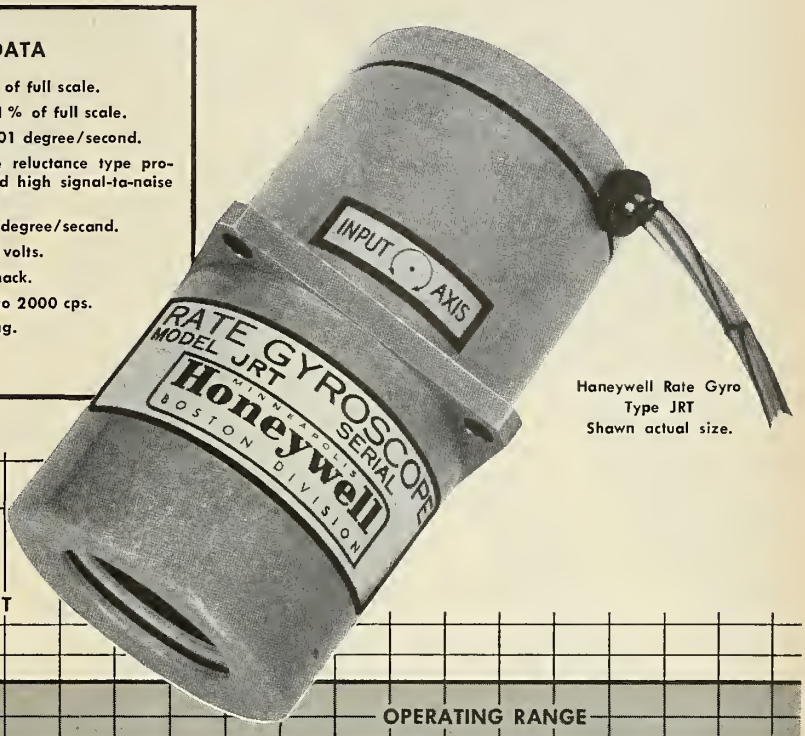

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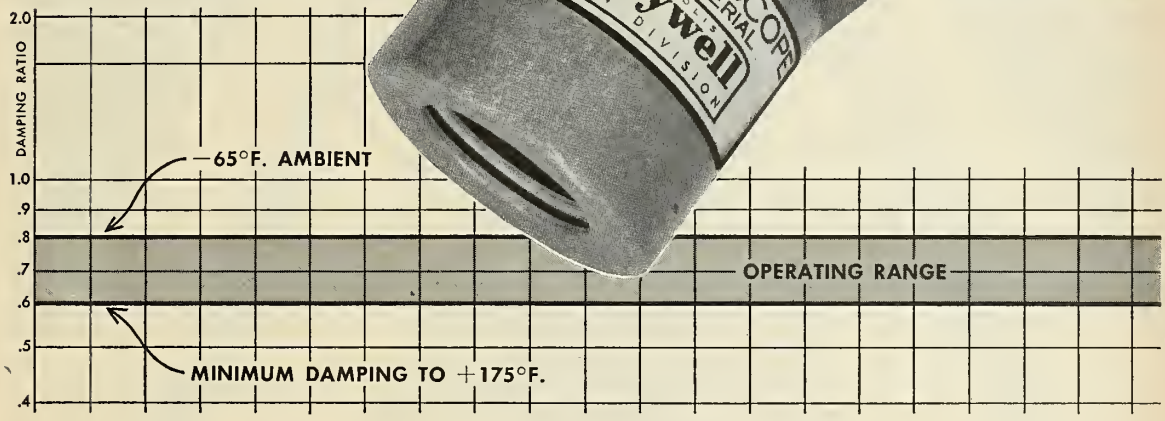

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By Rear Admiral John E. Clark U.S.N.

Director, Guided Missiles Division

Office, Chief of Naval Operations

Navy Missile Progress:

Death of the Big Gun

THE NAVY'S INITIAL missile effort was directed towards basic research. Early work included firing the *Aerobee* and *Viking* rocket series to obtain cosmic radiation data from very high altitudes. Other work tested new ideas and approaches to specific problems such as the feasibility of firing a supersonic missile and controlling it during flight.

One of the earliest missile programs was initiated in 1945 by the Bureau of Ordnance to develop a surface-to-air guided missile. The contract for the research and development of this project was awarded to the Johns Hopkins Applied Physics Laboratory and assigned the now famous code name *Bumblebee.*

The Applied Physics Laboratory was staffed with an outstanding group of scientists and engineers who had done a great deal towards the wartime development of the VT fuze. Their *Bumblebee* program has made great progress and is responsible for the development of all of the Navy's current surface-to-air missiles. Research was also undertaken to develop missiles in the air-to-air, air-to-surface, and surface-to-surface categories.

The *Bat,* an active homing glide bomb, was developed by the Bureau of Ordnance in cooperation with the Bureau of Standards and sank several Japanese ships at the end of World War II. It carried a small radar in the nose which was given a target by the pilot in the mother aircraft prior to launch.

Once launched, the *Bat* homed on its target without further assistance, allowing the aircraft to maneuver as desired. Although successful, *Bat's* short range and slow speed soon put it in the obsolete category.

Another early missile was the *Lark* developed by the Bureau of Aeronautics and Fairchild Aircraft Corp. to prove the feasibility of certain homing techniques. The *Lark* was surface launched and flew at subsonic speeds. It was quite successful and in 1950 knocked down an F6F drone with a direct hit.

This was the first example of what has become an ever-increasing Navy problem, namely that guided missiles have such small miss distances that they frequently splash the expensive drones even without using a warhead.

In the surface-to-surface category, the Bureau of Aeronautics redesigned the German V-1 Buzz Bomb for firing from a submarine, the *USS Cusk.* The *Loon,* as it was called, pioneered a command guidance system, explored the possibilities of pulse-jet propulsion, and gave the Fleet practical experience in developing defenses against guided missile attack. This was also the first time a missile was fired from a submarine by Fleet personnel.

The build up was commenced at such facilities as the Naval Ordnance Test Station, China Lake (Inyokern) Calif.; the Naval Air Missile Test Center, Pt. Mugu, Calif.; the Naval Aviation Ordnance Test Station, Chincoteague, Va.; and the Naval Ordnance Missile Test Facility, White Sands Proving Ground, N.M.

Many now have extensive laboratories and engineering staffs and have made numerous contributions to the solution of such problems as telemetering, flight data reduction, drone control, and miss distance measurement techniques. At least one has been responsible for conceiving and designing an entire new missile system.

For shipboard testing, the Navy converted the 15,000 ton seaplane tender *USS Norton Sound* to handle missiles. To date, she has fired a variety of missiles that would rival the record of any shore facility. These include *Loon, Lark, Aerobee, Viking, Regulus,* and *Terrier.*

Later, in 1952, when the *Terrier* program needed extensive shipboard testing and evaluation, the old 35,000 ton battleship *Mississippi* was given a *Terrier* battery aft. The "Old Miss" has since gone to the scrap pile but before she did the *Terrier* became "the new Fleet weapon."

Early R&D missiles were handmade by scientists and engineers at nearly prohibitive costs. These were R&D missiles and frequently bore little resemblance to the final production weapon. Operability prior to a particular firing was established by a team of scientists and engineers that gave the missile a most rigorous check-out.

The team members were frequently the same personnel who built the bird. These procedures were necessary with the state of the art at the time but out of the question for a service shipboard missile. A great deal of improvement would have to be made in this area. The missiles would have to be reliable and rugged over a tremendous range of service conditions and yet be maintained by relatively untrained enlisted personnel.

Another lesson learned was the advantage of the "weapon system" concept. In this approach responsibility for the entire system's design is vested in one central activity. Coordination of design can be much more closely controlled and the function and importance of a given part can be kept in proper proportion. This is particularly important when a unit is under development and frequent design and production changes are the order of the day.

Related to this approach is the assignment of contractor responsibility. Formerly contracts were let by the technical bureaus for each piece of a system. The complexity of a guided missile system and the necessity of designing each piece to maxi-

High over the Mojave desert, a Sidewinder missile is fired from a Navy jet fighter and streaks through the air for a kill against a target drone. Sidewinder is one of the most potent weapons in current use. Future versions will employ infra-red self-homing guidance.

mize system performance led to the development of two new types of contractual agreements. In one, a designing agency is selected to be responsible for the R&D and basic design.

Other firms are then selected to be the production contractors for the pieces of the system using the basic designs given them. The designing firm remains responsible for the overall system design and coordination but the production contractor is responsible for his hardware.

In the other type of agreement, one contractor is made responsible for system design, coordination and production. He sub-contracts but is still responsible for the finished product. Both techniques have their place and the selection is usually based upon the complexity of the system and the individual capabilities and organizations of the contractors.

Developing a missile from the R&D stage to shipboard service normally starts with a series of test vehicle flights to prove out the basic ideas. When this is completed and the necessary design changes made, a series of prototype missiles are fired. These are hopefully similar to the final product and are the first test of the complete missile system.

Upon successful completion of this phase, a test of the first production pilot line missiles is commenced. This is supposed to work out the bugs so that the production line version is reliable. Lastly, the production line missile is evaluated and released to the Fleet. During this whole time problems arise and have to be solved.

The missile might be exposed to icing conditions in the North Atlantic or to temperatures above 100° in the South Pacific. In one case the wing controls and launcher shoes must be kept operable despite ice formation. In the other, the missile electronics must be able to stand long periods with warm up power applied without overheating from the combined effects of sun and internally generated heat.

The missile must be able to withstand the continuous vibration of a ship yet be so sensitive in flight that it can detect the slightest acceleration. Missiles must be stowed aboard ship so that they are readily available for action but be safe as possible. Fire, shock, battle damage and inadvertant ignition are hazards of the trade.

What do you do, for example, if a rocket engine goes propulsive in a magazine? How do you store a volatile inflammable like av-gas in a submerged submarine full of electrical equipment with sailors who like an occasional smoke? These problems have to be solved before the missile can be accepted for service use.

Another thorny problem area is missile reliability and check-out. How do you produce a missile which has thousands of components yet is always ready to go when you want it? It has been found that one way to lick this is to allow the production contractor to start his production engineering and reliability work as early in the program as possible, preferably in the test vehicle stage. This gives him time to work out the bugs before his designs are finalized.

A good test and maintenance philosophy is required. What components should be tested in the field, how often should they be tested and, if a component fails, what level of repair and replacement should be used? These are extremely important questions affecting not only the missile and the test equipment but such areas as logistics and training as well.

Our present thinking is to have test equipment which tests the missile components known to have a relatively high failure rate or whose function is particularly important. This is a "go-no-go" test and pinpoints a fault only to a replacement level.

Then a package replacement is made and the faulty package is turned in for repair to a depot. The degree to which the package replacement is carried depends upon many factors such as reliability, test equipment simplification, cost and ease of maintenance.

In these days of fantastic budgets missile costs have to be reduced. This problem is attacked across-the-board. Designs are examined for producibility and component economy. Standard "shelf" items are used where performance isn't penalized.

Interchangeability of parts between missiles or components within a missile help to increase production and cut down unit cost. Logistics are thoroughly investigated and planned to increase efficiency and cut costs.

Missile transportation from factory to dockside has to be worked out carefully. The possibility of high explosives detonating in public transportation has to be minimized, yet speed of delivery is important. Missiles in transit are unavailable and this effectively means buying more missiles. Will the missile fit in the conveyor, can it be handled by the equipment available at the transfer points, will handling damage the missile? These and other questions must be answered.

Consideration must be given to the training of personnel so that at the time of a missile release adequately trained personnel are available. To do this schools and courses are set up, usually during the final stages of the missile R&D. Sometimes courses are conducted at one of the Navy's training centers such as the Fleet Air Defense Training Center at Dam Neck, Virginia.

In other situations a school may be set up right at the contractor's plant. Naval "Guided Missile Units" are set up to assist in the R&D flight testing and provide a trained manpower pool for future expansion. GMU-21, for example, did the shipboard testing of *Terrier* in the *USS Mississippi* and then provided a nucleus of trained personnel for the first missile cruisers, *USS Boston* and *USS Canberra.*

The Bluejackets have now taken over from the scientists and engineers and missiles are handled aboard ship entirely by Naval personnel. Reliability has improved if anything and the Bluejackets have shown that they are fully capable of maintaining and operating their new weapons.

These are a few of the problems along the road of developing service guided missiles.★

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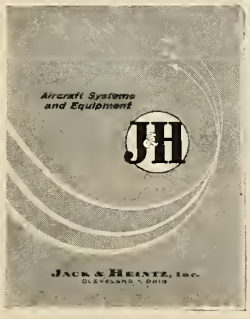

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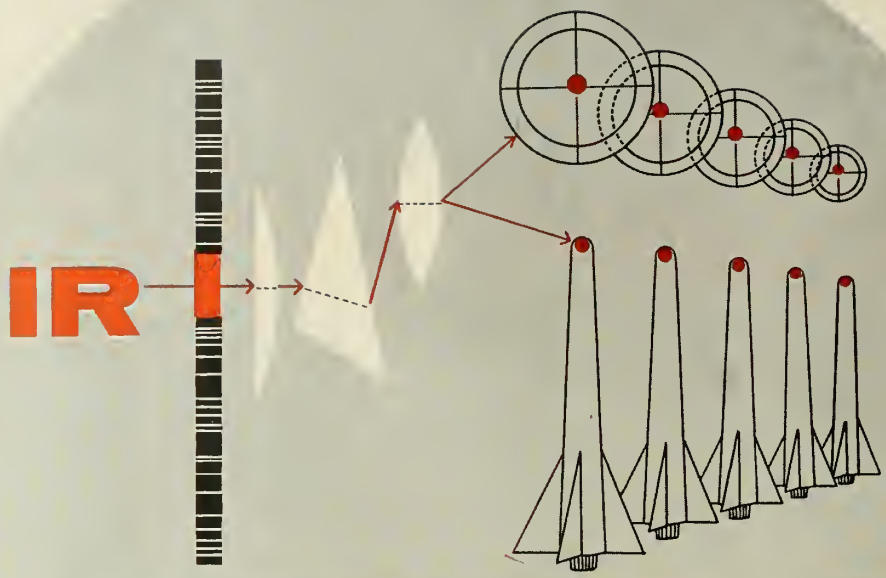

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Progress in Air Force Scientific Research

By Brig. Gen. Hollingsworth F. Gregory, USAF
Commander, Office of Scientific Research (ARDC)

ALL STRATEGIC and tactical military planning is evolved from an "estimate of the situation." This can be prepared only on the basis of the most complete knowledge possible of friendly and enemy weapon capabilities and the factors of personnel, material, communications, terrain and weather. The fighting man puts weapon capability, terrain and weather at the top of his estimate.

It is important for the airman to have full knowledge of his theater of operations—the atmosphere and the space around it—as it is for the infantry to know the surface of the earth. He must be acquainted with every aspect of the atmosphere or space, its environment, our own and the potential enemy's capabilities. This includes vehicles, weapon systems and closely related human factors.

We must adapt the old infantry rule to the aerial dimension: "Take the high ground."

Elevation is as important to the airman as it has ever been to the rifle-bearing soldier. There is no aspect of space which can be ignored if we are to obtain intelligence essential for domination of this future theater of operations.

The weapons and vehicles of this theater demand an exploratory effort equal to that of the new environment itself. Exploration is of value only as its findings are correctly interpreted and usefully related to solving the military problems at hand.

The mission of the Air Force Office of Scientific Research, an agency of the Air Research and Development Command, is the encouragement of exploratory effort, the understanding of its results and the utilization of its findings for the present and future needs of the Air Force. AFOSR's contribution to the estimate of our present defense situation and future potential helps the Air Force maintain a dominant position on the "high ground."

Our method of operation includes making our mission known to research sources, examining their lines of investigation and providing whatever support and guidance they may need.

To accomplish this we seek help from our academic and industrial laboratories. AFOSR and its military and civilian personnel are charged with the sole task of recognizing the military implications of this work and supporting with funds, tools, procurement methods and communication, those persons who can supply us with the essential ingredients for our changing estimate of the situation.

Materials are our initial problem. Recent breakthroughs in propulsion technology have presented us with rigorous new parameters imposed by higher altitudes, the thermal barrier, accelerated corrosion, protection from radiation and stresses due to ever-increasing performance requirements.

An AFOSR-sponsored study with great promise is under way at the Institute of Engineering Research of the University of California. Because upper temperature limits of commercially available metals are approximately 1700°F., investigators at this university proposed a study to improve the ductility of refractory ceramics.

Stimulated by Joffee's disclosure in 1924 that normally brittle crystals of sodium chloride become ductile and deformed when immersed in warm water, the investigators recently attempted similar work with crystals of potassium chloride and silver chloride. These investigations showed promise and have received our support.

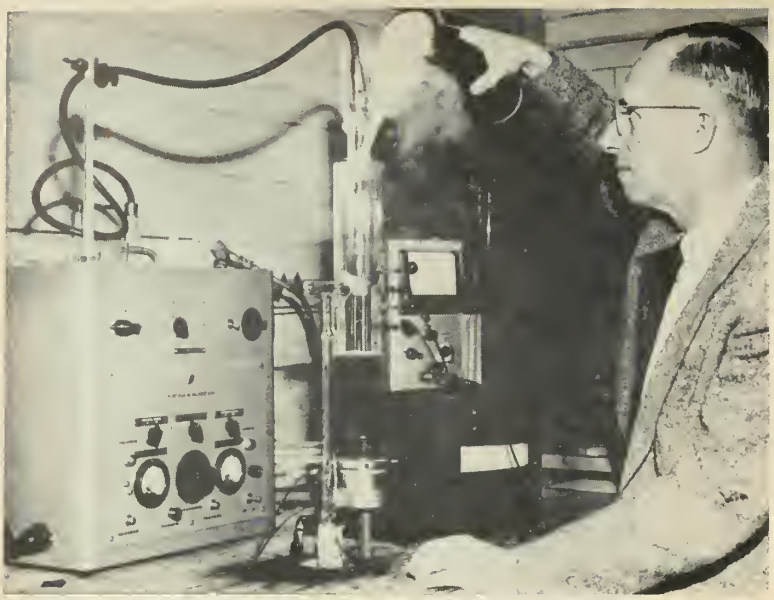
The cost of this program is less than that of three conventional 2½-ton military trucks. AFOSR's recognition of its implications may save countless millions in future airframe and powerplant development.

Our future fighting vehicle undoubtedly will traverse the highest regions of the atmosphere, where it will be subjected to constant bombardment by intense ultraviolet radiation. Knowledge of the reaction of light metal shells to this radiation is important. Recognition of this stimulated AFOSR's interest in the work of Drs. H. Margenau at Yale and B. Henke at Pomona College. They are both investigating the absorbtivity and emissivity of metals over the wave length of 10 to 1000 angstrom units.

The reaction of light metal shells to the extreme ultraviolet and soft x-ray regions is a special area of AFOSR interest. Incident radiation is an important factor governing the equilibrium of missile skin temperature. Indications are that certain light metals and alloys, by exposure to selected wavelengths, may give enhanced absorption properties.

Many materials for Air Force application may evolve from studies under way at the University of Florida. A group under Dr. George E. Butler is tracking down new methods and answers to the problems of polymerization. Substituting silicon, phosphorus, selenium, germanium, zinc, or sulphur for nitrogen in allyl-derived polymer may yield new high-temperature materials. Among these are nonflammable lubricants, antioxidants, and new types of oil-resistant synthetic rubber.

When metal foil is bombarded on one side by positive ions, it ejects metallic atoms from the other side. This phenomenon, discovered by Dr. L. G. Parratt of Cornell University under an AFOSR contract, may provide



Dr. Erwin W. Muller, Pennsylvania State University Physics Professor pours the cooling agent into his field ion emission microscope for photographing single atoms.

new methods of mass spectrometry which will greatly enhance techniques employed in the analysis of solids.

The work described here is a very small representation of AFOSR's total effort in this area. The importance of this knowledge to a valid estimate of our technological situation cannot be stressed too heavily.

The performance of a vehicle and its potency are largely governed by its propulsion system. Many AFOSR contracts aim for a major breakthrough in this field.

Since the early development of liquid-fuel rockets, extensive research effort has been devoted to the evaluation of various fuel and oxidizer combinations BMW (Bavarischen Motor Werke), for example, evaluated some 3,000 fuel-oxidizer combinations for the Germans during the Second World War. AFOSR contractors are studying conventional fuels, and hoping to obtain a better understanding of the combustion process.

AFOSR work in propulsion involves many vital areas of investigation. Three can be mentioned here: studies of ultra-energy fuels, solid propellants and flame speeds. The problem of propelling vehicles longer distances at higher altitudes involves fuels with higher specific impulse than current, conventional, chemical compounds.

Aerojet General Corp., under AFOSR contract, is investigating the use of free radicals and atoms to augment burning rate and thrust. It has been discovered that stable molecular particles can be made to dissociate into free radicals if enough energy is introduced from an external source to break their chemical bond.

When the recombination of these particles occurs, the energy release is tremendous. The bulk of U.S. free-radical research is now being carried out at the National Bureau of Standards under a tri-service contract. However, AFOSR had sponsored some of the initial investigation in this field.

Studies of flame speeds must necessarily accompany investigation of propulsion methods. AFOSR has a number of contracts involving flame speeds. The fact that turbulent flames have higher speeds than laminar flames has been established, but as yet attempts to correlate speed with the intensity of the turbulence have been only partially successful.

Research efforts at the Bureau of Mines have disclosed an important anomaly: Indications are that turbulence intensity accounts for the increased flame speed at Reynolds Numbers of 50,000 to 100,000, but not for increased speed at lower numbers.

Investigation disclosed that flame speeds had a maximum value close to 25,000 rather than an increased speed in direct proportion to the increase in intensity. Flame-speed studies are becoming increasingly important as attempts are made to achieve better yardsticks for the measurement of the combustion processes.

Research has given us two new devices which have application as spectrometers, amplifiers, or oscillators. They were by-products of recent molecular and nuclear investigations sponsored jointly by AFOSR, the Office of Naval Research, and the Signal Corps Engineering Laboratory, and are known as the solid-state maser and gas maser. (Maser is short for microwave amplification by stimulated emission of radiation.)

These devices have military applicability almost as widespread as that of the transistor, but they will not compete with the transistor in use. The solid-state maser may give us (1) a low-noise variable microwave amplifier, (2) an extremely sensitive device for long-range radar detection, (3) better components for a long-range celestial navigation device, and (4) more accurate missile-guidance and weapon-firing systems.

The gas maser promises to yield extremely accurate frequency standards which means an accurate clock for use in electronic navigation and guidance systems. In addition it will make possible a better device for reducing data obtained by use of photoelectric cells.

The principle of the solid-state maser was evolved by Dr. N. Bloembergen at Harvard University. Hycon Eastern is now applying it to some of its weapons-development programs. The gas maser was brought about by the work of Dr. C. H. Townes at Columbia University. It is currently being applied to the development of improved long-range navigation systems by Rome Air Development Center.

A project promising considerable new information about the ionization density in far outer atmosphere and the way in which very low frequency electromagnetic waves are propagated at some 20,000 miles above the earth is now underway. Dr. R. A. Hellwell is investigating the "whistler" mode of propagation, at Stanford University under AFOSR contract.

The "whistler" is an atmospheric disturbance in the audio-frequency range resulting from lightning discharge. If sufficient ionization is present some of the energy of the discharge will be guided along a line of the earth's magnetic field through the ionosphere and far into space, returning to the earth as a dispersed wave train at the other end of the magnetic field line.

It has been demonstrated by the transmission of manmade signals between Annapolis and Cape Horn (approximate conjugate points of an earth's magnetic field line), that the "whistler" mode of propagation is real and can be used for communication and guidance systems. This research may uncover new possibilities for vehicles traveling far out from earth.

The "whistler" also offers a new "probe" into the properties of the outer atmosphere, notably the variation of

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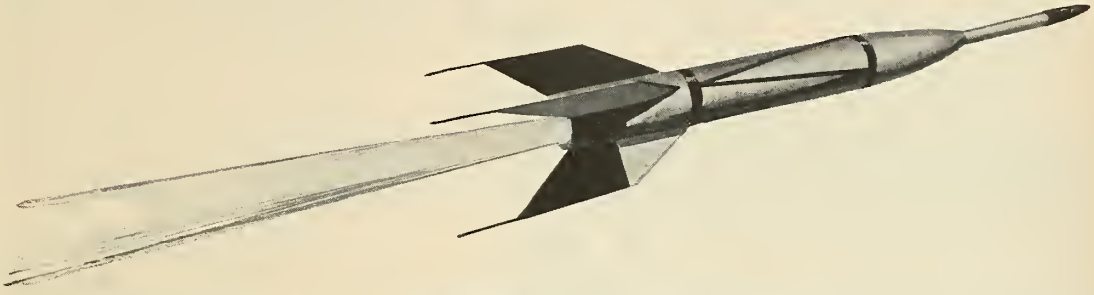

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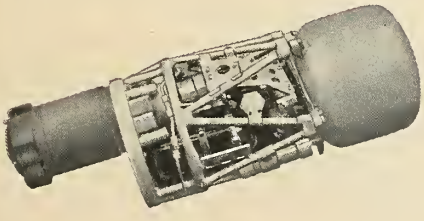

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ambient ionization density with distance and the existence of the "ring current" which should be found between 25,000 and 35,000 miles from the earth.

This research will provide information on ionospheric irregularities, velocities of solar streams entering the atmosphere and perturbation of the earth's magnetic field, thus providing a better theoretical interpretation of magnetic storms and aurorae, both of which strongly affect communication and guidance.

Obtaining accurate estimates of future propulsion, materials and guidance and communications characteristics of our future weapon implies a complete study of its aerodynamic characteristics. To gain this knowledge, AFOSR is sponsoring work of great importance in rarefied gas dynamics.

In addition to the results of the basic work in this field, much has been developed in new equipment for better study and understanding of related problems.

A major breakthrough occurred under an AFOSR contract with the Cornell Aeronautical Laboratory. This was development of a shock tube, a facility for realistic testing of configurations in an air-flow of 10,000 mph and at temperatures of 9000°F for longer periods of time than previously had been possible.

This facility incorporates a "wave superheater," a new departure which increases the length of time an object in the tube is exposed to the heat and pressure of the shock wave. This factor of prolonged exposure permits more sustained and closer observation of the effects of heat and hypersonic flow around objects placed in the tube.

Further valuable knowledge concerning the field of high temperature will be forthcoming as a result of the record-breaking achievements of Dr. A. V. Grosse, at the Research Institute of Temple University, in Philadelphia.

Dr. Grosse's group, working under an AFOSR contract, has succeeded in mixing cyanogen and oxygen to achieve a temperature of 4500°C. By mixing carbon subnitride and oxygen, this group has attained a temperature of 5000°C. Dr. Grosse and his staff have also produced a flame from pure ozone.

With the exception of a small region near the nose, modern high-performance aircraft flying at high speeds are confronted with boundary-layer turbulence. Results of an AFOSR-sponsored study of the interaction of shock waves with turbulent boundary layers have been applied to design of better diffusers, closer predictions of control effectiveness, predictions of separation on supersonic wings and bodies and improved design criteria for the flow passages in supersonic compressors. The past year's work has resulted in the first complete series of tests covering a range of Mach numbers 1 to 4.

Further work toward defining the laws of aerodynamics is sponsored jointly by AFOSR and ONR at the University of Southern California. Results of this work now indicate that skin friction is a much higher factor than existing theories had indicated.

An estimate of the capabilities of our space weapon system would be hopelessly inadequate if we were to ignore the human factors involved. If our vehicle is man-carrying, it must be maintained by men who must be selected, trained and motivated to utilize our system to full advantage in combat.

Whether temporary oxygen deprivation produces reversible or irreversible changes in living tissue is knowledge essential to man's safe existence in a synthetic environment. The Pharmacological Institute of Heidelberg University, sponsored by AFOSR under contract to ARDC's European Office, is investigating this area.

In studying the biochemical changes in brain tissue under low oxygen conditions, attention was concentrated on the phosphate esters which are important in metabolism.

Preliminary experiments on human red blood cells revealed for the first time that anoxia does not change their energy-rich phosphate content. Studies of brain changes produced different results.

Techniques developed by these investigations now make it possible to document all changes in the important compounds in brain tissue whether caused by lack of oxygen or drugs. Research is under way to determine if available chemicals will increase resistance to these damaging effects of oxygen lack.

The Astronautics Symposium held at San Diego last February by AFOSR and the Convair Division of General Dynamics Corp. highlighted the interest and rapid advance in the science of flight.

More than 60 scientists gave papers on various aspects of astronautics, covering such areas as re-entry, tracking and communications, environment and measurements, propulsion, orbits and human factors. The open sessions were followed by a one-day classified session which was highlighted by a talk on "The Military Requirements for Manned Space Vehicles" by Colonel W. O. Davis, AFOSR Deputy Commander for Operations. Over 550 clearances were obtained for this session.

Total symposium registration was over 700. All major press, radio, and television organizations were represented, and the meeting received excellent coverage by all media.

It is clearly recognized today that military success is born of plans conceived by what is known as the indirect strategic concept. Direct strategic concepts are those plans which are evolved primarily to offset known enemy capabilities or intentions.

The indirect approach is predicted on plans evolved from complete knowledge, understanding, and application of our own techniques and weapons, largely independent of hostile influences to our thinking. The few examples of research work mentioned here are a random selection from the more than 600 basic research contracts supported at this time by the AFOSR.★

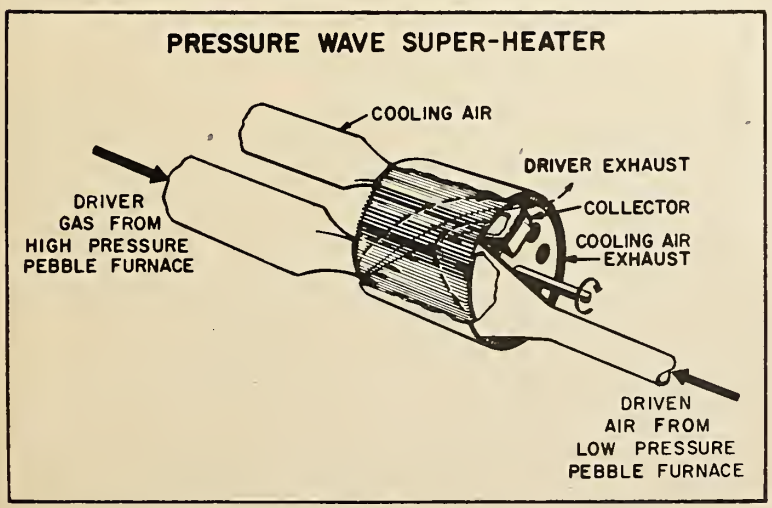

Diagram of a pressure wave super-heater such as that employed to extend the period of test conditions in a shock tube. This is typical of AFOSR-supported research programs.

TECHNIQUES and DEVELOPMENTS
in oscillographic recording

FROM
SANBORN

DESIGN PRINCIPLES AND SOME APPLICATIONS OF A PREAMPLIFIER FOR LOGARITHMIC MEASUREMENTS

THE Model 150-1400 Log Audio Preamplifier (Figure 1), one of eleven plug-in "front ends" now available for 150 Series systems, permits measurements involving logarithmic or exponential functions. The "Log Diode" circuit (shaded portion of circuit block diagram in Fig. 2) is the heart of this instrument, and is based on the logarithmic relationship between the voltage across a thermionic diode and the current through it. If R is large, the current through the diode i_1 becomes proportional to the voltage e_1, and the logarithmic relationship of e_2 and i_1 is transformed into a logarithmic relationship between e_2 and e_1. Circuit constants for this Preamp were chosen to provide an accurately logarithmic relationship between e_2 and e_1, over the range of 200 to .63 volts for e_1. This is a 50 db spread, and the gain of the DC output amplifier (fed by e_2) is arranged so that a 50 db variation in e_1 produces a 50 mm stylus deflection.

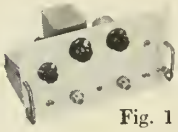

Fig. 1

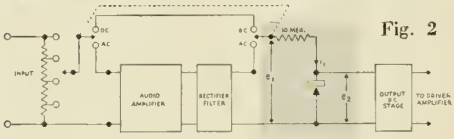

Fig. 2

In audio or AC measurements, e_1 is derived from a peak reading type rectifier-filter circuit, which follows a high quality 20 cycle — 20 KC audio amplifier. With an input of 100 mv RMS, this amplifier will produce a 200 volt output from the rectifier. The 50 db chart, therefore, corresponds to a variation in AC input voltage of 0.316 to 100 mv.

In DC measurements, the audio amplifier is bypassed and the input applied to the diode circuit. Since the diode itself is a rectifier, used in the forward direction with its cathode near ground, the DC input must be polarized with the high side positive.

One broad area of application for the Log Audio preamplifier is audio level recording. For example, room reverberation time can be measured by recording sound level decay after the sound source is suddenly turned off, the reverberation time considered the period required for a 60 db decay to occur. Another example of audio signal recording is the plotting of frequency response curves of audio equipment such as microphones, filters, loudspeakers, etc. A multi-channel recording system with appropriate filters also makes possible audio spectrum analysis.

A second major type of application of this Preamp is the recording of DC voltages on a db basis. If the signals are small, a chopper can be used to convert DC to AC, thus taking advantage of the Preamplifier's audio amplifier. With an impedance matching transformer added to such an arrangement, the system becomes a logarithmic DC millivoltmeter or logarithmic DC microammeter of extreme sensitivity. Such a device could be used for plotting the volt-ampere characteristic of a germanium diode, which might be very helpful in selecting matched pairs of diodes. Another possibility is plotting the output of a fixed gain radio receiver and linear detector to a db scale, to rapidly record antenna performance data.

A comprehensive discussion of the design and these applications of the Log Audio Preamplifier is contained in an article by Dr. Arthur Miller, Chief Electrical Engineer of Sanborn Company, published in the Sanborn RIGHT ANGLE. Copies are available on request.

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Propulsion Engineering

By Alfred J. Zaehringer

RESEARCH LABS OF TWO FIRMS engaged in the high energy fuel program are in for expansion. Olin Mathieson (Buffalo, N. Y.) has a new research lab for defense work. Stauffer Chemical Co. (Richmond, Calif.) is spending several hundred thousand dollars in a major lab addition. American Potash & Chemical is now turning out decaborane at its Henderson, Nev. pilot plant. Capacity: 1 lb/day. Cost: $600-800/lb. Eventual cost under $100/lb.

BORON SPECIALTIES will be produced at a second Callery Chemical plant at Lawrence, Kan. Operational by 1958, the plant will cost some $3-4 million . . . React triethylaluminum, aluminum, and hydrogen at 300 atmospheres pressure and you wind up with ethylaluminum hydride. Ethyl Corp. has made the material which may pay its way as a boron-production intermediate, a fuel, or a fuel-igniter . . . An organic system for production of hydrogen peroxide from anthraquinone has been patented (US 2,791,491) by the English Laporte Chemicals Limited . . . Purdue Research Foundation is working on the production of alpha nitroesters. Propellant use is seen.

FRENCH SEPR FIRM has come up with a line of igniters for non-hypergolic rocket propellants. They use organometallics which ignite on contact with an oxygen-containing oxidant. Materials named are: diethyl aluminum bromide, dimethyl aluminum bromide, ethyl aluminum iodobromide, methyl zinc iodide, and methyl aluminum di-iodide . . . Meanwhile, SNCASE reports that it is using dichromates or permanganates as catalysts in nitric acid oxidant systems. The fuels—mixed amines—as catalyzed with 0.1-5% of iron carbonyl.

HOW MUCH ETHYLENE OXIDE (ETO) is being used as a propellant? US ETO capacity is over ½ million tons/year. Estimates tag propulsion uses at about 10-100 tons/year. At current market prices, this would represent an upper chemical market of about $30,000-$50,000/year. Virtually all ETO goes into APU's for the IRBM and ICBM program.

AMMONIUM PERCHLORATE, smokeless oxidant for composite solid propellants, is now being made on a continuous basis. American Potash & Chemical Co., Henderson, Nev., is turning out about 10 tons/day at the Navy-owned plant. Capacity is 40 tons/day. Since this is the only large-scale US production facility, ammonium perchlorate solid propellants are being produced at the 10-14 tons/day level.

NEW SOLID PROPELLANT gas generating composition: 55-75% ammonium nitrate, 25-45% calcium formate, and ½% calcium stearate. Imperial Chemical Industries developed this pressed charge. The firm has also studied the combustion of methane with oxygen. A CH_4:0_2 ratio of 2:1 gives the most reactive condition. 1:1 is easiest to detonate, while 1:2 was the most flammable . . . Other new solid propellants were patented by Aerojet. One smokeless composite uses trinitrocyclohexylamine (85%) with beeswax (15%). Ammonium perchlorate (50%) and TNT (25%) are used in other propellants using thermoplastic fuel-binders (viz., asphalt-oil) (25%).

CHALK UP ANOTHER COMMERCIAL APPLICATION for solid propellants. NRL has developed a fire extinguisher for use at polar temperatures (to —75°F.). A standard 2½ gal. extinguisher has a head fitted with a nitroguanidine-guanidine nitrate cartridge. The propelling charge gives a 10% increase in extinguisher capacity . . . More lithium compounds for solids are shaping up. American Potash & Chemical is now producing two lithium oxidants—the nitrate and the perchlorate. The latter promises to give the most oxygen per pound of any stable, inorganic compound.

Astrionics

By Henry P. Steier

Air Force countermeasures equipment requirements for fiscal 1957 was $113.3-million. In 1958 it was considerably more. Total $207.3-million. There's lots of room and an especially critical need for advances in this field. Electronics countermeasures techniques used by U.S. are a well kept secret. It's no secret that traveling wave tubes and other wide-band generators are at the heart of the equipment. In the light of Russian radar advances we're falling behind in finding ways to foil their radar. More power and bandwidth are needed.

Superconductivity may give us new jamming capability. Federal Telecommunication Laboratories reports it is applying superconductivity to an Air Force countermeasures problem. Superconductivity causes a metal's electrical resistance to drop to near zero and involves use of very low temperatures such as the 452.2 degrees F used by FTL. This is near absolute zero temperature and sounds like an excellent way to boost radio frequency efficiency in a traveling wave tube, and thus get great gains in power.

Infra-red countermeasures are likely to crop-up soon. *Sidewinder* missile is said to zip right up the tail pipe of a jet plane because its IR sensing cell looks for the highest intensity IR source. Similar, but "hotter" IR-spots might be created by countermeasures flares using a variation of the old thermite incendiary bombs to create the right kind of infra-red source.

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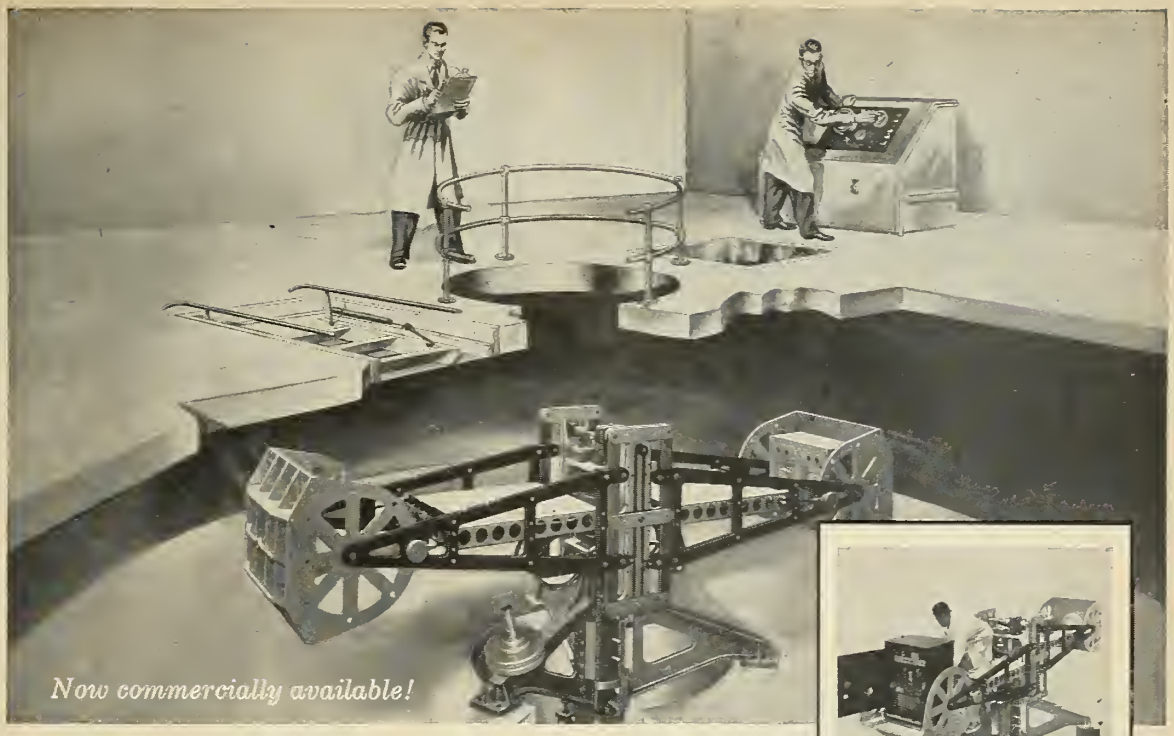
Transducers for missiles are big business. Retirement fund investors apparently think its a stable business. General Electric, U.S. Steel, Bethlehem Steel and Yale University were reported to have invested heavily in Gulton Industries, Inc. recently. Gulton's products are used by every engine, aircraft and missile maker. Important products are accelerometers, pressure gauges, pressure switches, thermistors, ultrasonic equipment, etc. A key material in these is barium titanate which has piezo-electric properties and high temperature capability. They make instruments that work to 800° C. Gulton just sold Convair $1.6-million worth of accelerometer systems for *Atlas* missile project. Devices that fit in palm of the hand cost $900 and have wide sensitivity from ½ to 1000g in one unit. Barium titanate is becoming a critical defense item. Supplied solely by one outfit, Titanium Alloy Metals, Buffalo, N. Y., the material's purity control is a key factor in its application. Even so, Gulton has a six acre lot full of barium titanate rejects. Devices using the material cost $5000-$10,000 per pound according to estimate of Endevco Corp., a competitor in the piezo-electric instrument field.

•

Watch it boys! Original plans to use a two-tone audio signal on a rf carrier to turn satellite's electronics on and off have changed. One tone will be used. Previously reported in this column was big concern of satellite scientists as to whether high-school kids and other amateur hams might build equipment to detect satellites passing and find the key tone to turn it on. John T. Mengel, the satellite's electronics designer says the one tone system will be used because of weight saved. If you don't think weight is a problem, here's the answer. Removal of one tone saves 3 ounces! The press knows the approximate frequency to be used. Let's hope it doesn't broadcast it.

•

It had to happen! A new company known as Kentron Hawaii Limited, Honolulu, advertises: "Why Honolulu? Honolulu is a modern American community in the center of the Pacific and is *2400 miles closer to military electronic problems* in the Pacific area than the west coast of the United States." Kentron manufactures tubes and supplies engineering design services.



New Genisco Centrifuge subjects two 300 lb. assemblies to 100 G's

Genisco's Model E185 G-Accelerator, capable of subjecting complete electronic and mechanical systems to G-loadings that simulate actual flight operation, incorporates numerous unique features that simplify operation, reduce servicing, and allow precision testing to meet the most stringent military specifications.

The absence of belts, pulleys, and gears permits smooth and vibration-free rotation of the 12-foot rotor so that delicate inertial guidance systems can be tested. The machine is rugged enough, however, to accommodate proof-load testing.

Operation is unusually simple. Operator responsibility has been minimized, with many operational functions being accomplished automatically. Numerous built-in safety features afford maximum protection to both personnel and the machine.

These design features, plus wide flexibility in the use of the machine, reduce maintenance requirements, and together with low initial cost make the Model E the best large centrifuge currently on the market. Complete specifications will be sent on request.

SMOOTH, CONSTANT ROTATION—Hydraulic drive system permits a clean, compact design. Problems of backlash, gear noise, and frequent lubrication are eliminated. Wow and drift during a one-minute period are less than 0.5% of the operating rate at any speed.

SIMPLE SPEED CONTROL—A single handwheel, located on a remote-control console, determines boom speed. Speed adjustments are made quickly without reading complicated scales or dials.

AUTOMATIC DYNAMIC BALANCING—The boom seeks a dynamically balanced condition automatically. Manual computation to determine centers-of-gravity is eliminated.

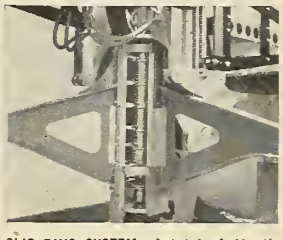
BOOM SPEED EASILY MEASURED—Coarse speed indication is accomplished by a specially-calibrated tachometer, accurate to within 1% of actual speed. Precision measurements are provided by a pulser/electronic counter, on a 4-decade digital display.

REDUCED HORSEPOWER REQUIREMENTS—By utilizing aircraft design techniques and enclosing the structure in an aerodynamically clean compartment, horsepower requirements are reduced to 15 h.p. for a 100-G machine.

BUILT-IN SAFETY FEATURES—Eight safety interlocks, including three which are key-operated, prevent the machine from being started inadvertently. Removal of any key renders the machine inoperable, permitting the operator to make adjustments to the test object in absolute safety.

CLOSED-CIRCUIT TELEVISION SYSTEM—A closed-circuit industrial television system, incorporating a camera, control unit and remote video monitor, can be provided as auxiliary equipment for the optical surveillance of test objects under acceleration.

MOUNTING PLATFORMS LOCK IN FIVE POSITIONS—The mounting platforms can be locked in the horizontal, 45°, 90°, 135°, and 180° positions, permitting test objects to be subjected to G-loadings through several axes without demounting.



SLIP RING SYSTEM—A total of 48 slip rings are provided as standard equipment in a configuration of 24 unshielded leads rated at 14 amperes maximum, and 24 shielded leads rated at 1 ampere. Brush holders have been removed in the above photograph.

REMOTELY OPERATED—A control console permits complete operation of the rotor assembly from a remote position. All operating controls and switches are located on the console panel.

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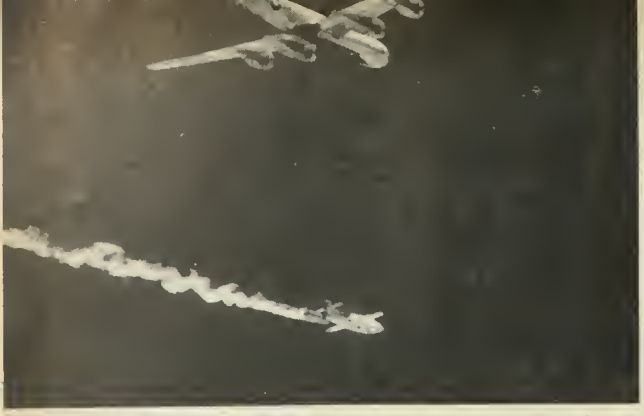


The Bell X-1E was carried aloft by a B-29 over Edwards AFB a few weeks ago for its maiden flight. These exclusive in-flight shots of the X-1E shortly after having been released from the B-29 (and chased by a tracking aircraft) were taken by Loyd Mallan, aviation and science writer. The copyrighted (1957) pictures will appear in Mallan's forthcoming book Rocket Test Pilot.

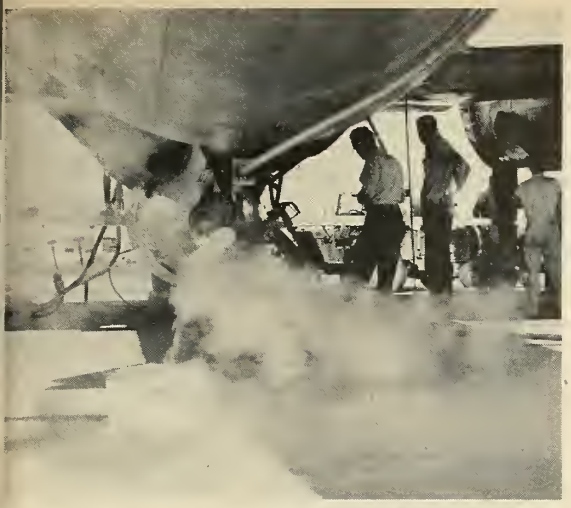
m/r exclusive:

X-1E Goes Aloft

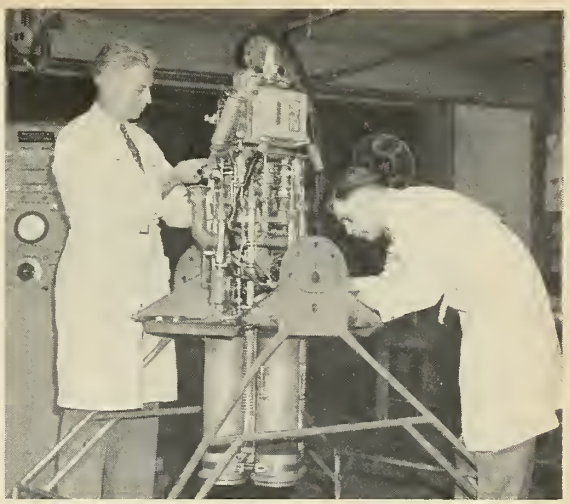
X-1E is prepared for hook-up to its B-29 mother plane. Pilot's breathing oxygen system is checked at Edwards AFB. X-1E uses advanced pilot ejection seat equipment and modified fuel feed system.

Airplane is readied by NACA, Bell and RMI engineers. First flight lasted for a few minutes and was successful. Landing gear was slightly damaged at landing, delaying the second flight.

The NACA X-1E research aircraft was modified from original X-1 (No. 2) employing 4 per cent thick wing (thickness measures 4 per cent of wing cord) produced by Stanley Aviation Corporation Denver, Colorado. Aircraft is built by Bell Aircraft Corporation

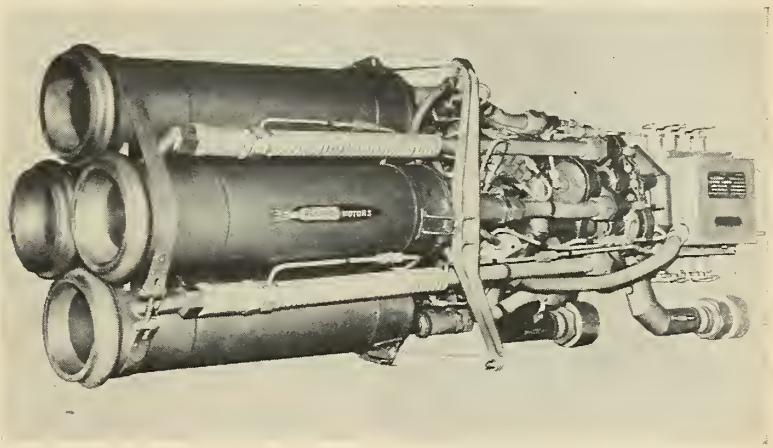


Oxygen is vented to the atmosphere as propellant tanks are being topped prior to takeoff. X-1E has fuel supply for about four minutes. The aircraft obtained a maximum velocity of Mach 2 plus during the first flight. No speed record run was attempted.

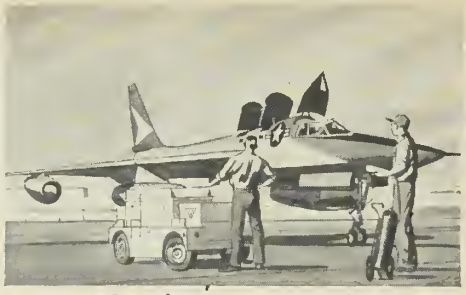


RMI employees, John Wickstead, left, and Holbrook Smith, perform operational check on the 6,000 lb. thrust engine in preparation for test firing. Engine used in the X-1E is designated XLR11-RM-11, basically the same as the one used in the original Bell X-1.

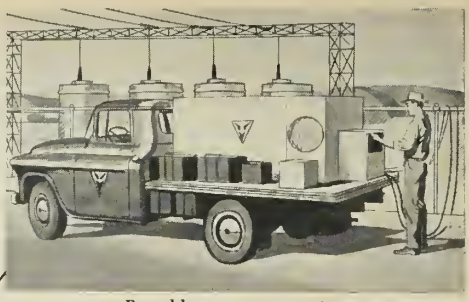
Reaction Motors, Inc., a pioneer company in liquid rocket aircraft engines, has produced a whole series of the 6,000 lb. thrust power plants of the kind employed in the X-1E. The four chambers can be fired simultaneously or in any sequence or combination of one, two, three and four. Each chamber produces 1,500 lb. thrust. Output is controlled by cutting off one or more chambers. Engine uses liquid oxygen and alcohol; pump drive employs peroxide and catalyst.



Static test of RMI's FLR11-RM-11 rocket engine at company's New Jersey facility. These engines have been built under both Navy and Air Force contracts. RMI now is working on similar power plants of much higher thrust for tomorrow's experimental rocket aircraft.



Ground support for jet aircraft.



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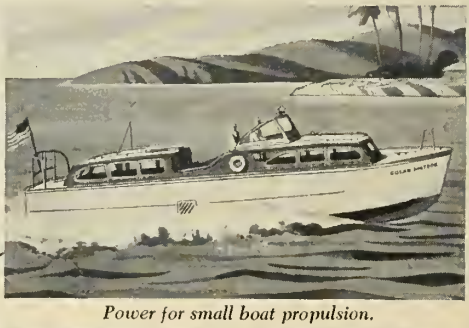
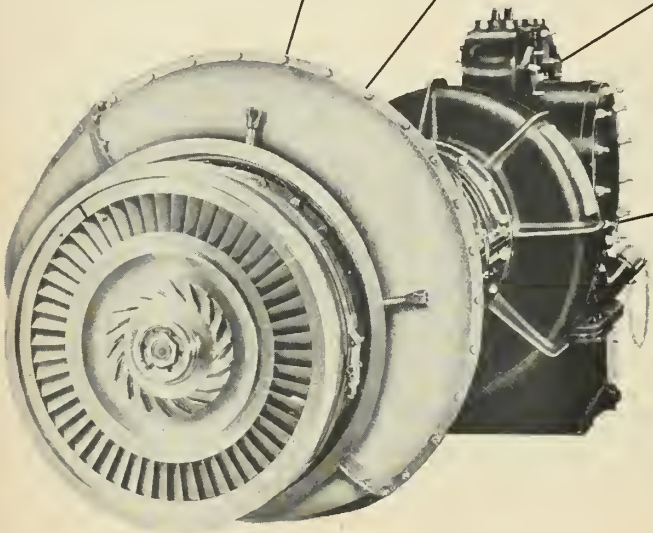
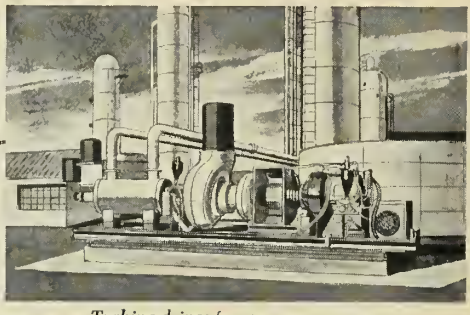


Power for small boat propulsion.





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at the start of the IGY . . .

Project *Vanguard*

Past, Present and Prospects

VANGUARD MAY make it after all if it can clear the red tape. Office of Naval Research Head Rear Admiral Rawson Bennett promises that the first *Vanguard* vehicle will be ready to try to launch a satellite "in the spring of 1958." Meanwhile the first blush of pride and prestige that flushed the egos of the major subcontractors pales into anger as Project *Vanguard* wallows in fantastic bureaucratic mire.

During the International Geophysical Year the U.S. will launch 193 research rockets to altitudes up to 200 miles from Fort Churchill Canada; White Sands N. M.; Guam; and from ship board from pole to pole. These will include 42 *Aerobees* 14 *Nike-Deacons* 52 *Nike-Cajuns* and 85 *Rockoons.* But from a publicity point of view at least the six scheduled U.S. attempts to place four artificial satellites in orbit is the biggest deal of all.

It's also big from a money point of view. Traceable costs of the $39-million project already exceed $50 million. Real total may top $100-million.

Eulogized and advertised ad nauseum as mankind's greatest adventure there is still no assurance that any of the *Vanguard* satellite-launching attempts will be successful during the 18 months of the IGY. It's the nature of the still-young state of the rocket art.

Even if *Vanguard* is ready by spring, it still may not be first. Reports point to a Russian try within 10 weeks. And to the south the missile team everybody tries to ignore may beat even that date.

For some still unexplained reason, no *formal* approach has ever been made to the highly successful Wernher von Braun rocket team at Redstone Arsenal, Huntsville, Ala—despite the fact that *Redstone-Recruit* satellite launching hardware has been in being at the arsenal for nearly a year now.

Off the record, however, Dr. John P. Hagen, Project *Vanguard* Chief, and his Naval Research Laboratory associates have more than once gazed with interest if not envy, on Dr. von Braun's stepping stones to space flight. And, within the last few months, the Army has developed its own satellite transmitter. There seems to be a possibility, in fact, that the Army may have been placed on unofficial stand-by alert—just in case.

The recent three-day special meeting of the U.S. National Committee for the IGY at the National Academy of Science, Washington, D. C., provided the most details of the official satellite program released to date. Particularly revealing were papers by Dr. Hagen and by Dr. R. W. Porter, Chairman, Technical Panel for the Earth Satellite.

Project *Vanguard's* target is to place an instrumented sphere with a diameter of 20 inches and a gross weight of 21½ pounds in an orbit at a nominal altitude of 300 miles—perigee no less than 200 statute miles and apogee no more than 1400 miles—with an inclination of the orbit to the equator of 40° ± 5°; to be launched from Patrick Air Force Base, Fla. Required orbital velocity is 25,000 feet per second. Latest estimate puts its period at 100 minutes.

The original idea, according to Dr. Hagen, was to use as many "off-the-shelf" components as possible; "to use a configuration for which the preliminary design had already been done and to employ a rocket vehicle contractor who had intimate and recent experience in the design and manufacture of research rocket vehicles and who had experienced engineering personnel."

Prime vehicle contract went to The Martin Company, which had previously made the *Vikings.* General Electric received a subcontract to modify the less-than-20,000 pounds thrust *Hermes* engine into an over 27,000 pounds thrust *Vanguard* first stage. Aerojet-General would adapt the Aerobee main engine into a second stage.

Selection of a three-stage vehicle with a minimum gross weight of 20,000 pounds required, Dr. Hagen said, "a *minimum* thrust level for the first stage (for safe takeoff) of 27,000 pounds . . . (This) dictated to a large degree the characteristics of the remaining propulsion systems."

This prediction of stages two and three by stage one may explain why GE's hopped-up *Hermes* engine, was first rejected as unsatisfactory and then hastily and unexplicably reinstated. Had it been dropped, the whole project might have had to be re-engineered. Meanwhile, it isn't certain the first stage engine's problems have yet been solved. G.E.'s Dr. Porter, referring to the fact that the last of the Nunn-Baker satellite cameras will not all be in place before March, 1958, said: "This may therefore be the limiting part of the entire satellite program, *with the possible exception of the booster vehicles.*" He could also have been talking about his own company's first stage engine.

An example of how *Vanguard's* too many generals have really hauled out the red-tape lies in the difficulty of finding out just what *is* going on. Obtaining specific information from the various *Vanguard* chiefs and contractors is now almost impossible.

The "security" system for controlling the release of information about this project of "no military significance" seems more calculated to give everyone a chance to check for possible embarrassment. The system would do justice to political censorship in the Kremlin!

No information may be released under the name of any Martin Company subcontractor unless it has first been checked either for "technical accuracy, military security or both" by: The Martin Company; NRL's Technical Information Office; NLR's Security Office; Admiral Bennett, ONR; Office of the Chief of Naval Information; Department of Defense Office of Public Information (including representatives of Army, Navy, Air Force and DOD); Central Intelligence Agency; State Department; National Science Foundation; and National Academy of Science (U.S. Committee for the IGY).

Since, in the final analysis, NRL alone would suffice to assure technical accuracy and protect military security, it must be assumed that *Vanguard* is politically a very sensitive vehicle. Says one important subcontractor: "It is just disgraceful!"

However, m/r has been able to determine that: Aerojet-General's second stage engine is ready to go—no troubles; Grand Central Rocket's third stage flew on the nose of *Viking-14* and "performed like a doll"—no troubles; Raymond Engineering Laboratory's spring-loaded satellite ejector mechanism "is perfect" according to NRL engineers; Atlantic Research has all but finished work on the spin and retro rockets for separating the second stage from the third; Minneapolis-

Honeywell's gyro reference system also appears to be trouble-free and on schedule; Brooks & Perkins' delivery of satellite spheres is ahead of schedule; Allegany Ballistics Laboratory seems to have overcome its early burning problems; Loewy-Hydropress has already delivered the static test and launching platform to Patrick; NRL has instrumentation and circuitry for the satellites well in hand.

Bendix Radio Division is on schedule in the manufacture of Minitrack receiving stations; the 80 U.S. Moonwatch teams have been organized; the Nunn-Baker satellite tracking camera is reported to be experiencing mechanical difficulties, but Perkin-Elmer's optics will be delivered in time for the last of the 12 cameras to be in place by next spring; International Business Machines' 704 satellite data computer is in place and ready to go whenever a satellite is launched; and Army Signal Corps is busy arranging for the instantaneous transmission of satellite data from South American tracking stations.

This quick look at Project *Vanguard's* status would seem to leave the burden of proof of success or failure up to the prime systems contractor, The Martin Company, and the first stage engine-maker, GE. However, a lot of components haven't yet been flown, and until they experience an actual launch and flight, their true readiness will not really be known.

In this last connection, the next *Vanguard* test vehicle shot, TV-2 (TV-0 and TV-1 were *Vikings*), will be a GE first stage with dummy second and third stages loaded with measuring and transmitting gear. If it works, O.K. If not, somebody's got to hop, and fast.

TV-3 will be a GE first plus Aerojet second plus dummy third stage. TV-4 is slated to be the same as TV-3 but with an ABL third stage. TV-5 and TV-6 should be full system test firings —a total of seven test flights before the first shot in earnest.

Statistically, the *Vanguard* launching vehicle is 72 feet long; has a first stage diameter of 45 inches and a second stage diameter of 32 inches. It is finless, employs integral tanks and has a loaded gross takeoff weight of 22,600 pounds.

Its first stage is a liquid oxygen and kerosene motor fed by turbine-driven pumps. Orientation and flight path are maintained through control of the gimballed motor. "The electro-hydraulic controls that position the motor have the necessary response to stabilize the composite finless airframe in pitch and yaw."

Roll control comes from changing the direction of the turbine exhaust. The inertial reference system for guidance is carried in the second stage. In Dr. Hagen's words, "In essence, the first stage is a guided, liquid propellant booster which provides about 65 per cent of the energy to raise the remaining stage to orbital altitude and about 15 per cent of the required orbital (horizontal) velocity."

The second stage uses white fuming nitric acid and unsymmetrical dimethyl-hydrazine fed directly from high pressure integral tanks. In both first and second stages the pressurizing gas is helium. Motor is gimballed, as in the first stage. "An array of gas jets provides roll control during second stage powered flight and complete control of vehicle orientation during coasting flight."

The reference system and flight programmer, both located in the second stage, are responsible for all major in-flight operations, such as change of pitch rate with altitude. The third stage spinning mechanism is also in the second stage.

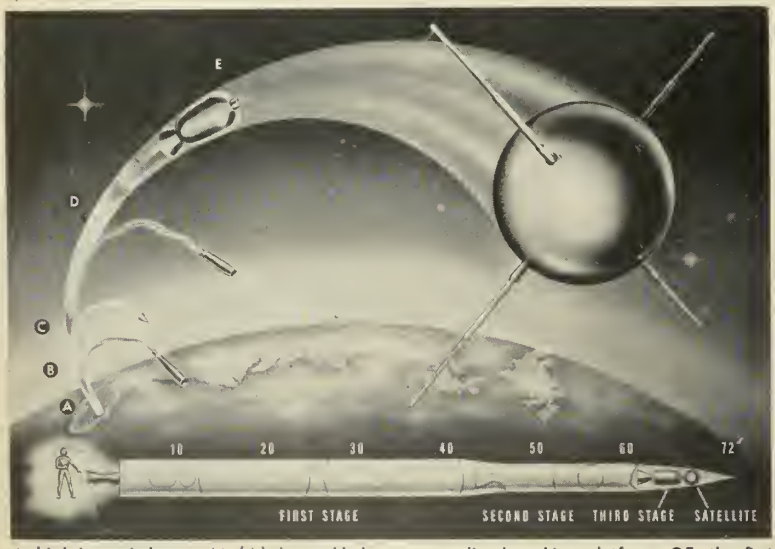
This stage which, fully loaded and including the third stage, weighs about 4800 pounds, contains the brain of the launching vehicle, and supplies the remaining energy required to reach orbital altitude and about 32 per cent of the orbital velocity.

The third stage weighs about 500 pounds fully loaded and is an unguided solid propellant rocket, spin stabilized with its longitudinal axis roughly parallel to the earth's surface. It is fired at orbital altitude and provides 50 per cent of the required orbital velocity, the remaining three per cent coming from the earth's rotation. rotation.

The sequence of events in a "typical" firing will be as follows: vertical flight until "satisfactory" clearance of ground installations; then maintain an approximate zero-normal-force trajectory until aerodynamic forces are no longer critical; first stage separation and second stage start up; jettison nose cone, revealing third stage and satellite, in latter part of second stage powered flight; pitchover after second stage cut-off so that third stage will be fired roughly parallel to the local horizontal; second stage separation and third stage firing; third stage fires until orbital velocity is attained; saltellite ejected from third stage with a differential velocity of three feet per second.

The six planned business shots will hope to get four satellites successfully into orbit. These four will perform basic experiments as follows: NRL's ultra-violet, temperature and meteoric measurements; University of Iowa cosmic ray and AF meteoric experiment; NRL magnetometer and NACA expandable plastic foil sphere experiment; and for the fourth one, a choice to be made "shortly after November first" between University of Wisconsin energy balance and Signal Corps cloud distribution experiments.

Design of equipment for all five of these projects appears to be progressing on schedule and without major hitches.



A bird is an industry: At (A) Loewy-Hydropress supplies launching platform; GE, the first stage engine; at (B) first stage falls off; second stage engine is by Aerojet-General and contains gyro reference system by Minneapolis-Honeywell, spin and retro rockets for separating and spinning third stage by Atlantic Research; at (C) during second stage powered flight, nose cone pops off; at (D) second stage falls free and third stage either by Allegany Ballistics Laboratory or Grand Central Rocket propells satellite to orbital velocity; (E) Raymond Engineering Laboratory's ejection device kicks sphere loose with three foot-per-second differential velocity over dead third stage assembly, which becomes a kind of satellite itself.

In Control–with U. S. TIME GYROS

Poised on their launchers, the Navy's Terrier guided missiles. Official U. S. Navy photograph.

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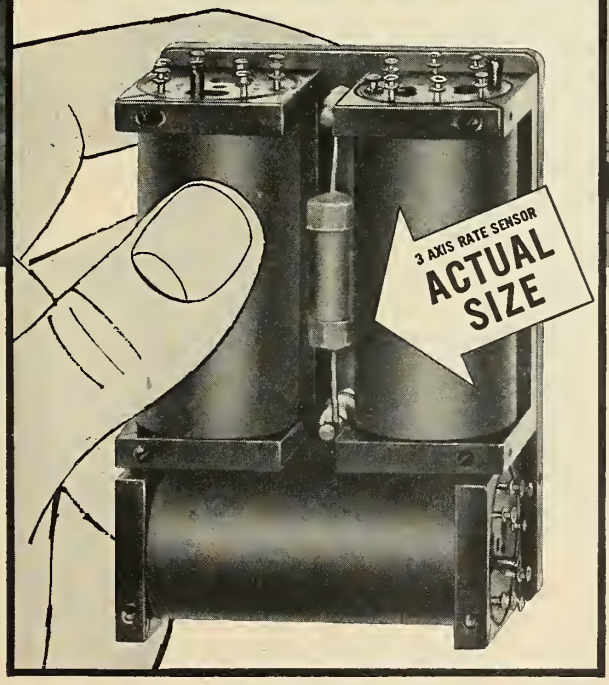

United States Time Corporation offers the systems manufacturer the long sought after optimum performance/weight ratio in Gyroscopic Instruments. The 3-Axis Rate Sensor package achieves high performance in one third the weight and volume of previous rate gyros. Flight proven under severe environmental conditions, microsize gyros and gyro packages can be supplied in production quantities to satisfy your specific requirements.

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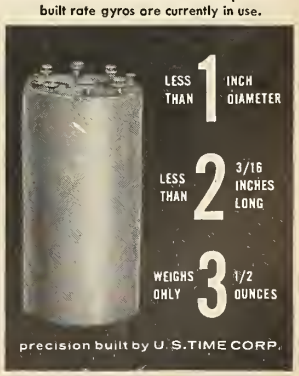

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ELECTRONICS EVOLUTION

The 1957-60 missile era may some day be referred to as the period in which electronics first came into its own as a 50 per cent partner dollar-wise with the missile frame and propulsion business.

The specific spending picture for missile electronics is clouded by security and hidden factors in any accounting breakdown available. Despite this, a conservative estimate for 1957 spending shows electronics to be well along toward 25 per cent of the total $2.3 billion missile business.

Of the approximately $600 million for electronics about half is for missile-carried gear and the other half for ground gear. For the Air Force alone the dollar volume picture for aviation and missile electronics will expand over 100 per cent in the next few years, according to a recent estimate of USAF Maj. Gen. David Baker, Air Materiel Command. The Navy and Army needs must be added to this.

As things stand by 1960 a predicted $1-billion missile electronics business seems as sure as the importance of making missiles go where we want them once they are fired.

At the present time missile guidance and control in operational, developmental and research missiles ranges from the "puppet-like" guidance of the Army's *Dart* through a wire cable attached to the missile to the ultra-sophisticated (for 1957) attempts to design a 5000-mile ICBM that will reach its target point without any ground-communication guidance over at least half its trajectory.

Between these two extremes are various systems using either electromechanical inertial techniques coupled with some electronics or pure electronics for guidance.

These might be defined as:

Closed-loop guidance:

1) *Nike* is typical of this method, as are the new *Talos* and *Terrier*. *Nike's* guidance is based upon information acquired by radar, calculated by a ground based computer and then sent to the missile as commands. Even the firing of *Nike's* three warheads is done by command.

Talos and *Terrier* use a refinement of this technique. They seek out the rider beam of a two-beam radar and then switch over to a proximity system during the terminal part of their flight. The beam system uses track and capture beams sent by one radar antenna system. The track beam follows the target. After launching, the missile seeks the capture beam that leads it to the target's vicinity.

2) *Bomarc* utilizes computer-derived information from the Semi-Automatic Ground Environment system being implemented for continental defense. *Bomarc's* position is relayed by data link equipment on board to a SAGE center. Directions for interception of its assigned target come back to it through the data link for guidance to the terminal area. Near its target it uses radar equipment similar to interceptor fire control to "lock-on" to its target for a kill.

Self-contained:

Early user of this technique was *Matador*. An inertial system on board is distance-direction programmed to carry the missile to its target and to program the terminal dive. Recently reported was guidance of *Matador* by utilization of low frequency hyperbolic navigation signals such as produced by Decca, Cytac and Radio-Web.

Snark and *Navaho* use a hybrid system combining inertial navigation with celestial position fixing. The enroute flight is preprogrammed through the inertial system and periodically corrected by automatic star-sighting equipment on board.

Target seeking:

Early user of this technique was the *Corporal*. The same technique seems to be the mainstay of current hopes for ballistic missile "guidance." The short range *Corporal* is guided during the first part of its flight by radio commands. These are derived from Doppler radar and optical data on the missile's initial trajectory. Adjustments to correct the trajectory are sent to establish the required ballistic path for a particular target. The same general technique is applied to *Redstone* and is believed planned for missiles such as *Atlas, Titan* and *Jupiter*.

Guidance of an ICBM has been described as "shooting through a hole in the sky 800 miles up." That "hole" will be the ideal point in outer space for the ICBM to go through if its calculated ballistic trajectory is to carry it to the target. But how is "hole in the sky" found and how can the missile men be sure of the trajectory?

There have been numerous reports that radiometric corrections will be applied to the ICBM flight during the find-the-hole flight stage. Other reports have said that radiometric correction was abandoned in favor of inertial programming.

The handicap of intense ionization around an ICBM and the inability of radio energy to penetrate the ion sheath would probably limit the range over which control could be exercised. Once up to full speed, radio control could be impossible. Inertial control would not have this handicap, but would probably be less accurate than the best radiometric techniques.

Although the manufacturers of gyroscopes and accelerometers have made phenomenal progress in raising the precision of guidance it seems apparent that in the long run electronics will win out. It's hard to compete with the speed of light and precision control advantage in radiometric methods.

A big item in planning for ICBM operational centers are the computers that will be needed. They will undoubtedly do the job of taking the myriad and varying conditions under which an ICBM will perform and integrating them to determine where that "hole in the sky" should be at any given time and place the ICBM is launched.

Only recently Cornell Aeronautical Laboratory dedicated an IBM 704 scientific computer for ICBM work. Purpose, it was stated, is to provide a complete table of properties of air at high temperatures. Over half-million thermodynamic values covering the properties of air for some 8000 different cases of temperature and density will be computed.

Microminiaturization of electronics is just starting. With improved sensors and high power computers in a tiny package missiles may some day need only the latitude and longitude of the ground target to find their way at any speed and from any altitude.

This same electronic "brain" together with ultra-advanced sensors may also make possible counter weapons capable of seeking out and destroying missiles attacking from outer space.

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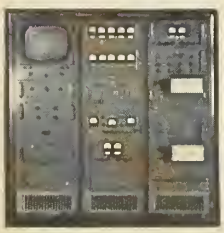

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on the following pages
m/r rounds up
missiles of the

U.S. ARMY	page	U.S. NAVY	page	U.S. AIR FORCE	page
Nike Ajax	124	Bullpup, Corvus, Diamondback	137	Mighty Mouse	151
Hawk	126	Sidewinder	138	Falcon	152
Nike Hercules	127	Zuni	140	Bomarc	153
Dart	128	Sparrow	141	Rascal	154
LaCrosse	129	Torpedoes	142	Matador	155
Little John	130	Terrier-Tartar	143	Snark	156
Honest John	131	Regulus I	144	Navaho	158
Corporal	132	Talos	146	Thor	159
Sergeant	133	Triton	147	Atlas	160
Redstone	134	Regulus II	148	Titan	162
Jupiter	136	Polaris	150	Miscellaneous Missiles	164

** Some of the specifications and performance figures given for the missiles and rockets in this encyclopedia have been calculated and have not necessarily been officially confirmed.*

U.S. Army's NIKE AJAX

Nike-Ajax, named *Nike* after the Greek goddess of victory, is the Army's first supersonic antiaircraft guided missile designed to intercept and destroy the enemy target regardless of evasive action. *Nike* guided missile units are now deployed around vital industrial, highly populated and strategic areas of the U.S.

Nike-Ajax is a missile about 20 feet long and about one foot in diameter, with two sets of fins for guidance and steering. It is boosted to supersonic velocity by a solid-propellant booster and maintained by a liquid sustainer motor. The missile and booster weigh more than one ton.

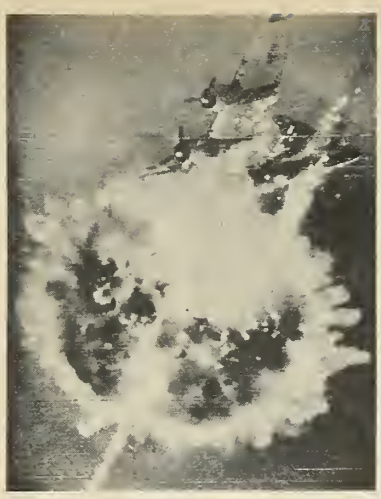
Speed, range, altitude and lethality of *Nike-Ajax* can meet an attack from any direction and its kill potential has far exceeded expectations. There are 12 launchers in each *Nike* battery, each battery being operated by approximately 100 officers and men. Personnel are trained at the Anti-aircraft and Guided Missile School, Fort Bliss, Tex., and the Ordnance Guided Missile School, Huntsville, Ala.

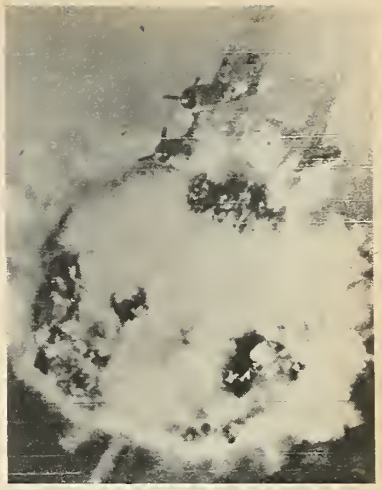
The *Nike-Ajax* system consists essentially of a two-stage missile and elaborate control equipment requiring approximately 1,500,000 separate parts. The missile is about 20 feet long and one foot in diameter with two sets of fins for guidance and steering. Its weight is more than one-half ton.

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

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

Nike Ajax batteries ring most important cities in the U.S. today. Missile has demonstrated its kill capability against slow drones. Nike still is considered effective.





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

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

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

When notified by early warning radar networks of unidentified aircraft approaching his defended area he orders "Battle Stations!" and sets the launching into action. Previously prepared missiles and boosters are raised to the ground surface on elevators from the underground launcher installation. Propulsion and guidance components have been previously checked, propellant tanks filled with acid and JP-4, and the warhead installed. *Nikes* are loaded on the four launchers associated with each underground installation and final tests and checks are then completed.

When unidentified aircraft come into the range of the acquisition radar the information is presented on the scopes in the battery control van. The target is still far away and out of sight of everything but the radar's searching beam, but at this point the control officer gives the word to "Engage!" and the command is relayed to the launchers. The missiles now are erected to firing position.

Next the battery control officer must decide when to fire. Hesitation or a mistake might let the bomber slip in close enough to drop his atomic weapon. The battery is placed under its final "red" alert status and the missile tracking radar slews and locks on the first missile to be fired. As the target approaches the maximum range of the *Nike*, the firing button is pushed.

• • •

SPECIFIC DATA:

MANUFACTURER:	Douglas Aircraft Co. Western Electric
MISSION:	surface-to-air
RANGE:	10 to 30 mi.
SPEED:	1,500 mph
WEIGHT.	1,000 lbs.
WAR HEAD WEIGHT:	300 lbs.
LENGTH:	20 ft.
DIAMETER:	1 ft.
SPAN OF NOSE FINS:	2 ft.
SPAN OF TAIL FINS:	5.25 ft.
COST:	$20,000
STATUS:	service

• • •

Nike Ajax being boosted to altitude in test firing. Douglas Aircraft developed the Ajax. Western Electric produces guidance equipment. The system consists of 1.5 million parts.

U.S. Army's HAWK

Despite the frightening array of super-weapons funneling down the research and development pike, warfare sooner or later gets down to the messy foot-sloshing business of ground-fighting. This means low-flying attack aircraft and short-range missiles doing a tactical airpower job must be contended with.

The Army's answer to this requirement is a highly mobile missile called the *Hawk*.

Approximately 17 feet long and 14 inches in diameter, the *Hawk* is deployed on an unusual triple launcher from which three of the weapons can be fired in rapid sequence against low-flying aircraft.

Development of the new air defense system was carried out by Redstone Arsenal scientists under the direction of Dr. Martin Schilling.

Hawk is described by the Army as capable of operating both in the continental U.S. air defense complex at fixed installations as well as with mobile combat troops of the field Army. It may be transported on the highway with a minimum of vehicles or flown by helicopter or aircraft. It will be adopted both by the Army and the Marine Corps.

The new *Hawk* will probably be installed first at sites in the New York City and Washington-Baltimore areas and later at emplacements in other cities where it will very likely replace or supplement the *Nike* chain of air defense weapons. Each battery will require some 40 acres for emplacement.

Prime contractor for the *Hawk* is Raytheon Manufacturing Co.'s Andover, Mass., plant. Northrop Aviation Co. of California is the major subcontractor. *Hawk* uses a solid fuel engine developed by Thiokol Chemical Corp. at its Redstone Arsenal installation.

Hawk uses guidance techniques said to be unusually successful in hunting down and destroying attacking aircraft. Unusual radar instrumentation has been designed and installed in the *Hawk* to gain effectiveness in the so-called "blind zone" of conventional radars. It has also been spoken of as a possible bomber defense missile.

Pilot production of the *Hawk* has already begun at Raytheon, with full production scheduled for the near future.

• • •

SPECIFIC DATA:

MANUFACTURER:	Raytheon Manufacturing Co.; major sub contractor, Northrop Aircraft Co.
MISSION:	surface-to-air
RANGE:	15-plus mi. slant trajectory
VELOCITY:	highly supersonic
LENGTH:	16 ft. 4 in.
DIAMETER:	14 in.
SPAN:	47 in.
GUIDANCE:	radar
POWERPLANT:	(1) SPR Thiokol
ALTITUDE:	sea level into stratosphere
STATUS:	final development
REMARKS:	gap between zero altitude and minimum NIKE capability.

Army HAWK missiles on mobile launcher.

Furious blast-off of Army's new AAM.

U.S. Army's NIKE-HERCULES

Integration of *Nike-Hercules*, Army's latest surface-to-air defense missile, into existing *Nike-Ajax* batteries will begin within the year. An advanced version of the *Nike-Ajax*, the *Hercules* has about three times the range of the operational *Ajax*. The final testing phase of the *Hercules* is being conducted at White Sands Proving Ground, N.M.

Hercules is actually a "double" *Ajax*. It is longer, heavier and more than double the diameter of *Nike-Ajax* and capable of extreme maneuverability at altitudes far in excess of those achievable by the *Ajax*. The most outstanding feature of the missile is its three-barreled solid-propellant booster. The increased rate of climb to altitude will permit swifter interception of the most advanced types of aircraft and its vastly increased range will make it the most effective operational air defense missile in the United States.

The atomic warhead of the *Hercules* is designed to insure that detonation occurs only at altitudues sufficiently high to prevent damage to friendly surrounding terrain. It can engage and destroy single or formations of aircraft.

The missile is 27 ft. long, 2 ft. in diameter; booster is 14.5 ft. in length. It is reported to have a slant range of approximately 70 miles.

The design, development and production of the missile system by the Army is the result of extensive coordinated efforts by the Army Ordnance Corps, Western Electric Co., Bell Telephone Labs., and the Douglas Aircraft Co. The *Nike-Hercules* is to be produced initially at the Douglas Aircraft Santa Monica plant and followed with additional production at the Douglas-operated Charlotte Ordnance Missile Plant at Charlotte, N.C.

Fuels and acids used in the missile for propulsion have contributed to corrosion in present *Nike* models. The incorporation of a solid propellant sustainer unit in *Nike-Hercules* will eliminate the corrosion problem. Fueling, handling and storage problems for *Hercules* launching sites will be simplified or eliminated completely.

Meanwhile, the Army has requested funds to support continued development of the *Talos* as a possible supplement to *Nike-Hercules*.

• • •

SPECIFIC DATA:	
MANUFACTURER:	Western Electric Co. Douglas Aircraft Co. Bell Telephone Laboratories
MISSION:	surface-to-air
RANGE:	70 mi.
VELOCITY:	2,000-2,300 mph
LENGTH:	27 ft.
DIAMETER:	2 ft.
POWERPLANT:	sustainer (1) SPR Thiokol booster (3) SPR
STATUS:	development & production

NIKE HERCULES in firing position.

New NIKE being tested at White Sands.

U.S. Army's

DART

The Army's end-product concern remains ground-fighting. This means foot-soldiering and everything that goes with it, not the least of which are heavily armored, heavy fire-power vehicles such as the modern tank.

By the end of World War II a reasonably effective series of weapons had been developed to combat these units—the bazooka and both 75 mm and 105 mm recoilless rifles. These were the first rocket power systems to be effectively used against tanks. But they left considerable to be desired.

They had to be aimed, often at a target moving 30 miles an hour. There was no in-flight guidance, and once the recoilless rifle had fired, its position was given away by its back blast. Furthermore, these weapons were within range of an enemy tank's guns.

The Army's highly mobile, versatile *Dart* suffers none of these disadvantages. The wire guided missile can be fired from either fixed or mobile positions, such as jeeps and helicopters. The *Dart's* range exceeds that of any known tank armament. Its velocity in flight is such that possibilities of shooting it down en route are very slim.

But its main beauty is the simplicity of its guidance from the point of view of the firing crew (one man, if necessary). The operator controls the flight of the *Dart* through a special telescope where his only duty is to keep the image of the missile on the image of the target. The guidance system automatically computes the problem and transmits the proper signals to the missile by means of electrical impulses through the trailing wire.

Furthermore, being wire guided, the missile is virtually jam-proof. Contrary to expectations, no problems have been reported from breaking wires. The *Dart* uses a single solid propellant rocket for propulsion.

Wire guidance for airborne missiles probably began first with the Germans near the end of World War II. They made a few firings with an air-to-ground guided missile electrically guided through a trailing wire, but they didn't have much luck. The design was never really put into service.

The French made the first real efforts to develop wire guidance, first with the Nord SS-10 and later with the SS-11. These missiles are in production in France now. Their disadvantages are that their range is less than that of a tank's guns; guidance is by straight visual reference; and the in-flight velocity is 328 ft/sec for the SS-10 and 665/680 ft/sec for the SS-11. Ranges are 1.25 and 1.85 miles respectively. Both the velocities and the ranges of these French missiles are considerably under that of the *Dart*. The French missile's main advantage is even greater portability and greater simplicity than its American product.

In one public firing demonstration the *Dart* achieved a 0.01% accuracy by hitting a cloth bullseye just six inches from dead center at a range of 2100 yards.

This missile is not yet officially operational, but is expected to be "very soon." Aerophysics Development Co. developed the *Dart*. A production contract has been placed with Utica-Bend Corp. (subsidiary of Studebaker-Packard). The rocket engine is by Grand Central; optical guidance system by Wagner Corp.

• • •

SPECIFIC DATA:

MANUFACTURER:	Utica-Bend Corp. (subsidiary of Studebaker-Packard)
MISSION:	surface-to-surface
LENGTH:	5 ft.
DIAMETER:	8 in.
SPAN:	3 ft. (cruciform wings & fins)
VELOCITY:	over 900 ft/sec
POWERPLANT:	(1) SPR (Grand Central)
GUIDANCE:	wire-electrical-optical
STATUS:	production

REMARKS:

designed as an anti-tank and anti-emplacement weapon; optical guidance system by Wagner.

Aft view of the DART positioned on field launcher ready for firing.

The highly mobile DART is shown on weapons carrier-launcher.

U.S. Army's

LACROSSE

Lacrosse is an all weather missile capable of destroying enemy strong points in the field to supplement air or artillery attack. Essential components of the *Lacrosse* system are the missile, a launcher mounted on a standard Army truck and a command guidance system.

Lacrosse is propelled in flight by a solid fuel rocket motor manufactured by Thiokol. Field units will be able to answer calls for fire in the same time required for conventional artillery and with a rapidity comparable to that of a 105 mm howitzer. The extremely mobile and accurate *Lacrosse* has undergone a series of successful test firings at White Sands Proving Grounds.

Lacrosse was designed and developed by the Cornell Aeronautical Laboratory of Buffalo, N. Y. Production is by the Martin Co. at its temporary Orlando, Fla. location. The recent production contract supplements an existing research contract of over $8 million.

The Martin Co. has let contracts totaling $6,031,950 with Thompson & Street Co. of Charlotte, S. C. for construction of a new plant at Orlando, Fla., location of its present *Lacrosse* missile production.

The new facility, situated on a 6,777-acre site purchased by Martin last September, is slated for use in R&D and production of newer weapons in the missile, electronics, nucleonics and small weapons fields.

Martin is handling *Lacrosse* manufacturing in interim facilities near Orlando and presumably will shift this activity to the new plant when completed later this year. Plans for the new structure calls for about 488,000 sq. ft. in four buildings. Main building measuring 640 by 500 ft. will provide 290,000 sq. ft. of manufacturing, assembly, shop and storage space.

Four fins positioned 45 degrees from the plane of the wings and at the aft end of the fuselage are movable for flight control and stability. Range of the *Lacrosse* is approximately 20 miles.

With the addition of the *Lacrosse*, supplementing the role of *Little John* and *Honest John*, the field artillery has stacked up a formidable arsenal for close support of the ground troops.

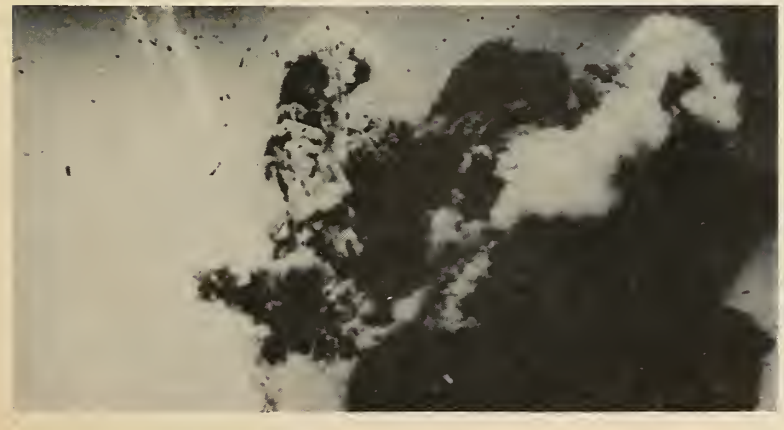
• • •

SPECIFIC DATA:

MANUFACTURER:	The Martin Co.
MISSION:	surface-to-surface
RANGE:	15-20 mi.
LENGTH:	20 ft.
DIAMETER:	20.5 in.
SPAN:	wing—108 in. tail fins—87 in.
POWERPLANT:	(1) SPR Thiokol
STATUS:	quantity production

REMARKS:

Federal command guidance system; controlled by forward observer



Lacrosse in action. From the top: Missile leaves launcher, in flight to the target buries in target and explodes with deadly accuracy. Target and impact information is relayed to the launching position by a forward observer.

LITTLE JOHN atomic missile reaches for the sky after firing from White Sands, N. Mex.

U.S. Army's

LITTLE JOHN

For Redstone's 400-man Rocket Development Laboratories, *Little John* has been a manifold triumph. The 12½ inch, 318-millimeter rocket, about 12 feet long and packing the explosive power of heavy artillery, was successfully produced and demonstrated in a crash program that started in February 1956. It was test fired in June 1956, only a matter of months after initiation.

Honest John filled the need for a free-flight rocket artillery weapon with high accuracy, simplicity of design and operation, extremely high mobility, no electronic controls and a range equivalent to medium-to-long-range artillery.

The dimensions of *Little John* are about one-third and its weight one-sixth that of its predecessor. It can be carried in a helicopter. *Little John* thus represents perhaps the growth of a new family of rocket weapons that ease logistical problems and give Army field commanders a wider choice of warheads for use against combat targets.

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

Under the direction of OCO (Office, Chief of Ordnance), the task force itself provided the necessary research and development work and guidance in design control, aerodynamics, metal parts and powerplant. The Allegheny Ballistics Laboratory at Cumberland, Md., supplied propellants. Powerplant metal parts were fabricated by consolidated Western Steel of Los Angeles.

Emerson Electric of St. Louis manufactured the air frame. Army Ordnance's Rock Island Arsenal, Ill. provided the launchers. Proof testing was assigned to White Sands Proving Ground N.M. and by Redstone's own staff. Warheads came from the Army's Picatinny Arsenal at Dover, N.J.

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

Little John is being developed to supplement *Honest John*. This lightweight free rocket can reach out beyond ranges of any existing tube artillery to increase further the all-weather support capabilities of the ground commander.

A great advantage of this rocket is obviously its high degree of mobility. This is the ideal "fire brigade" atomic missile for the airborne infantryman and it was developed to meet this requirement. *Little John* was first fired publicly at the U.S. Ordnance Annual Meeting in Aberdeen last Fall. Its development is well on schedule.

The first class of key personnel of the Army to be given instruction in the handling of the *Little John* began its studies on June 17th. Classroom work includes orientation in rocket parts, systems and warheads of the 12-foot missile. Ten classes are to be trained, with 20 students to a class. They will then become instructors at other Army installations.

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

• • •

LITTLE JOHN is 12 feet long and 12½ inches in diameter. Fins are moveable and equipped for flares.

SPECIFIC DATA:

MANUFACTURER:	Douglas Aircraft Co./ Emerson Electric Mfg. Co.
MISSION:	surface-to-surface
LENGTH:	12 ft.
DIAMETER:	318 mm.
SPAN:	33 in.
STATUS:	production

REMARKS: smaller version of HONEST JOHN; for GTG applications; developed at Redstone Arsenal; shorter range than HONEST JOHN; no figures released

U.S. Army's

HONEST JOHN

HONEST JOHN positioned on rails of its self-propelled launcher in preparation for firing.

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

Honest John's trajectory to the target is determined by the elevation and azimuth of the launcher prior to firing. The effect of the direction and speed of the surface wind at firing is considered in a final setting of the launcher. A slow spin is imparted to it by small spin rockets which give a more stabilizing effect to the trajectory.

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

The *Honest John* with a 30-mile range and a maximum accuracy scatter factor at that distance of 150 yards, along with its 21-ton launching system is now air transportable in conventional military transports. Soon to be delivered is ultra-light weight launching equipment capable of being dropped by parachute.

The eight *Honest John* missile launchers currently assigned to the new streamlined pentagonal divisions give unprecedented fire power to paratroopers. A major factor in the Army's overwhelming acceptance of *Honest John* is its extreme mobility and simplicity. It can be moved about at will and fired by fewer than half a dozen men if necessary.

The first separate tactical Army unit to be armed with the 21-ton *Honest John* weapon system (developed at Redstone Arsenal, Huntsville, Ala.), is the recently reactivated 101st Airborne Division, Fort Campbell, Ky.

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

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

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

• • •

SPECIFIC DATA:	
MANUFACTURER:	Douglas Aircraft Co./ Emerson Electric Mfg. Co.
MISSION:	surface-to-surface
RANGE:	20-30 mi.
WEIGHT:	6,000 lb.
LENGTH:	27 ft.
DIAMETER:	2.5 ft.
SPAN:	109 in.
POWERPLANT:	(1) SPR Hercules Powder
GUIDANCE:	free flight—rail launch
STATUS:	production

Powered by a solid propellant rocket HONEST JOHN leaves rails of launcher. A slow spin is imparted to the missile by small spin rockets.

U.S. Army's CORPORAL

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

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

Launching procedure is as follows: The missile is erected on its launcher by a large transport vehicle called the erector. Prior to this the propulsion and guidance components have been thoroughly checked for proper functioning, the propulsion tanks have been filled with acid and aniline, and the warhead attached.

Guidance equipment vans are placed slightly to the rear and are warmed up and checked for the required electronic indications that will guide the *Corporal* to its target.

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

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

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SPECIFIC DATA:

MANUFACTURER: Firestone Industrial Products Co.
MISSION: Surface-to-surface
RANGE: 50 to 150 mi. variously quoted
SPEED: Mach 3
WEIGHT: 6 tons
LENGTH: 40 ft. (45 and 46 ft. are given by a few references)
DIAMETER: 2.5 ft.

LEFT—CORPORAL leaves launcher in a burst of flame from burning acid and aniline. The missile has a range of about 100 miles. ABOVE—Missile is erected on launcher.

U.S. Army's SERGEANT

Sergeant is the latest addition to the Army's tactical missile arsenal. Powered by one of the largest solid propellant rocket motors yet developed *Sergeant* has been mentioned as a possible *Corporal* replacement. *Sergeant*, extremely mobile, safe for handling and storage and a fire mission dream is a tremendous advance over the complex and logistical problem-loaded *Corporal*.

Sergeant was developed by the Caltech Jet Propulsion Laboratory, pioneers in the field of rocket and missile research and development. Sperry Gyroscope, prime contractor for *Sergeant* production, broke ground on July 1st for their new plant at Salt Lake City. The rocket motor will be produced by Thiokol at their Utah Division facilities near Brigham City. Douglas Aircraft Co. has been unofficially reported as contractor for *Sergeant*'s airframe

Sergeant's rocket motor was developed at Thiokol's Redstone Division near Huntsville, Alabama. Testing of the production motors will be handled by the Utah Division on their new horizontal test stand. The static test facilities are capable of handling solid propellant motors up to 12 ft. in diameter and designed to withstand a two million lb. load.

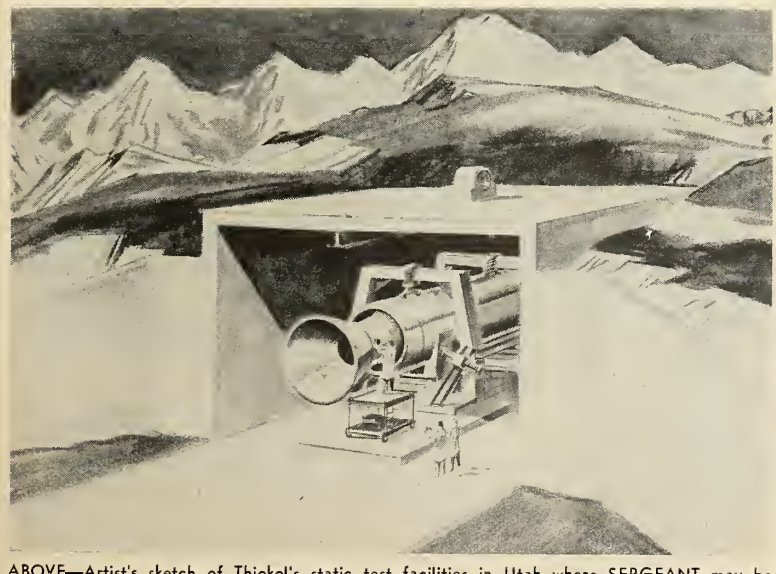
The *Sergeant* has been building up an impressive record of flights as a research rocket. Modified to serve as the first-stage of the X-17 three-stage test vehicle, it has made numerous successful flights from Patrick Air Force Base, Fla. The X-17, designed to test materials for nose cones of ballistic missiles and to solve problems encountered in re-entry of ballistic missiles, is fired vertically into the atmosphere by the *Sergeant* first stage. As it starts to descend the other two stages are fired to accelerate the payload to high velocities.

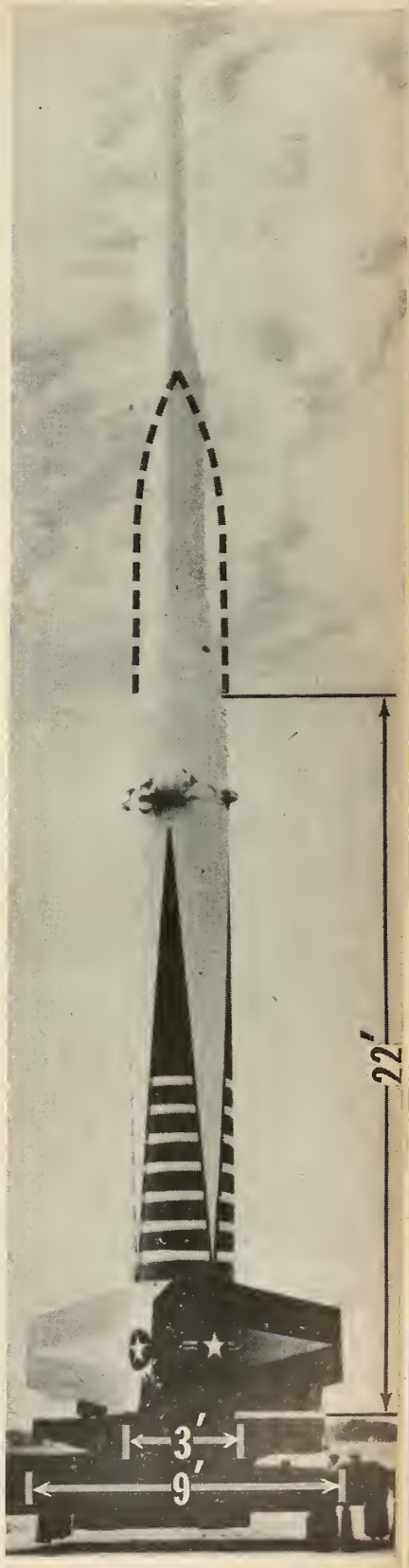
The huge concrete bunker built into the rocky terrain is larger than any other test facilities of Thiokol's divisions at Elkton, Redstone or Longhorn. It is possibly the largest solid propellant test stand in the country.

• • •

SPECIFIC DATA:

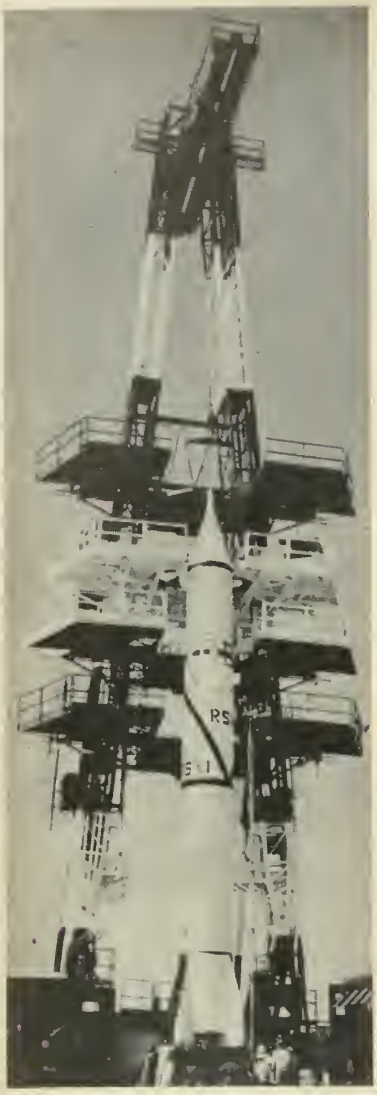
MANUFACTURER — Sperry Gyroscope Co.
MISSION — surface-to-surface
RANGE: — 50-75 mi.
WEIGHT: 25,000-35,000 lb. (at launch w/ payload)
LENGTH: — 22 ft. (w/o nose cone)
DIAMETER: — 3 ft.
SPAN: — 9 ft.
POWERPLANT: (1) SPR 50,000-70,000 lbs. thrust. Thiokol polysulfide cast composite, burning time 30 sec (approx)





ABOVE—Artist's sketch of Thiokol's static test facilities in Utah where SERGEANT may be tested. RIGHT—The possible SERGEANT configuration superimposed on X-17 test vehicle.

U.S. Army's REDSTONE



Army's REDSTONE missile in its servicing station at Patrick Air Force Base, Cape Canaveral, Fla., is being readied for test launching out over the Atlantic Ocean.

Redstone, surface-to-surface ballistic missile, is in quantity production at the Chrysler missile plant at Warren, Mich. The *Redstone* has been described as the prototype for the Jupiter IRBM. The well-tested and successful *Redstone* became the test-bed for guidance and major components of the *Jupiter.*

Range is 200-300 miles although one unit with reduced warhead is reported to have traveled a distance of 350 miles. Powerplant is a North American liquid oxygen-alcohol engine yielding a thrust of 75,000 pounds. This powerplant is considered the most proven of U.S. liquid rockets.

Operational status for this medium-range missile is expected soon. The first *Redstone*-equipped unit, the 217th Field Artillery Missile Battalion, was activated and is being formed at Redstone Arsenal. The first Army Ordnance Corps company organized for the specific purpose of providing supply and maintenance for the *Redstone* long-range rocket has been activated at Redstone Arsenal. It is the 630th Ordnance Company and is assigned to the Army Ballistic Missile Agency. It supports the 217th Field Artillery Missile Battalion which was the first Army unit formed to handle the missile. The 630th's support mission includes responsibility for supply and maintenance of warheads, fuels, the missile and other items of the missile system. The Ordnance Corp's most advance class of officer trainees concluded a one week course of study at the Ordnance Guided Missile School, Redstone Arsenal, in November.

The *Redstone* missile is designed for rough handling and typical field service transportation and environment. Chrysler Corp. has been praised in its effort to make the *Redstone* a most reliable weapon while encumbered with the large amount of complex systems and wiring that make up this missile. Production output and amount of money allocated for the program has not been revealed. It is the largest and most potent of the operational U.S. missiles.

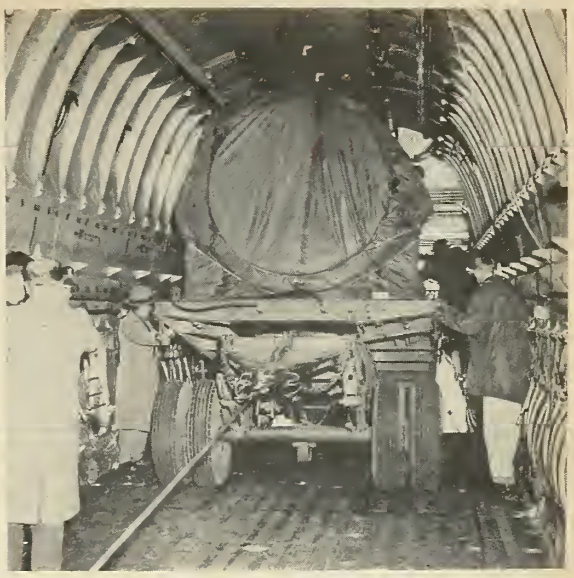
The missile is launched vertically from relatively light portable launching platforms and travels toward its target on a ballistic path. The warhead separates from the missile proper and continues to the target stabilized by four small fins. Warhead compartment will accommodate either conventional or atomic payloads. The *Redstone* recently supplied the major impetus for establishing a new distance record for rocket flight. A modified *Redstone* was used as the first stage of a three-stage assembly known as the *Jupiter C.* The *Redstone* burned out, separated and fell into the sea approximately 100 miles from the launching site. The final stage of the configuration fell into the Atlantic 3000 miles from the pad at Patrick.

The Guided Missile Development Division, under Dr. Wernher von Braun, drew nationwide recognition for its competence in developing the *Redstone* missile. In February 1956 the personnel and facilities of this division were transferred to the new Army Ballistic Missile Agency, specifically established for the expedited prosecution of a program to put the ballistic missile in operational status as rapidly as possible. The *Redstone* is a product of cooperative effort between the Army and private industry, and exemplifies the state of the art in missile development that exists today.

Dr. von Braun, in a recent article

Monitor of aggression . . . giant rocket, Army's REDSTONE, 300-mile missile has just rolled off the assembly line of Chrysler Corporation's Missile Operations. Note the dollies on fixed rail lines, two for warhead and two for engine indicating assembly sequence.

REDSTONE test vehicle for the Intermediate Range Ballistic Missile, JUPITER, illustrates Army step-by-step development philosophy.



Even the big boys fly. Here, REDSTONE missile is shown being eased aboard AF Globemaster for air-freighting to Patrick Air Force Base.

on the philosophy employed in the development of ballistic missiles, stated: "The Army has pursued a minimum-risk program in the development of the *Redstone* and *Jupiter* ballistic missiles which provides optimum development and performance.

"The Army's *Redstone* and *Jupiter* missile programs are being handled by a closely-knit and tightly integrated team with many years of experience in the ballistic missile field. This team consists of experienced scientists and engineers of virtually every field involved in this new art. The need for utmost flexibility during the research and development firing period governs our design philosophy. All the guided missile experience to date, including that on the *Redstone*, indicates that this procedure is an effective and economical one for guided missiles.

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SPECIFIC DATA:

MANUFACTURER:	Chrysler Corp.
MISSION:	surface-to-surface
RANGE:	200-250 mi.
LENGTH.	69 ft.
DIAMETER:	6 ft.
SPAN (FINS):	12 ft.
POWERPLANT:	(1) LPR 75,000 lb trust North American Aviation
PROPELLENTS:	Liquid Oxygen-alcohol
GUIDANCE:	Ford Instrument Inertial Guidance
STATUS:	Production

Mighty REDSTONE thunders towards stratosphere. Missile is development of famous von Braun team at Army's Redstone Arsenal.

Army Chief of Research and Development, Lt. Gen. James H. Gavin, stands beside model of REDSTONE missile, his hand indicating the warhead. This missile is now in production at Chrysler Corp. and is in the process of being weaponized by Redstone Arsenal.

U.S. Army's JUPITER

The *Jupiter* IRBM has scored the first victory in the controversial IRBM evaluation program. After two failures earlier this year, the Army has succeeded in firing a *Jupiter* missile to the limit of its designed range or approximately 1,500 miles. The instrumented vehicle attained an altitude of approximately 250 to 300 miles.

Trouble with the first two *Jupiter* test vehicles apparently stemmed from sloshing fuel. Fix was made by incorporating *Thor* anti-slosh devices in fuel tanks. Anti-slosh devices are reported to be a set of baffles proof-tested in earlier missile flights with similar tank configuration. These were designed to hold fuel slosh to a minimum without interrupting fuel flow. The first two *Jupiter* test vehicles exploded prior to scheduled burnout.

The Army also took steps to eliminate two other potential weak spots in the third *Jupiter*. It removed a gust sensing indicator mounted on a forward probe and installed a heat blanket shield at the base of the missile to prevent eddies of exhaust flame from burning out the control wiring. *Jupiter* has also solved its gas generator exhaust problems by shifting from hydrogen peroxide decomposition to hot gas drive for auxiliary power turbine. The hot gas drive burns missile propellants for operation of the power turbine.

The *Jupiter* carried instrumentation in place of the warhead it would normally carry in operational use. It was controlled by a preprogrammed auto-pilot which held its attitude during flight to the programmed course. Later vehicles will be equipped with a full-fledged guidance system which will include computing as well as sensing elements.

North American Aviation is supplying the same rocket engine for the *Jupiter* that is used by the *Thor*. The similarity of the two missiles will become even more pronounced if the expected airframe switch for the *Jupiter* materializes.

The engine for the *Jupiter* is reported to develop approximately 135,000 lbs. thrust. The missile is approximately 60 ft. in length and 8 ft. in diameter. Separation of the warhead is expected as a performance feature as a result of *Redstone* development.

The Defense Department has removed the Air Force from its funding responsibility for the IRBM program until a decision is made between the *Jupiter* and the *Thor*. Current plans now call for Defense to transfer a portion of its emergency R&D funds to the Army sometime in August to allow the *Jupiter* program to continue. Despite the funding deviation from the Wilson memo, Defense officials emphasized that there is no change in the basic roles and missions assignment.

USAF and Army ballistic missile experts met at the Army's Redstone Arsenal last month for a technical information exchange on the *Jupiter* and *Thor* programs. Nineteen USAF missile experts accompanied Maj. Gen. Bernard A. Schriever, director of ARDC's Ballistic Missile Division, to the Huntsville, Ala., facility. The presentation highlighted the programs achieved by the agency in the development of the *Jupiter*. A joint release stated "The Army is continuing this development under authority of the Secretary of Defense, who has determined that operational employment of the IRBM will be the responsibility of the Air Force." The statement further asserted: "The sole interest of both uniformed services is to provide the best IRBM at the earliest practicable date in the urgent interest of national defense. It is to achieve this objective that we have committed all resources, manpower, facilities and funds for the purpose. Out of this joint effort will emerge the weapons systems determined essential to the security of our country." This statement, coupled with the recent successful firing of the *Jupiter*, lends support to the Army's contention that it can have *Jupiter* operational before *Thor*. It is felt in some quarters that the *Jupiter* has taken a wide lead in the development race. At the same time Air Force officials express doubt that the IRBM will be ready for operational units inside of a year.

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SPECIFIC DATA:

MANUFACTURER:	Chrysler Corp.
MISSION:	surface-to-surface IRBM
RANGE:	1500 mi.
LENGTH:	50-60 ft. (est)
DIAMETER:	8 ft. (est)
GUIDANCE:	Ford Instrument Co. Inertial System
POWERPLANT:	(1) LPR 135,000 lb. thrust North American Aviation
STATUS:	research & development
REMARKS:	thrust control system designed and manufactured by Servo-mechanism

U.S. Navy's
CORVUS

Corvus, which is Latin for crow, is being developed by Temco under a $16 million contract. It is an air-to-surface missile for use on carrier-based aircraft. Navy has issued invitations for new carrier-based craft capable of carrying *Corvus.* The only aerodynamic model of *Corvus* recently completed wind tunnel testing at Massachusetts Institute of Technology. Data submitted by Temco to Navy for clearance is reported to be at the bottom of the list as far as releasing it is concerned.

DIAMONDBACK

Diamondback is an air-to-air missile believed to be a successor to the infra-red homing *Sidewinder.* It may be one of the missiles in development now known as *Sidewinder II* or *Sidewinder III.* Increased performance and range over *Sidewinder* is the goal of the *Diamondback* project.

BULLPUP

Navy is now evaluating the *Bullpup* air-to-surface missile and it will soon be introduced into fleet service as a service weapon. Prime contractor of the missile is The Martin Co. and production is underway at the Orlando, Fla. plant. Powerplant is a solid propellant rocket by Aerojet-General. Republic Aviation is working on a guidance system for *Bullpup.* Missile has canard layout with delta and trapezoidal control and stabilizer surfaces. It is 11 feet long and has a diameter of 1 foot. *Bulldog* is a larger and improved version of *Bullpup.*

Manufacturer: Martin Co.; Range: PUP-15,000 ft., DOG-25-30,000 ft.; Speed: PUP-Mach 1.8, DOG-Mach 2; Diameter: 12 in.; Span: 12 in.; Guidance: self-contained navigation system; Powerplant: (1) Aerojet-General; Status: advanced development.

The ultimate in simplicity, Navy's SIDEWINDER air-to-air infrared missile, has less than two dozen moving parts and no more electronic components than an ordinary radio.

U.S. Navy's SIDEWINDER

Sidewinder, Navy's air-to-air infrared homing missile is named after the deadly, fast-striking, desert rattlesnake which habitates the area around China Lake, Calif., where the missile was conceived and developed by the Naval Ordnance Test Station.

Designated AAM-N-7, the *Sidewinder* is operational with TacRon 46 aboard the *USS Randolph* with the 6th fleet in the Mediterranean and FitRon aboard the *USS Bon Homme Richard* with the 7th fleet in the western Pacific. Among the aircraft which are or soon will be equipped with the rocket are the F9F-8, FJ-3, FJ-4, F8U, FD-4, F3-H, F-104, F-100 and F-89.

The missile is a rugged, inexpensive weapon capable of operating against high-performance type aircraft, and can destroy enemy fighters or bombers from sea level to altitudes over 50,000 feet. It needs no complex launching equipment and is highly maneuverable at supersonic speeds. Basically a defensive weapon for the protection of men and ships from attacks by enemy aircraft, *Sidewinder* also will be employed in the air defense of the continental United States.

Ground crewmen attach SIDEWINDER AAM-N-7 to launching rack of F9F-8 COUGAR fighter. No specialized training is required to handle and assemble it effectively.

Because of its simplicity the missile, which has less than two dozen moving parts and no more electronic components than an ordinary radio, requires no specialized training to handle and assemble it effectively. Pilots will require little or no special flight training to effectively use *Sidewinder* in combat.

Sidewinder is 4½ inches in diameter and 9 feet long. It is positioned on the launching rack by three lugs that are slid into place. Four stabilizing fins are located on the aft section. These are about 21 inches long and 8 inches high with a swept-back leading edge 10 inches long. Four canard control fins are located about 11 inches from the missile nose and attached to the body by single pivot points. Swept-back leading edges of the canards are about 11 inches long and the trailing edge is about 6 inches. The base of each fin is about 8 inches long.

The guidance system is passive infra-red and this usually takes the missile up the tail pipe of the enemy aircraft. The guidance has been described as being so accurate as to seek and "kill" flares attached to drone wings without harming the drone itself.

The seeker occupies the first 4 inches of the missile, followed by guidance section; servo is located between control fins, followed by warhead, influence fuse and solid propellant rocket motor. The motor is 75

inches long, has a nozzle 7 inches long with 3-inch inside diameter. Burning time is 2 seconds.

Current kill rate of *Sidewinder* is reported to be 7 out of 10 and this is expected to be improved to a single-shot kill capability of 9 out of 10. Range at high altitude is 11,000 feet and at sea level about 3,500 feet. Contact fuses are located at tips of control surfaces. The influence fuse takes care of a miss situation detonating the missile which is lethal within 35 feet.

Sidewinder's seeker is operative from the moment of the launcher aircraft's takeoff. Control surfaces are stabilized by a small bucket-type wheel turning at a very high speed.

The idea for *Sidewinder* came from Dr. William B. McLean, technical director of NOTS in 1949. Development at NOTS included structure, aerodynamic configuration, infrared guidance, rocket motor, pilot presentation, aircraft-missile umbilical connection, launcher and test devices. All this was under surveillance of Bureau of Ordnance. Bureau of Aeronautics was responsible for the launcher and envelope.

Prime contract for *Sidewinder* production is Philco Corp. The company is producing the missile at its Philadelphia plant under a contract totalling approximately $14-million.

Other industrial concerns connected with the program are the Avion Division of the American Car and Foundry Industries at Paramus, N. J., who produced experimental missiles used in the research and development program and General Electric Co. at Utica, N. Y. which has been awarded a production contract amounting to more than $17 million.

Eastman Kodak Co. of Rochester, N. Y. and the Bulova Research and Development Laboratories of Weedside, N. Y. are also involved in the *Sidewinder* program. Eastman is reportedly doing the infra-red work.

Power plants for the missile are of the solid propellant type reported to be supplied by Norris Thermador, Hercules Power and Hunter-Douglas.

Although it is a Navy development, *Sidewinder* will be used by the Air Force. Funds have been allocated in the AF 1958 budget for purchase, presumably for use on the F-104. First firings of *Sidewinder* from the Lockheed fighter were announced a few weeks ago. F-100 and F-89 aircraft are also expected to carry *Sidewinder*.

Advanced models, *Sidewinder II* and *Sidewinder III* are reportedly in test and prototype stages, respectively.

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SPECIFIC DATA:

MANUFACTURER:	Philco Corp., General Electric Co.
MISSION:	air-to-air
RANGE:	18,000 ft.
SPEED:	Mach 2.5
LENGTH:	9 ft.
DIAMETER:	4½ in.
GUIDANCE:	infra-red
COST:	$1,000; some reports as low as $800
POWERPLANT:	solid propellant rocket
STATUS:	service

Bird is 4½ inches in diameter and 9 feet long. Current kill rate is 7 out of 10.

SIDEWINDER was developed by the Naval Ordnance Test Station at China Lake, California. Now operational with the 6th fleet in Mediterranean and 7th fleet in the western pacific.

U.S. Navy's ZUNI

Replacing Navy's World War II high velocity aircraft rocket is the recently announced *Zuni,* named after the Pueblo Indian tribe of Western New Mexico.

Zuni is a 5-inch rocket, 110 inches long and weighing 107 pounds. It has jet operated folding fins, a feature that allows an aircraft to carry four times as many rockets as they could *HVAR's. Zuni* carries a variety of warheads and fusing systems.

This folding fin, solid propelled weapon has been extensively tested by both BuOrd and the Fleet Operational Development Board, and is now approved for operational use. It has twice the velocity of the HVAR of World War II fame.

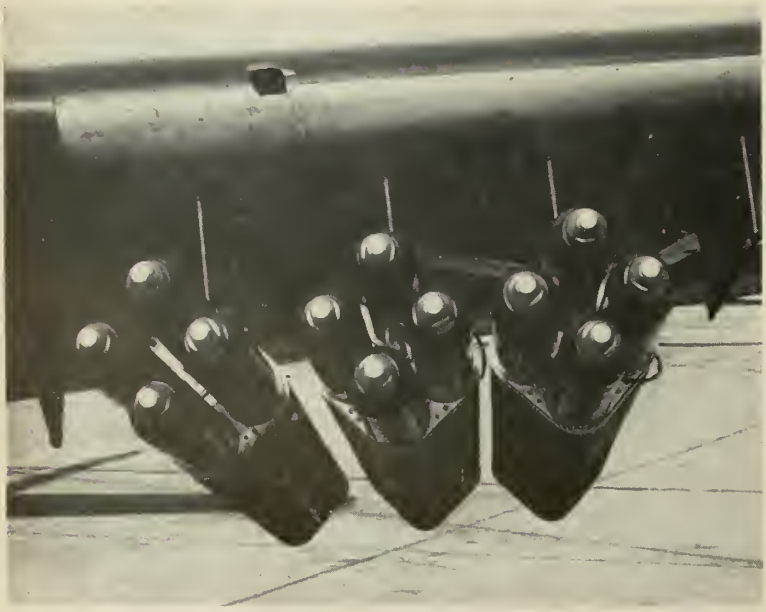
The new rocket will be used on high-performance fighter and attack-type aircraft for both air-to-air and air-to-ground firing. As an air-to-ground weapon it will be highly effective against tanks, pillboxes, gun emplacements, trains, ammunition and fuel dumps and small ships. Its high velocity and short time to target promise a high kill potential in air-to-air combat.

The *Zuni* launcher, mounted on the aircraft's wing, holds four rockets and is used for transporting and storing the rockets as well as launching. Launchers are jettisoned after firing.

The elimination of the normal packing case is expected to result in considerable time savings. *Zuni* is also designed for air-to-surface applications.

The unguided rocket generally has good static stability and reports indicate that *Zuni* is no exception. Detailed performance figures, however, are not yet available. In guided rockets, on the other hand, one must allow for a large displacement of controls to maintain a given flight path or to change direction. With relatively low static stability, they enjoy a high maneuverability rate.

Zuni's solid propellant rocket motor powers it at speeds in the vicinity of Mach 3. Cost of each rocket has been reported as $150. It was developed by the Naval Ordnance Test Station, China Lake, Calif. for the Bureau of Ordnance.



ZUNI is folding fin, solid propellant rocket, designed for fighter and attack-type aircraft, for air-to-air and air-to-surface attack. Expendable launcher holds four rockets.

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SPECIFIC DATA:	–
MISSION:	air-to-air & air-to-surface
SPEED:	Mach 3
WEIGHT:	107 lbs.
LENGTH:	110 in.
DIAMETER:	5 in.
POWERPLANT:	solid propellant rocket
REMARKS:	
STATUS:	Quantity production

REMARKS:
air-to-air, air-to-surface, developed by Naval Ordnance Test Station for Bureau of Ordnance.

Sparrow I is a supersonic air-to-air missile operational in the fleet. It was developed by the Bureau of Aeronautics at the Naval Air Missile Test Center at Point Mugu, Calif., and the Sperry Gyroscope Co.

Described as a powerful deterrent against attack by jet bombers and fighters, it is about 12 feet long, weighs about 300 pounds, and is powered by a solid propellant rocket motor.

Guidance signals deflect the missile's wings and direct it to intercept the target, even under evasive action. The *Sparrow I* weapon system is versatile, permitting effective attacks against high and low altitude targets flying singly or in groups.

Guidance is of the beam-rider type directed by the launching aircraft. The complete system is manufactured by Sperry Gyroscope Co. and the rocket motor is made by Aerojet-General. Speed of *Sparrow I* is about Mach 3 and range is 5 to 8 miles.

McDonnell DEMON armed with a formidable array of SPARROW I air-to-air missiles.

U.S. Navy's SPARROW I

Official designation of *Sparrow I* is AAM-N-2.

The deadly accuracy of the missile has been demonstrated by hundreds of missile launchings against drone targets. Successful attacks have been completed against high speed jet aircraft and against other missiles.

Operational squadrons have been assigned to carriers. Additional carriers of both Atlantic and Pacific fleets, including the super-carrier *Forrestal*, will be equipped with squadrons armed with *Sparrow I*.

Sparrow I contracts of more than $50 million were awarded Sperry for the missile guidance radar and test equipment and for production of the missiles at the Sperry Farragut Co. in Bristol, Tenn.

Sparrow I systems are on the Chance Vought F7U-3M *Cutlass* with fleet units operating both from carriers and shore and with a night-fighter squadron of the Marines employing the Douglas F3D-2M *Skyknight*.

Sparrow II missiles were developed by Douglas presumably for use on the Douglas F5D which was cancelled. The *Sparrow II* has an active homing system with a radar dish behind a blunt nose. Control surfaces are trapezoidal rather than delta-shaped as in *Sparrow I* and *III*. Some reports have been heard that the Royal Canadian Air Force will use *Sparrow II* to replace the *Velvet Glove* missile.

Sparrow III missile is a Raytheon development and has been ordered into production at the Sperry Farragut plant under direction of Raytheon. Retouched photos indicate that *Sparrow II* is about the same size as *Sparrow I*. The Raytheon guidance system is said to be completely automatic in operation. Raytheon has a $60 million production contract for the missile and is reported to be working on two still more advanced models.

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SPECIFIC DATA:

MANUFACTURER:	Sperry Gyroscope Co.
MISSION:	air-to-air
RANGE:	5 mi.
VELOCITY:	Mach 3
WEIGHT:	280 lbs.
LENGTH:	8.25 ft. ex booster 11.75 ft. including booster
DIAMETER:	0.5 ft.
SPAN:	2.25 ft. (has smaller tail fins also)
COST:	$10,000
STATUS:	service

REMARKS:

SPARROW-II, officially known as the XAAM-N-3; length is said to be 4.2 ft. with weight 300 lbs.

SPARROW I missile system is combat-ready. Fighters armed with SPARROWs are equipped with airborne guidance gear developed by BuAer and Sperry Gyroscope to direct missiles.

U.S. Navy's TORPEDOES Mark 27, 37, and 43

The first modern guided missile was World War II's sonar-guided torpedo. Even though it worked solely underwater, it fit the definition of a guided missile and beat its airborne cousins by some years.

With designations like Mark 27, Mark 37 and Mark 43, World War II and present operational torpedoes have speeds ranging from 20 or 30 knots to 45 knots. Generally speaking, electrically powered torpedoes were slower but gave off no tell-tale wake and were thus more silent. Steam torpedoes or gas generator-turbine powered units reached higher speeds but gave off both visual and audible wakes. Generally speaking, the practical operational range of the torpedo was considered to be 10,000 yards.

The World War II electric torpedo used a conventional lead-acid battery. Silver cell batteries (Zn-alkali-Ag202) are up to six times lighter and five times smaller than lead-acid batteries for the same output. Primary batteries such as the magnesium sea-water-silver chloride are even lighter and smaller and are considered for torpedo use.

For the higher speed, longer range torpedoes, total energy requirements are such that thermal power plants must be used. A wide variation in performance is achievable, depending upon the propellant combination. Because of their relatively high performance and their potentially wakeless exhaust products, hydrogen peroxide-hydrocarbon systems have been widely used.

Use of either carried fresh water diluent or free sea water diluent is necessary in turbine propulsion systems in order to decrease the operating temperatures. The use of sea water, although significantly increasing the performance per unit of carried expendables, poses serious salt problems.

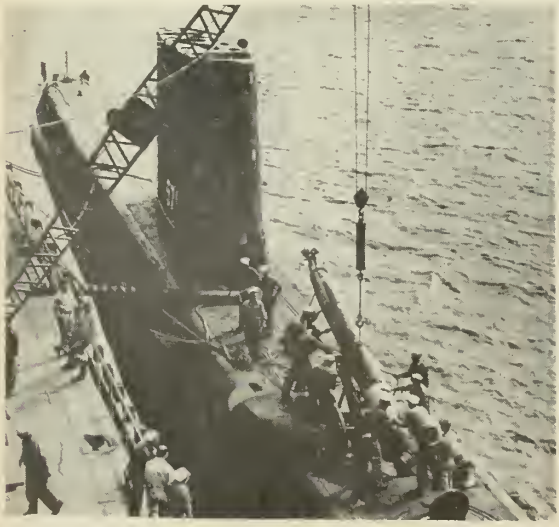
For reciprocating engine power plants, no diluent is necessary. Copious quantities of sea water are required, however, to cool critical engine parts.

However, underwater warfare appears on the verge of a technological revolution. Noisy, bubble-forming cavitation, a major problem of high-speed underwater flight, appears about to be overcome by more close emulation of the hydrodynamics of a fish. Propulsion systems under study now include not only the gas turbine but hydroducts (ramjets) and pure, conventional rockets as well. An Aerojet-General test torpedo utilizing one of the latter propulsion systems has done 155 knots underwater in captive runs. At speeds of this order, the fact that it is noisy and can be readily detected by conventional sound gear diminishes in importance. Even if the torpedo is detected, the vessel attacked would scarcely have adequate time for evasive action.

One problem, however, of large noise levels emanating from the torpedo itself is that of interference with the missile's own sound-based guidance system. However, recently highly successful work with the detectability of sounds in the very low frequency ranges may make it possible to tune guidance gear so that it will ignore its own self-made noise.

One view of the torpedo of tomorrow might be as follows: Its body will be made of magnesium, plated to provide a smooth high gloss finish. Its detection and homing gear will be acoustic; will have a range of well over 100 miles if necessary; and will concentrate in the ultra-low frequency ranges. Its speed may be anywhere from 150 knots upwards. Its propulsion system will consist of a hydroduct (ramjet) whose "combustion" products are solubles, thus leaving no visible wake. Hydrodynamically, it will be near-perfect, providing means of pressure equalization (boundary layer control), perhaps with ducts to feed in or draw off water as necessary. Its range may be anywhere from ten to several hundred miles. Its warhead will be either nuclear or with conventional explosives.

In addition, there are several projects now under way—some in the feasibility study stages; others under actual development—that involve transitional concepts where the missile starts out underwater and then becomes airborne, or vice versa.



U.S. Navy rightly can claim to be the producer of the first guided missile. Future underwater missiles may have speed of 150 knots.

U.S. Navy's TERRIER & TARTAR

A slim, needle nose weapon, *Terrier* is designed to intercept aircraft at longer range and higher altitudes than anti-aircraft guns, and under all weather conditions. A contract for about $29 million has been awarded to Convair at Pomona, Calif., for production of guidance and control units of the missile. Convair, prime contractor, participated in the engineering of *Terrier*, which was developed for the Bureau of Ordnance under technical direction of the Applied Physics Laboratory, Johns Hopkins University.

Now in operational use, *Terrier* is installed on the cruisers *USS Boston, USS Canberra,* destroyer *USS Gyatt* and will be used on many other destroyer-frigate type vessels.

The "coke handling" system for launching *Terrier* is a product of Northern Ordnance, Inc., Minneapolis. Solid propellant power plant is by Aerojet General. It is launched by a booster and is beam-rider guided.

Terrier is 13 feet long, 27 feet long with booster. It is about one foot in diameter, has a fin span of 4 feet, weighs about 3,300 pounds. Speed is 1,500 miles per hour, range about 20 miles, ceiling 60,000 feet. Cost is about $62,000. Effectiveness has been reported at 80 per cent.

Terrier II is reported to be twice the size of *Terrier I* and will have radar homing guidance to supplement shipboard beam-rider direction. Radome of Corning Glass Works Pyroceram will withstand temperatures of 2,400°F.

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SPECIFIC DATA:

MANUFACTURER:	Convair
MISSION:	Surface-to-air
RANGE:	20m
SPEED:	Mach 2.5
LENGTH:	15 ft.
DIAMETER:	1 ft.
SPAN:	4.1 ft.
GUIDANCE:	Reeves beamrider
POWERPLANT:	(1) Aerojet General SPR (1) Aerojet General SPR booster (14 ft.)
ALTITUDE:	60,000 ft.
STATUS:	early production

REMARKS: surface/ship-to-air, anti-aircraft missile. Replacing TERRIER 1; now in use on cruisers and one destroyer—will be installed on 4 more ships by 1959, 13 by 1960 and 22 by 1961, when it is replaced by TARTAR.

Tartar is a surface-to-air guided missile about three-fourths the size of *Terrier*. Prime contractor is Convair and the solid propellant rocket motor is supplied by Allegany Ballistics. *Tartar* will be used on destroyers and other small vessels.

Rear Adm. John H. Sides has said that *Tartar* will also be used in secondary batteries of large ships. He reported that it outperforms the original *Terrier* and will replace five-inch batteries. Adm. A. A. Burke, Chief of Naval Operations, said *Tartar* should be cheaper than *Terrier*.

Convair's Pomona, Calif., plant has the *Tartar* contract for engineering and production under Bureau of Ordnance. In March this year contracts were let for construction of eight destroyers which will be equipped with the missile. Bureau of Ordnance has asked for $32 million in fiscal 1958 for production of the *Tartar*. This is $19 million more than received this year.

In recent hearings before the House Defense Appropriations Subcommittee Rear Adm. Frederic Withington, Chief of Bureau of Ordnance said, "I am committed to have this weapon completely ready for destroyers in the 1957 building program. As I have told the committee, this is a considerable gamble. I hope we will make it but I cannot guarantee it."

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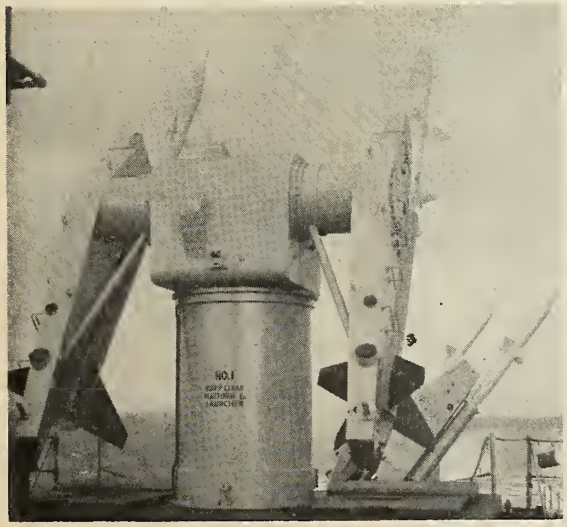
SPECIFIC DATA:

MANUFACTURER:	Convair
MISSION:	surface-to-air
GUIDANCE:	beamrider with homing head
STATUS:	development
POWER PLANT:	(1) SPR

REMARKS: surface ship-to-air, anti-aircraft missile; essentially a refined and improved TERRIER, smaller in size; scheduled to be standard armament on destroyers and secondary armament on capital ships by 1961.



The deadly Terrier, supersonic Navy surface-to-air missile was fired experimentally in November 1954 from the Navy's USS Mississippi.

U.S. Navy's REGULUS I

Regulus I is the first in a series of surface-to-surface missiles developed and manufactured by Chance Vought. Its name is taken from a star in the constellation Leo. Regulus also was a popular name in the middle ages for a snake that was supposed to kill by its hiss.

The *Regulus I* resembles a swept-wing jet fighter, 33 feet long, span of 21 feet, diameter about 4½ feet. Take-off weight is 14,520 pounds, speed is about 600 miles an hour and range is 600 miles maximum.

Designated SSM-N-8, the missile was developed in 1948 by Chance Vought under the sponsorship of the Bureau of Aeronautics. It was designed for launching from submarines, surface ships, and shore bases. Launching equipment can be installed in a short period of time on several types of vessels at relatively low cost with only slight modification to the ship.

Tactically it will be used by Marines against appropriate land targets.

Although the assault missile and certain other configurations will employ a drone version of *Regulus I*, tactical employment will also include those techniques and guidance systems associated with the operation of all-weather, distantly controlled guided missiles. This makes it possible to utilize *Regulus I* in various ways without the expense and effort of designing and procuring a separate one for each function.

At the end of 1956 Chance Vought's Dallas plant had orders totaling $26 million for production of *Regulus I* which had been in service as the Navy's first operational attack missile since 1955.

The non-recoverable version of *Regulus I* is capable of delivering a nuclear warhead over a range of hundreds of miles guided by a built-in electronic brain built and developed by Stavit Engineering and Advance Industries, Inc. The recoverable version, equipped with a retractable landing gear, flies pilotless missions and lands intact. As many as 16 flights have been made by a single *Regulus I*. The drone designation is KDU-1.

Powerplant of *Regulus I* is an Allison J33-A-18A turbojet delivering

REGULUS I on a test flight. It travels at about 600 miles an hour with a 600 mile range. Successful flights with wing pods have been made extending range to a possible 1000 miles.

4,600 pounds of thrust. The missile is launched by two Aerojet-General solid propellant 1,000-pound thrust ATO rockets or by means of a steam-driven catapult.

Regulus I is directed by a command guidance system, parts of which are manufactured by Bendix, Ultrasonics Corp., Sperry Gyroscope, Motorola, Inc., and Bell Aircraft.

The subs *Tunny* and *Barbero* carry the *Regulus I* in round watertight hangars on their decks just aft of the conning tower. In a matter of minutes after surfacing, crews can roll out and launch the missile. The sub *Halibut* will have an internal hangar for both *Regulus I* and *Regulus II*. It will be the first nuclear submarine specifically built for missiles.

Airframe subcontractors for *Regulus I are* R. H. Osbrink and Bendix. Subcontractors on the powerplant are Goodrich and Goodyear.

Fuselage of *Regulus I* is cylindrical with heavy gauge skins wrapped on bulkheads, stringers and longerons. Wings consist of cast magnesium outer panels on a conventional built-up center section. Wings fold for shipboard stowage. There is no horizontal tail—both pitch and roll control being exercised through ailavators on the trailing edge of the wing.

Missile is launched from a short rail launcher in which it rests on four slipper fittings. Launching boost is from two rockets which accelerate the missile to flying speed in a little over 2 seconds. Rocket cases and slippers are ejected after launch.

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SPECIFIC DATA:

MANUFACTURER:	Chance-Vought Aircraft Inc.
MISSION:	surface-to-surface
RANGE:	600 mi.
SPEED:	600 mph
WEIGHT:	14,520 lbs.
LENGTH:	32 or 33 ft.
HEIGHT:	9.5 ft.
DIAMETER:	4.5 ft.
SPAN:	21 ft.
STATUS:	service

REMARKS:

several models known; one is experimental model with parachute recovery device; second, training model; third, a gunnery target; all have wheels; tactical model does not have wheels or recovery mechanism

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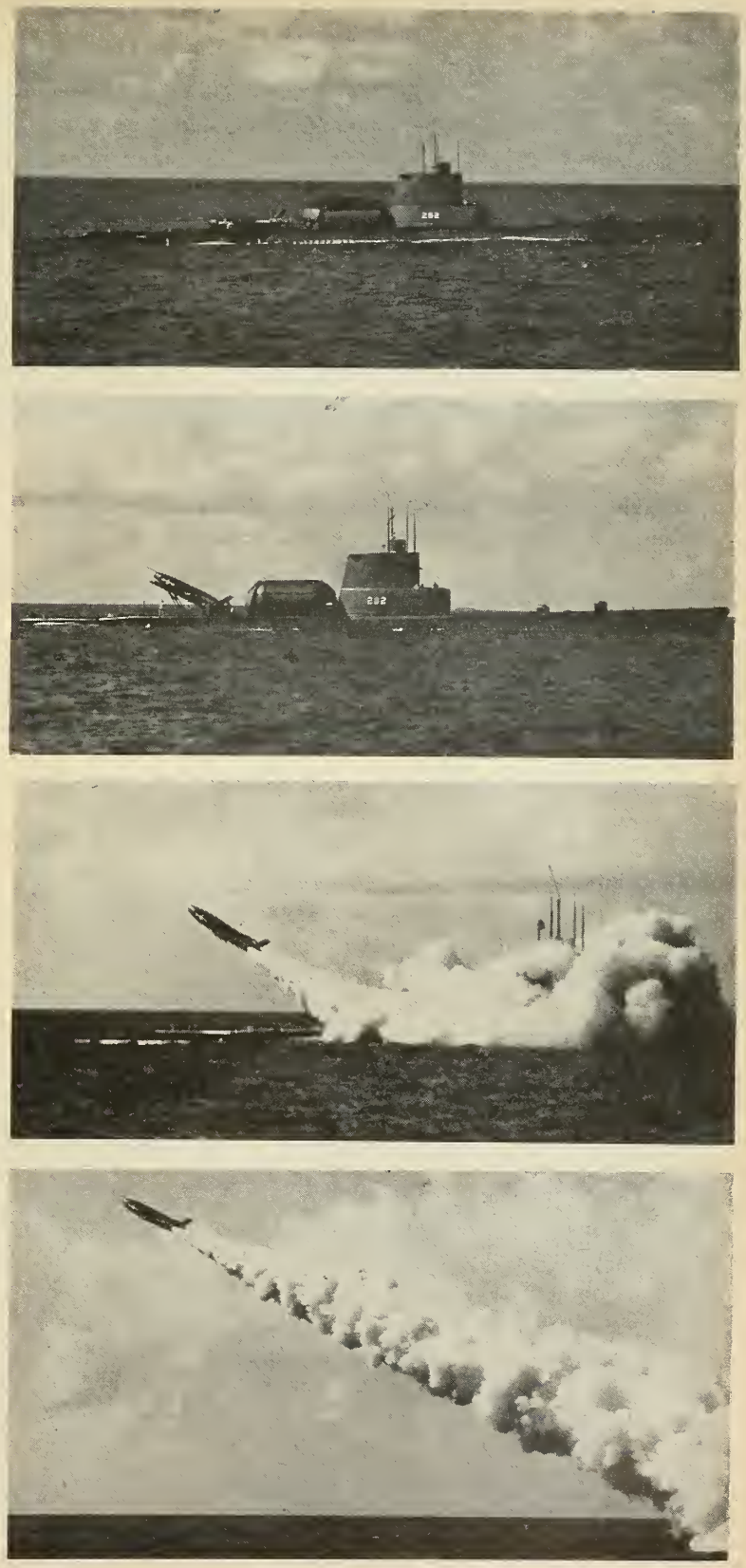

The subs TUNNY and BARBERO carry the REGULUS I in round watertight hangars on their decks just aft of the conning tower. Photos show launching sequence aboard USS TUNNY. Missile is moved from hangar to launch platform, is prepared for firing, and soars skyward leaving clouds of smoke from its solid propellant booster rockets.

Slated for arsenal of the U.S. Fleet next year TALOS can, in addition to its surface-to-air mission, be used against ship and shore installations. Army may use it for air defense.

U.S. Navy's TALOS

Talos, Navy's long-range, surface-to-air missile, will be added to the fleet early in 1958. It will form the major armament of the light cruiser *USS Galveston* now undergoing conversion to a guided-missile cruiser at the Philadelphia shipyard. A year later cruisers *USS Little Rock* and *USS Oklahoma City* will be armed with *Talos* and will rejoin the fleet. The first nuclear-powered cruiser *Long Beach* will also have *Talos* armament.

Talos is capable of delivering a high explosive or nuclear warhead at any altitude that airplanes can fly and far beyond the range of human vision. Originally designed for shipboard installation, *Talos'* great range and accuracy have drawn the interest of Army as ground defense weapons in the Continental Air Defense system.

Production of *Talos* is underway at the Naval Industrial Reserve Ordnance plant, Mishawaka, Ind., operated by Bendix Aviation, for the Bureau of Ordnance. Bendix received a $27 million contract early this year.

The missile is the second to come out of the *Bumblebee* program at the Applied Physics Laboratory for Johns Hopkins University.

Talos is powered by a McDonnell ramjet engine which operates after the missile has been boosted to supersonic speeds by a solid rocket motor. The ramjet using zip fuels is reported to propel the missile at Mach 3.5.

The guidance is a mechanical brain called steering intelligence system which insures great accuracy. When within lethal range of target a proximity fuel detonates the warhead.

Rear Adm. J. H. Sides said "*Talos* is larger than *Terrier* and has longer range. It will reach out into zones now covered by interceptors." The missile is being evaluated at White Sands Proving Ground, N. Mex. In development tests it killed a drone at 25 miles with a direct hit. That was in 1954 and Navy says missile has undergone considerable improvement since.

Talos is essentially a 20-foot hollow tube 30 inches in diameter. Inside the open nose is a blimp-shaped diffuser which channels air past burners producing tremendous thrust. Four maneuverable stubby wings at mid point and four tail fins control its course and stabilize its flight. Fins are said to be made of fiberglass. Those made of magnesium were rejected.

McDonnell, in addition to supplying the ramjet engine, also builds the airframe. Radio Corporation of America is reported to be involved in development of ground and airborne radar beam-rider systems.

Reports early this year have indicated that *Talos* might become the standard antiaircraft missile of NATO. It is known that the British would like to procure the missile for replacing RAF interceptors.

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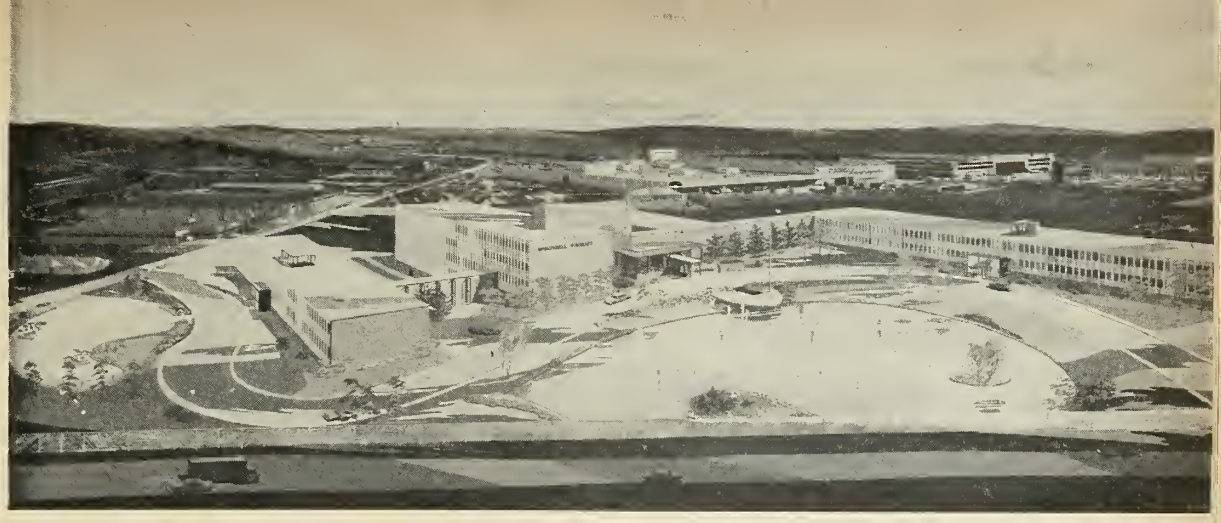
SPECIFIC DATA:

MANUFACTURER: Bendix Aviation Corp. (prime)
McDonnell Aircraft Corp. (airframe)
MISSION: surface-to-air
SPEED: Mach 4
WEIGHT: 3,000 lbs.
LENGTH: 15 ft.
DIAMETER: 18 in.
SPAN: 4.1 ft.
GUIDANCE: Bendix beamrider plus radar homing
POWERPLANT: (1) McDonnell 18" ramjet
(1) SPR booster
ALTITUDE: 75,000 ft.
GROUND CHECK-OUT: Reeves Instrument
STATUS: limited production for test
REMARKS:
surface-to-air, inner-defensive, anti-aircraft missile; land-based version recently transferred from USAF to Army cognizant under Wilson's "roles and missions" decree; future status uncertain in view of Army emphasis on NIKE HERCULES

TALOS, boosted by solid propellant rocket, gathers speed as it roars from launcher. It will lock on target and when within lethal range a proximity fuse detonates the warhead.



U.S. Navy's TRITON

Triton is the third generation of sub-launched surface-to-surface missiles on the drawing boards. It is powered by twin McDonnell ramjets and is in the 1,500-mile range class with speeds of Mach 3.5 and a self guiding system. It is expected to reach 80,000 feet in altitude.

Triton will use zip fuels. Solid booster rockets will launch the missile and push it to supersonic speeds when the ramjets take over. *Triton* is designed to fit *Regulus* launching and storage equipment.

Bureau of Ordnance is asking $2.6 million more than last year for *Triton* development. No figure on last year's sum has been reported.

Like *Talos*, *Triton* is an outgrowth of the *Bumblebee* program at the Applied Physics Laboratory at Johns Hopkins University. McDonnell is the prime contractor and also supplies the ramjet engines. Bendix has been reported as supplying the fuel control equipment and the inertial guidance system is by Kearfott.

In charge of the *Triton* program at McDonnell is Chief Engineer Ben G. Bromberg. His office is responsible for development and testing of guided and unguided missiles which the company has under contract and to involve new missile designs. McDonnell currently has some 750 engineers in the Missile Engineering Division. This is about 20% of the total number employed by the company. The missile engineers are moving into a new $1 million office building—the first of a series to form an "engineering campus" at the St. Louis facility.

Navy Missile Director Rear Adm. John Clark probably referred to *Triton* when he stressed the need for continued ramjet missile development because of the many problems still facing the ballistic missile before it could become a precision weapon. The ramjet missle, he pointed out, is fully controllable and can be guided in flight.

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SPECIFIC DATA:

MANUFACTURER:	McDonnell Aircraft Corp.
MISSION:	surface-to-surface intermediate range aerodynamic cruise
RANGE:	1500 mi.
SPEED:	Mach 3.5
WEIGHT:	20,000 lbs.
LENGTH:	47 ft.
DIAMETER:	57 in.
GUIDANCE.	inertial by Kearfott Co.
POWERPLANT:	ramjet plus booster
ALTITUDE:	80,000 ft.
STATUS:	development
REMARKS:	surface-to-surface, pilotless, aerodynamic tactical weapon, BUMBLEBEE (John Hopkins) project: a scaled-up TERRIER

Dr. Ben Bromberg (second from left), Chief Engineer of McDonnell's Missile Engineering Division, and his staff have TRITON development responsibility. $2.6 million additional '57 funds for TRITON.

Design engineering section of Missile Engineering Division's new $1 million St. Louis facilities. MED has some 750 engineers. This is about a 20% slice of McDonnell's total engineers employed.

U.S. Navy's REGULUS II

Regulus II is planned as the operational successor to *Regulus I*. Its increased speed and altitude make it a more effective weapon.

The second version of the Chance Vought surface-to-surface missile is designated SSM-N-9 and is designed for launching from a submarine, or ship and may also be used as a land-base weapon. It is 57 feet long, about six feet in diameter and has a wing span of about 20 feet. It may carry a nuclear warhead.

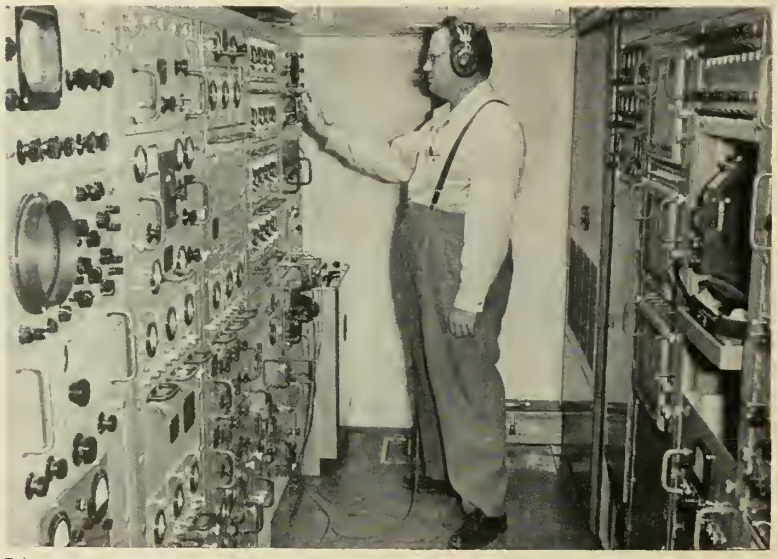
Test models of the missile are powered by the Curtiss-Wright J65 jet engine but production missiles carry the General Electric J79 turbojet—the same engine that powers the supersonic Lockheed F-105, Convair B-58 and Grumman F11F-1.

Regulus II features a fixed canard stabilizer just aft of the nose, swept wings with extremely sharp leading edges and a very large belly air scoop. There is no horizontal tail stabilizer. Test vehicles are equipped with tricycle landing gear for recovery. They are reported to land at about 250 knots on full afterburner with both elevons down.

Navy first showed the *Regulus II* in early March. By that time some 13 test flights had been carried out at Edwards Air Force Base, Calif. Six of these tests were reportedly with the same missile. At last report test models were averaging four flights each.

Rear Adm. John E. Clark said that the range of *Regulus II* is less than the IRBM range of 1500 miles. Most observers say the missile is capable of 1000 miles.

Regulus II test vehicle designed by Chance Vought for the U.S. Navy is recoverable.



Telemeter van used for checking telemeter gear in Regulus II during flights. Regulus II has flown at more than 1½ times the speed of sound and above 50,000 ft.

Reason for the relatively limited range of the *Regulus II* when compared to the 5000-mile range of the similar-sized subsonic *Snark* is that a heavy accent has been placed on speed.

The large air scoop beneath the belly of *Regulus II* has a smaller shovel-shaped inlet located above the engine intake. Air from this small scoop is led through large open ducts built into the fuselage and emptied beneath each wing from slots marked "boundary layer exits." This arrangement is believed to serve as a supersonic fillet to minimize wing-fuselage interference.

Regulus II's altitude has been announced as above 50,000 feet. Speed is Mach 5 to Mach 2.

Compared to *Regulus I*, the later missile is longer by 26 feet, about twice as heavy, and costs about twice as much.

When launched from a surfaced submarine or other ship the missile is boosted by a single, large, solid-propellant motor manufactured by Aerojet General. By the time the missile becomes operational, Navy will have two submarines converted as *Regulus II* launchers.

Firestone Tire and Rubber has a contract for installation of the launching on the subs *Grayback* and *Growler*. Guidance for the *Regulus II* is by Sperry. *Regulus II* is usable from the same ships and submarines that handled *Regulus I*. At present many carriers, four cruisers, in addition to subs, carry *Regulus I*.

Air Force has indicated interest in the *Regulus* missiles as air-to-surface weapons. There have been reports that a *Regulus I* was fired from a B-52. Before firing, the missile was carried in the bomber's big bomb bay.

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SPECIFIC DATA:

MANUFACTURER: Chance Vought Aircraft Inc.

MISSION: surface-to-surface aerodynamic cruise

RANGE: 800-1000 mi.

SPEED: Mach 1.5

WEIGHT: 12 tons

LENGTH: 57 ft.

DIAMETER: 6 ft.

SPAN: 20 ft.

GUIDANCE: radio command by Stavid Engineering Co.

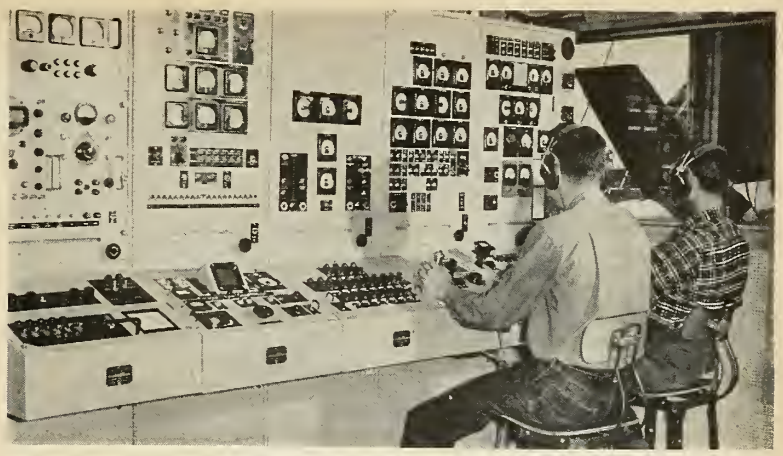
POWERPLANT: first eight a/c-Wright J65s; all others—GE J79s

ALTITUDE: 50,000 ft.

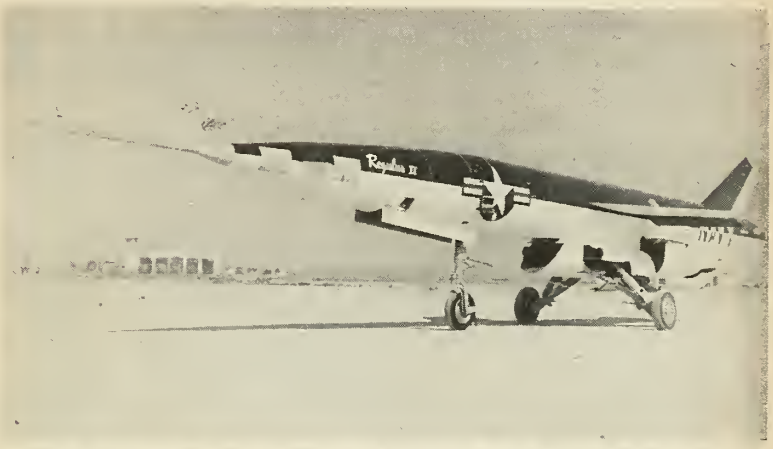
LAUNCHER: (2) Aerojet 4-second solid powder boosters

STATUS: early production

REMARKS: surface-to-surface, air-breathing, aerodynamic tactical missile, shore/ship/submarine launched; Firestone Tire and Rubber Co. Guided Missile Division, Monterey, to design, build, test and install launching system for submarines



Check out of controls for Regulus II is conducted from this Tunny Panel, which is identical to the control system used for Regulus missile in submarine.



Ground view of the supersonic Regulus II at Edwards Air Force Base, California. Missile can carry nuclear warhead and is designed to be launched from subs as well as surface vessels.

Regulus II test vehicle is powered by a J65 turbo jet engine. Later versions will employ the more powerful J79 power plant. This vehicle also employs boundary layer control.

U.S. Navy's POLARIS

Named for the North Star, *Polaris* will be the Navy's first underwater-launched intermediate range ballistic missile. It will be substituted for the *Jupiter* which the Navy was planning to use its ballistic missile system.

Polaris is described as a stubby weapon with a range of 1,500 miles maximum. One of the reasons mentioned for selection of *Polaris* instead of going along with *Jupiter* was the shipboard handling problem. *Polaris* will have a solid rocket motor instead of the *Jupiter's* liquid motor.

Prime contractor for the *Polaris* is Lockheed Aircraft Corp. at Sunnyvale, Calif. Aerojet-General is working on the rocket and recent reports that the company had fired the largest solid-propellant motor yet, indicates that the company is well along on the project.

Massachusetts Institute of Technology and General Electric are working on design and development for a fire control system for the missile. Loewy-Hydropress Division of Baldwin Lima-Hamilton Corp., has a $2,-million contract to build a ship-motion simulator for use in developing *Polaris*.

Other contractors include Westinghouse-Sunnyvale for design and manufacture of experimental seagoing handling and launching systems including development of various mechanical and electrical systems for launching *Polaris* from subs and surface vessels.

The inertial guidance package for *Polaris* is slated to undergo acceleration and vibration tests at the Supersonic Navy Ordnance Research Track at China Lake, Calif.

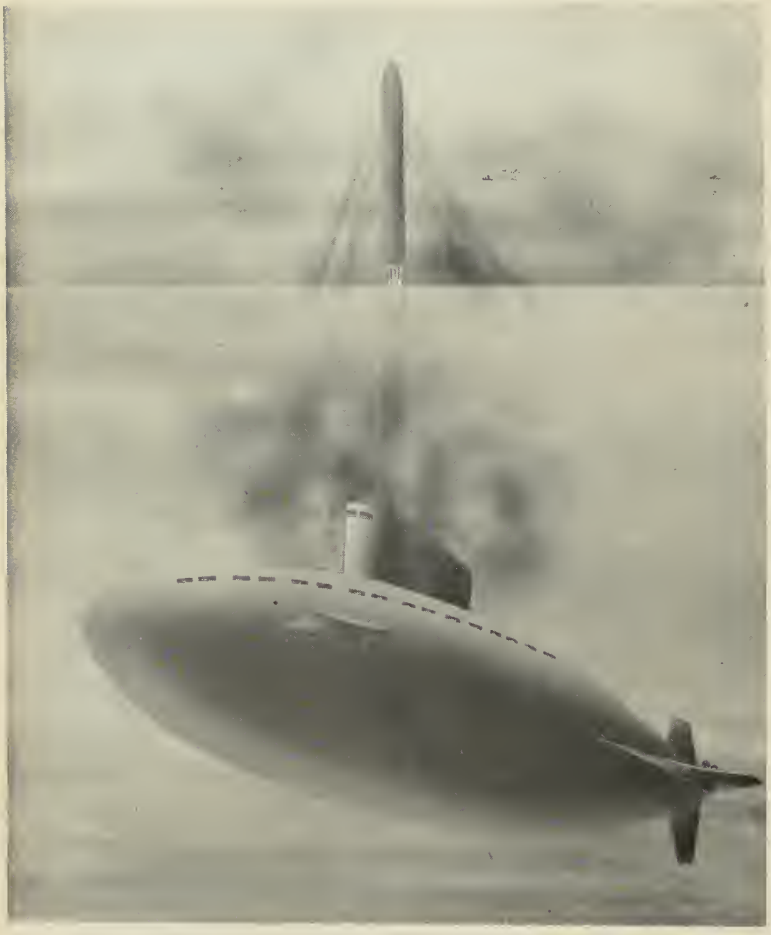
Rear Adm. W. F. Raborn, director of the *Polaris* project, said that *Polaris* will be a supporting weapon in future task forces which will be built around the aircraft carrier. Tactical mission would be to beat down fixed-base air and missile defense to pave way for carrier strikes. Infinite number of launching points will make it impossible for the enemy to pre-plot the *Polaris* trajectory.

Admiral Raborn said that the present *Polaris* program provides for a limited number of missiles plus a new nuclear submarine capable of launching the weapon.

Navy has requested $68 million for the missile and related equipment in fiscal 1958.

Some truly sophisticated underwater vessels are being planned by the Navy. These submarines are nuclear-powered guided missile carriers built to launch the solid-propellant, high-punch, intermediate-range *Polaris* Fleet Ballistic Missile. The submarines—possibly two prototypes on order at first—are part of the *Polaris* project.

Possibly the biggest missile and most complex weapons system the Navy has ever attempted, the *Polaris* will be a high-energy solid-propellant stubby 40-50-foot missile approximately 100 inches in diameter. Range is believed to be between 800 and 1500 miles. The atomic warhead in the *Polaris* will be quite sizable, 1000 pounds might be a fair guess.



The POLARIS is described as a stubby missile with a range of 1500 miles. Special submarines using ALBACORE-type hull are understood to be planned for the Navy's fleet ballistic missile. The Polaris can also be launched from surface ships. Lockheed is prime contractor.

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SPECIFIC DATA:

MANUFACTURER: Lockheed MSD
MISSION: surface to surface IRBM
RANGE: 1500 mi.
DIAMETER: 100 in.
LENGTH: 40-50 ft.
GUIDANCE: GE/MIT to be based on Ship Inertial Navigation System (SINS) developed by Dr. Draper
STATUS: early development
REMARKS: fleet ballistic missile. to be ready "in 5 years" for operational use.

U.S. Air Force's MIGHTY MOUSE

For years America's only operational air-to-air rocket was the reliable 2.75 inch, folding fin unguided *Mighty Mouse* or FFAR.

The rocket uses a proximity fuse, and has fins that fold out at launch. Some airplanes, for example the F-89 and F-94C, carry them in wing tip pods to improve dispersion, firing about twelve in a quarter of a second. Other planes, such as the F-86, fire them in single volleys of 24, leaving the aircraft at 200 miles per hour.

The F-89D can carry 104 of these 2.75 rockets and fire them electronically. A T-110 rocket gun has been developed to fire the *Mighty Mouse*.

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

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

Aerojet-General Corp., Azusa, Calif., manufactures the rocket motor and ingenious folding fin assembly; Hunter Douglas Aluminum Co., Riverside, Calif., which makes the tubes, and Heintz Manufacturing Co., Philadelphia, which produces the warheads. Colson Corp., Elyria, Ohio, produces rocket motor assemblies.

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

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SPECIFIC DATA:

MANUFACTURER:	Aerojet General Corp. Hunter Douglas Aluminum Co. Heintz Manufacturing Co. Colson Corp.
MISSION:	air-to-air
VELOCITY:	2,600 ft. per sec. (Mach 2.7 at Altitude)
WEIGHT:	18.5 lbs., 3.5 lbs. warhead
LENGTH:	48 in.
DIAMETER:	2.75 in.
GUIDANCE:	aimed
COST:	$65
STATUS:	service

REMARKS: most available, most ready, most operationally effective air defense weapon available today

Simple missile used by the Air Force is the 2.75" MIGHTY MOUSE, standard weapon for our jet fighters. Missile is easy to handle.

MIGHTY MOUSE packs a wallop equivalent to a 75 mm cannon shell. It is doubtful if the largest aircraft could survive single hit.

U.S. Air Force's FALCON

FALCON aerodynamic configuration is termed pseudo-canard. The forward wings are fixed with steering accomplished by control surfaces placed at trailing edge of stabilizers.

The Hughes GAR-1 *Falcon* is the Air Force's only operational air-to-air missile.

The weapon is smaller than Navy air-to-air weapons, weighing only about 100 pounds and having a range of about five miles. It utilizes a Thiokol solid-propellant motor which produces enormous thrust for a very brief interval, accelerating the missile to a velocity of more than Mach 2.

The *Falcon* is part of a complete weapon system developed by Hughes Aircraft Co. for the Northrop F-89 and Convair F-102A and F-106A interceptors. Approximately 1200 pounds of fire control equipment is carried in the aircraft to support the missile.

Its aerodynamic configuration is termed pseudo-canard. "Pseudo" because although having a typical canard configuration with small forward fins and large aft supporting surfaces, the forward wings are fixed and steering is accomplished by control surfaces hinged to the trailing edge of the stabilizers. A round nose fairs into a cylindrical fuselage which terminates in a boat-tail housing the exhaust nozzle of the rocket motor.

Guidance is by radar impulse generated by the interceptor. The system has all-weather capability and is entirely automatic. It has been reported that Hughes is working on an infra-red version of the *Falcon*. The Air Force is planning, however, to buy the Navy's *Sidewinder IR* air-to-air missile for use with its Lockheed F-104A interceptors.

This will probably mean mixed payloads on a single interceptor. A combination of radar and infra-red guided missiles on the same mission would greatly enhance the possibility of a successful hit. Everything that can be done to out-guess or confuse the enemy's airborne system of countermeasures serves to increase the probability of a successful mission.

Hughes Aircraft Co. says of the *Falcon*: "The GAR-1 has the lethal capacity to stop any bomber dead in its tracks and can do it frequently enough to have resulted in drone bomber targets being one of the major items of project expense. They have been a costly item even though *Falcon* test missiles carry payloads of telemetric equipment rather than warheads."

Cost of the GAR-1 was estimated at $19,000 a copy last year, but it was expected that the cost would drop. Early this year, Hughes announced the GAR-1D *Falcon* which incorporates aerodynamic improvements and can reach greater altitudes than the earlier model.

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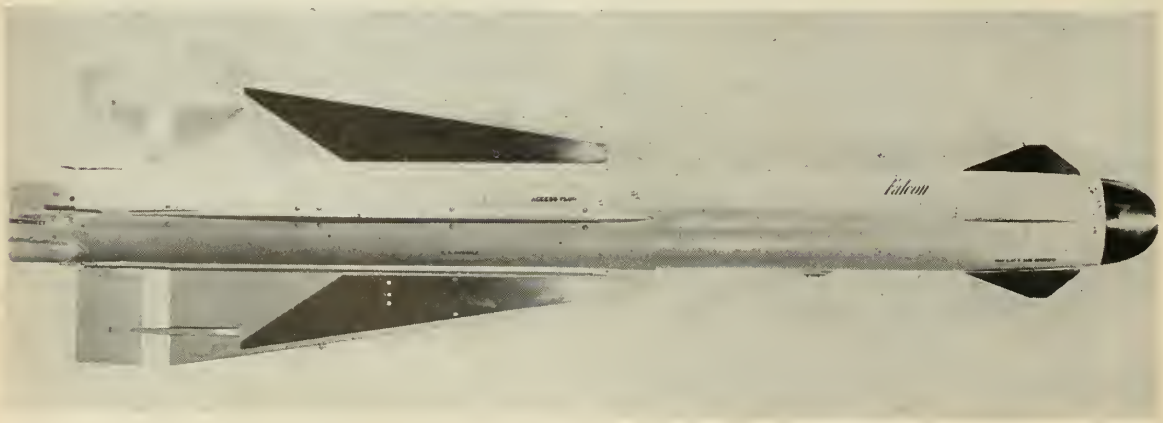
SPECIFIC DATA:

MANUFACTURER:	Hughes Aircraft Co.
MISSION:	air-to-air
RANGE:	about five mi.
VELOCITY:	Mach 2 plus
WEIGHT:	(take-off) about 110 lbs.
LENGTH:	77.8 in.
SPAN:	20 in.
PROPULSION:	Thiokol SPR motor 6,000 lbs. thrust



The air-to-air FALCON is the smallest guided missile in production. Slightly over 6 feet in length and weighing 110 pounds, it is powered by a Thiokol solid propellant propulsion unit. GAR-1D FALCON (above) incorporates aerodynamic improvements over earlier model.

U.S. Air Force's BOMARC

Most potent of all air-defense missiles now in advanced development is the IM-99 *Bomarc* pilotless interceptor. Boeing Airplane Co. is developing and producing the weapon for the Air Force.

Unlike the *Nike* and *Terrier* missiles, which are "point" defense weapons, the *Bomarc* is an "area" defense weapon. Its maximum capability may only be realized when the Air Force places the gigantic SAGE information gathering and computing system in full operation.

The Boeing weapon is powered by a pair of Marquardt ramjet engines plus an Aerojet liquid-propellant booster mounted in the tail. It has a gross weight of 15,000 pounds and an estimated range of 200-300 miles. Range may be increased through the use of high-energy synthetic fuels like pentaborane.

Bomarc takes off in a vertical attitude on the thrust of its booster rocket and climbs at supersonic speeds until the ramjets ignite. This occurs before booster burnout, so the total acceleration of the weapon climbs sharply as the upward flight progresses. At its programmed altitude of about 60,000 feet, the missile levels off sharply and proceeds toward its target at speeds in excess of Mach 2.5.

Boeing was awarded a production contract for the *Bomarc* IM-99 interceptor missile on May 16. The initial production contract was for $7,109,195.

Bomarc was revealed as a long-range ground-to-air interceptor missile designed to operate at "extreme" altitudes and supersonic speeds, with outstanding range characteristics.

In a series of successful firings against high-flying "drone" airplanes over the Atlantic Ocean, the *Bomarc* has proved itself an excellent interceptor weapon, according to the Air Force.

Bomarc will be operated by the Air Defense Command from bases where its range capabilities may be fully utilized. Because of its range, the IM-99 is known as an "area defense weapon" as opposed to short-range anti-aircraft missiles known as "point defense weapons."

The new missile is launched vertically by a liquid fuel rocket engine When it reaches a speed suitable for ramjet operation, the rocket cuts out as twin ramjet engines take over to provide supersonic cruise flight. The ramjets are slung on struts beneath the slim, cylindrical *Bomarc* fuselage.

Design of the *Bomarc* missile is based on technical background acquired in Boeing's "GAPA" (Ground to Air Pilotless Aircraft) program of the late '40s. These early missiles, of which 112 were test-fired, ranged up to 16 feet in length and reached speeds of 1500 miles an hour. Their operating altitudes ranged from 6,000 to 80,000 feet.

Speeds and altitudes of the *Bomarc* have not been officially revealed by the Air Force. Armament of the 15,000 pound weapon is described as a "high explosive warhead".

Individual IM-99 flights have been carried out since early autumn 1952. Piloted airplanes fitted with *Bomarc* electronic guidance system components have also been used in the test program, with the pilot cutting out the guidance system and pulling away from the collision course as the *Bomarc*-guided plane closed in on its target.

These extensive tests provided proof of components and supplied background for recent firings in which the Boeing IM-99 missiles were operated as part of an integrate weapon system, seeking out and intercepting "drone" bombers far out over the Atlantic.

The *Bomarc* missile is being assembled in Seattle. More than 70 per cent of the missile is subcontracted.

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SPECIFIC DATA:

MANUFACTURER:	Boeing Airplane Co.
MISSION:	Surface-to-air
RANGE:	200-300-mi.
SPEED:	Mach 2.5-3

BOMARC, trailing flame from its Aerojet liquid propellant booster engine, leaves launch pad at Patrick Air Force Base, Fla.

WEIGHT:	15,000 lbs.
LENGTH:	46 ft. 8 in.
DIAMETER:	3 ft.
SPAN:	18 ft.-2 ft.

GUIDANCE: SAGE programmed, with radar homing (developed by Westinghouse Air Arm)

POWERPLANT: (2) Marquardt ramjets-28 in. (1) Aerojet General LPR booster

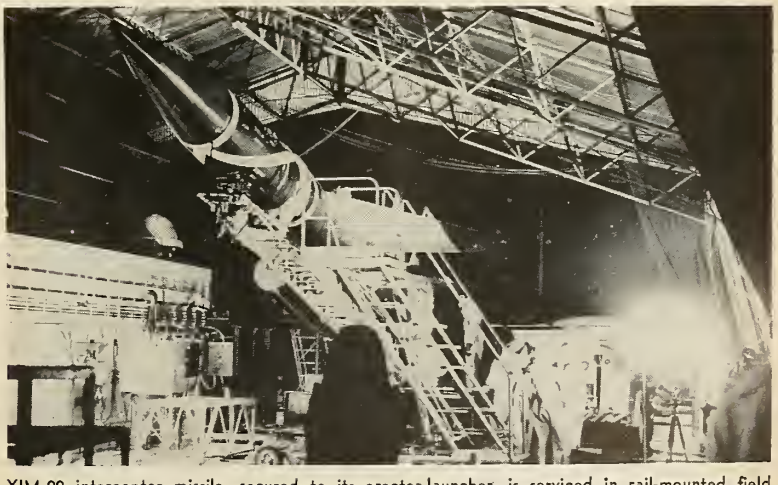
ALTITUDE: over 60,000 ft.

GROUND CONTROL: Remington Rand ERA 1103 computer system

GROUND ALIGNMENT AND CHECK-OUT: test equipment "GO-NO-GO" by Farnsworth Electronics

STATUS: quantity production, for IM-99

REMARKS: surface-to-air, pilotless, aerodynamic cruise interceptor missile. XIM-99 is experimental missile; YIM-99 is service model to be tested by Air Force.



XIM-99 interceptor missile, secured to its erector-launcher, is serviced in rail-mounted field shed in preparation for launching. XIM-99 flights have been made since autumn 1952.

U.S. Air Force's RASCAL

The GAM-63 *Rascal* is a liquid-propelled air-to-surface rocket missile under development for the Air Force by the Guided Missiles Division of Bell Aircraft Corp.

Purpose of weapons like the *Rascal* is to permit bombers to stand off from their targets when delivering nuclear weapons in order to avoid lethal combinations of defending interceptors and anti-aircraft missiles in the target area.

Rascal is undergoing flight testing against simulated targets at Holloman Air Development Center, New Mexico, where it has been launched from B-47, B-36 and B-50 bombers.

The division has made continued refinements in the *Rascal's* powerplants, including the rocket thrust chambers, turbine pump, propellant valves and propellant tanks.

More than 50 rocket propellants have been evaluated in the company's laboratories during the last three years and more than 15,000 rocket thrust chamber runs have been conducted in the more than 50 test cells located at the Wheatfield plant and the nearby Bell Test Center (Air Force Plant No. 38).

An estimated 350,000 pounds of oxidizer and 100,000 pounds of fuel are consumed in these evaluation and production tests each month and the consumption is on the increase.

Nineteen of the division's test cells can be used for environmental testing of thrust chambers and complete rocket engines, with temperatures ranging from minus 65 degrees to plus 287 degrees Fahrenheit.

Rocket engineers have designed and developed rocket engines for five guided missiles, one of which already is operational, and are engaged in designing more powerful rocket powerplants for other military missiles and weapons systems.

Range of the *Rascal* is generally estimated at 100 miles. It utilizes a three-chambered Bell liquid-propellant rocket engine which can accelerate it to speeds of approximately Mach 1.5.

The project came under fire in the report issued by Rep. George Mahon's (D-Tex.) House Defense Appropriations Subcommittee this spring. "Investigations carried out by the Committee Staff have indicated that a reduction in the so-called 'Rascal' program is justified, and the Defense Department agrees that this particular missile is in the marginal area," the report stated.

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RASCAL, the most advanced air-to-surface missile, is undergoing flight test evaluation.

SPECIFIC DATA:

MANUFACTURER:	Bell Aircraft
MISSION:	air-to-surface
RANGE:	100 mi.
VELOCITY:	Mach 1.5-2
WEIGHT.	13,000 lbs.
LENGTH:	35 ft.
DIAMETER:	4.5 ft.
SPAN:	25 ft.

GUIDANCE: Bell command; new inertial system under development by Federal Telecommunications under Bell subcontract

POWERPLANT: (3) Bell LPR (6,000 lbs. ea.)

ALTITUDE: launch altitude

LAUNCHER: B-47, B-52, B-58

FLIGHT CONTROL. radio guided from mother plane

STATUS: development

REMARKS:
40 built for test; under product improvement program; Bell awarded $22 million AMC contracts 1/29/57 for continued R&D; strategic air-to-surface.

U.S. Air Force's MATADOR

First of the Air Force's missiles to reach operational status is the TM-61 *Matador* surface-to-surface missile. It is manufactured by The Martin Co., Baltimore, and is powered by an Allison J33 turbojet engine. It can haul a 3,000-pound warhead more than 600 miles at high subsonic speeds and at altitudes of more than 35,000 feet.

The Air Force's first wing of *Matador* missiles is now operational in Germany as part of the Twelfth Tactical Air Force. It is designated the 701st Tactical Missile Wing and consists of three groups located at Bitburg Air Base, Hahn Air Base and Sembach Air Base, Germany. Each group has a tactical missile squadron responsible for actual preparation and launching of the weapon, plus a communication and guidance squadron and a support squadron.

One of the most difficult problems in operational missile units is that of sustaining the unit's combat proficiency at a high level without daily, weekly or even monthly firings. Even if there were space available for such training in Europe, the cost would be prohibitive since each *Matador*, plus its Thiokol solid-propellant booster, costs approximately $100,000.

USAF has developed an inexpensive technique for frequent and thorough tests without expenditure of the *Matador* weapons. This involves the use of a T-33 jet equipped with a Matador-type guidance system. The T-33 simulates the *Matador*, with the pilot responding to visual and audio signals—but no verbal communication—from the ground controller. Just like the missile, the manned aircraft is led through the various phases of a mission, including warhead arming, predumping procedure and simulated dumping on target. On a single flight, a T-33 assigned to the 701st Tactical Missile Wing may execute as many as three simulated *Matador* flights.

The Air Force recognizes that simulated flights, despite their great importance in maintaining proficiency, are not the whole answer. Therefore, the launching teams of the 701st are scheduled to make one actual firing each year at the firing range in Libya managed by the 17th Air Force at Wheelus AFB, near Tripoli.

There are 36 launching teams in the wing. Three versions of the *Matador* have developed to date. The first, TM-61A, was equipped with a single MSQ radar guidance system which requires line-of-sight communication with the missile at all times in order to effect positive control. The 701st has a network of radar tracking stations in Germany to keep tabs on the missile and inform the ground controller of its course and position at all times.

All squadrons of the 701st have now been converted to the TM-61C, which uses in addition to the MSQ system, the so-called "Shanicle" system. Though no details of the system were released by the Air Force, it is believed that "Shanicle" is the first known use of the "HYPERBOLIC grid system." This involves the creation of a grid pattern of radio waves by two separate transmitters.

The missile is pre-programmed to follow a set sequence of augmented and diminished signals across the pattern to target itself. This has the advantage of eliminating the possibility of human error on the part of the ground controller as well as providing positive control over much greater range than the line-of-sight MSQ, but it is not clear to what extent Shanicle might be subject to enemy jamming.

Latest version of the *Matador* is the TM-61B. This is several feet longer than the A and C models and has a clipped wing. It is said to have greater range as well as an improved guidance system requiring no assistance from the ground once the missile is launched. This suggests a number of guidance systems, such as inertial, celestial, a combination of both or a radar transmitter within the missile to determine position.

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MATADOR (TM-61A and C)—
SPECIFIC DATA:

MANUFACTURER:	Martin Co.
RANGE:	more than 600 mi.
VELOCITY:	high subsonic
LENGTH:	39 ft., 8 in.
HEIGHT:	9 ft., 9 in.
WINGSPAN:	27 ft., 10 in.

GUIDANCE: MSQ radar control, first used in Korea to direct fighter-bomber strikes. Also, on C model, the Shanicle system.

ALTITUDE:	more than 35,000 ft.

PROPULSION:
Booster; Thiokol solid-propellant rocket; 52,000 pounds thrust for two seconds
Sustainer; Allison J33 turbojet of 46,600 lbs. thrust.

PAYLOAD:	3,000 lbs.
STATUS:	service

MATADOR B (TM-61B)—
SPECIFIC DATA:

MISSION:	surface-to-surface aerodynamic cruise
RANGE:	over 600 mi.
SPEED:	Mach 0.9
WEIGHT:	13,800 lbs.
LENGTH:	45 ft. 10 in.
DIAMETER:	54 in.
SPAN:	28 ft. 9.5 in.
HEIGHT:	9 ft. 9 in.

GUIDANCE: radar; celestial (?); inertial-depending on model and modification

POWERPLANT:	Improved Allison J33 (4,600 lbs.) Booster Thiokol SPR, 52,000 lbs.
ALTITUDE:	45,000 ft.
STATUS:	In production
PAYLOAD:	3,000 lbs.

REMARKS:
Tactical, aerodynamic surface-to-surface, Nuclear warhead

The latest version MATADOR, TM-61B, is longer and has shorter wings than models A and C.

Below, Northrop's SNARK takes off from Patrick AFB at night. Two solid propellant boosters accelerate the missile from its zero-length launching rail. Missile cruises (above) at Mach 0.94. Range is 5000 miles. Warhead is delivered at supersonic speed.

U.S. Air Force's

SNARK

The Northrop *Snark* is the first intercontinental missile to go into production for the Air Force. It is expected that units of the Strategic Air Command will commence training with the weapon in the last quarter of 1958. It is a joint development of Northrop and the Air Research and Development Command. The SM-62 has demonstrated its long range and accuracy in numerous successful flights over the sea test lanes reaching southward across the Atlantic from Patrick Air Force Base.

It is a high altitude, swept-wing, single-engine, jet-propelled intercontinental guided missile equipped to guide the missile over extended distances for long-range delivery of a nuclear warhead. It has slim fuselage lines, with high-aspect ratio wings mounted near top and slightly forward of center of fuselage. Tail consists only of a vertical stabilizer. Engine air intake is located below underside of fuselage and aft of wing junction. The thin wings have a "sawtooth" leading edge. Elevons—combination ailerons and elevators—on the trailing edge of the wing eliminate the need for a horizontal tail.

Snark is powered during cruise flight by a Pratt & Whitney J-57 turbojet engine. Aerojet-General Corp., Azusa, Calif., supplies the zero-length solid-propellant boosters which hurl it

The Aerojet solid propellant boosters for the SNARK each yields 33,000 pounds of thrust. Zero-length launcher rail measures 29 feet.

into the air without a take-off run.

Snark is designed for a range of more than 5,000 miles; at least one flight of about 2,000 miles has been recorded. It utilizes a combination inertial and celestial guidance system. The weapon is subsonic, reportedly cruising at a speed of about Mach .9. Its altitude capability is probably better than 50.000 feet during the latter portion of its mission. It carries out its mission despite night or inclement weather. It can fly above turbulent weather and over long distances.

The *Snark* can be "zero" launched from a stationary or mobile launcher in a relatively small area. The missile and launcher are extremely mobile and can be flown to any point in the world within a few hours. The missile and its ground support equipment are normally transported by C-124 Globemaster aircraft and can be set up in launch position within a short time after its arrival at a given destination.

The mobile launcher, also developed by Northrop to Air Force strategic considerations, is a basic element of advanced ground support equipment which enables the *Snark* to aim its nuclear punch from a hidden site in any type of terrain—mountains, desert, or Arctic wastelands.

Designated the SM-62, the weapon is viewed by top Defense Department officials as a competitor to the North American *Navaho*. Former Deputy Defense Secretary Reuben Robertson, Jr., told the House Defense Appropriations Committee earlier in the year: "We view the *Snark* and *Navaho's* approach in the air breathing intercontinental group quite similar to the *Thor* and *Jupiter* competitive situation. One of them is going to win that race and one of them should be put into inventory."

Asked why the Defense Department continued its support of *Snark* in the face of opposition from Eger V. Murphree, former special assistant to Defense Secretary Charles Wilson for guided missiles, and other high military officials, Robertson replied:

"We felt that this is a weapon in which we had such a large investment that we should go ahead and get it in the inventory. While it has its disadvantages in being subsonic, it will probably have quite an accurate guidance system as now visualized, a very good CEP (circular error probability)."

The advantage of the air breathing missile is that, compared to its ballistic competitor, it's relatively slow in its terminal dive on target and is thus more readily susceptible to detection and interception. This advantage accrues to the ballistic missile only so long as an effective anti-ICBM missile has not been developed. But once such a counter-system is operative, the ICBM is then without further recourse. In the ballistic phase of its trajectory it cannot take evasive action and furthermore, it cannot—because of the conditions of reentry—employ countermeasures, electronic or otherwise.

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It's a big bird with plenty of room, auxiliary power supplies and full control over its course. SNARK can take evasive action, on-board countermeasures can be easily altered.

SPECIFIC DATA:

MANUFACTURER: Northrop Aircraft Inc.
MISSION: surface-to-surface aerodynamic cruise
RANGE: 5000 mi.
VELOCITY: Mach 0.94
WEIGHT: 35,000-38,000 lbs.
LENGTH: 74 ft.
HEIGHT: 15 ft.
DIAMETER: 4.5 ft.
SPAN: 42 ft.
GUIDANCE: Northrop MK I celestial and inertial (wt. 1,000 lbs.)
POWERPLANT: P&W J57 (11,000 lbs.) has also used Westinghouse J40 and Allison J71
ALTITUDE: 60-75,000 ft.
LAUNCHER: (2) Aerojet SPR Boosters (33,000 lbs. ea.) and zero-length rail (29 ft.)
STATUS: pre-production and redesign
REMARKS: intercontinental aerodynamic cruise missile

Operational tests using SNARK-type missiles against combined defenses show that this kind of missile is difficult to intercept. SAC is expected to employ SNARKs in 1958.

U.S. Air Force's

NAVAHO

Most ambitious of all air-breathing surface-to-surface missiles presently under development is the North American XSM-64 *Navaho*, an intercontinental weapon.

The Air Force-financed missile is undoubtedly the largest of all air-breathers. Although no photographs have been released, the weapon is said to be aerodynamically similar to the X-10 turbojet-powered test vehicle. Flight tests with the X-10 were completed early this year.

Navaho employs two large Curtiss-Wright ramjet motors for cruise power, plus a liquid-propellant rocket booster system for take-off and acceleration to the high Mach number necessary to permit the ramjets to ignite. *Navaho* models now under test employ a set of three North American rocket engines of 120,000 pounds thrust each for initial boost; the projected SM-64 production *Navaho* is scheduled to use a single North American motor of more than 400,000 pounds thrust. Latter is in advanced development.

As in the case of most missile developments, preliminary firings of the *Navaho* have been plagued with failures for trivial reasons. First XSM-64 aborted at 9,000 feet when a rate control gyro failed.

On the second firing attempt at Patrick, the big missile tore away part of its launching apparatus on take-off, causing the booster to lose power and the vehicle to fall in the sea. The third trial in April was a complete failure because the rocket boosters quit firing after two seconds in response to a wild signal from within the missile.

One of the interesting features of the XSM-64 is the fact that it incorporates retractable landing gear. A dead-stick landing procedure was worked out with the X-10, and it is hoped that some of the vehicles can be recovered for re-use.

The Defense Department last year struck out the Air Force's request for funds to support the *Navaho* in fiscal 1958, forcing the airmen to "reorient" the program to make fiscal 1957 funds last as long as possible. A decision on whether to go ahead with the *Navaho* will probably come in the fall.

The outlook now does not appear favorable for the weapon. Funds are expected to remain extremely tight, and top Defense officials have made it known they believe one air-breathing intercontinental missile is enough for the Air Force.

But many things might happen to change top-level Defense thinking, and test work on the *Navaho* will continue. North American believes its warhead-accuracy potential is much greater than that attainable with the intercontinental ballistic weapons, and that *Navaho* therefore has a specific place in the nation's future arsenal.

Whatever the *Navaho's* ultimate fate, its development has contributed more to advance the state of the missile art in the U.S. than any other single factor. It has introduced North American to many brand new fields of activity, including development of most of the engines which will be used in future ballistic missiles.

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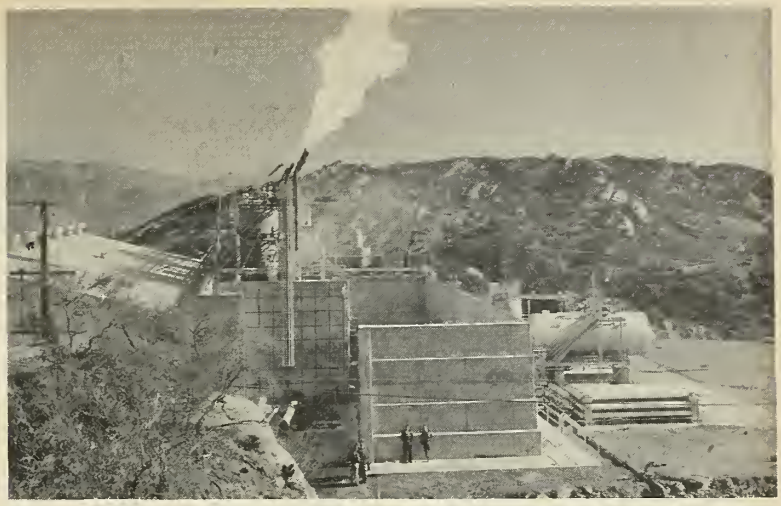
X-10, North American Aviation's unmanned test vehicle for AF's SM-64 NAVAHO intercontinental strategic aerodynamic cruise missile has concluded its flight test program. Launched by rockets and powered by turbojets, X-10 has provided much valuable research and development data for other missile programs. NAVAHO will use modern ramjet sustainers.

SPECIFIC DATA:
MANUFACTURER: No. American Av'n., Inc.
RANGE: more than 5,000 mi.
WEIGHT: (estimated) 200,000-300,000 lbs.
VELOCITY: Mach 3-3.5
ALTITUDE: 70,000-80,000 ft.
PROPULSION:
Booster; Three NAA liquid-propellant rocket engines, total thrust of 360,000 lbs.
Sustainer; Two Curtiss-Wright ramjet engines
STATUS: development
MISSION: surface-to-surface aerodynamic cruise

U.S. Air Force's

THOR



THOR's 135,000-pound thrust power plant is made by Rocketdyne Division of North American Aviation, Inc. Here, rocket engine gas generator flares at Rocketdyne test facility.

The WS-315 *Thor* is the Air Force's entry in the Intermediate Range Ballistic Missile race. Its main competitor is the Army's *Jupiter* IRBM, although the Navy is also developing an IRBM of its own, the *Polaris* Fleet Ballistic Missile.

The *Thor* is a single-stage weapon powered by a North American liquid rocket engine with a thrust of 120,000 to 140,000 pounds. Its range is 1500 miles. Its airframe is manufactured by Douglas Aircraft Co. Inc., while A.C. Spark Plug Div. of General Motors Corp. is developing the guidance. The nose cone undoubtedly features the blunt shape proposed by the National Advisory Committee for Aeronautics in 1953.

First test firings of new missiles are almost invariably fraught with surprises and failures, and the *Thor* has proven to be no exception. On its first launching trial, foreign matter contaminated the oxygen system and the engine failed to receive sufficient LOX to maintain combustion. Thrust deteriorated when the vehicle was a couple of feet in the air and it sagged back to the launching stand, broke in two and exploded.

On the second firing attempt, the USAF entry in the IRBM race appeared to wander off course and was detonated after a flight of 38 seconds. Later it was said that the range safety officer's radar monitoring system was out of kilter and that the missile was actually on course. But the third launching effort was even more frustrating; four minutes before launching, an electrical short circuit started a fire and the missile burned up without ever leaving the ground.

Despite these unhappy experiences, the Air Force is confident it will be able to prove out the *Thor* and that the weapon—or most of it—will ultimately be selected for quantity production for operational use with the Strategic Air Command.

Early this year, the Air Force announced it had awarded a $67,500,000 contract to Douglas for fabrication and testing of *Thor* airframes. The period covered by the contract was not disclosed, but the Air Force did say that none of the funds covered development of engines, guidance or other components.

The Air Force has frequently pointed out that the *Thor* development program is a considerable bargain because many of the components of the rocket missile are being developed for its big brothers, the *Atlas* and *Titan* Intercontinental Ballistic Missiles.

The Air Force was given complete operational control over all surface-to-surface land-based missiles with a range of more than 200 miles by the terms of Defense Secretary Charles Wilson's memorandum on roles and missions last November. Principal effect of the memorandum was to turn the Army's *Jupiter* over to the Air Force, for further financing and operational use.

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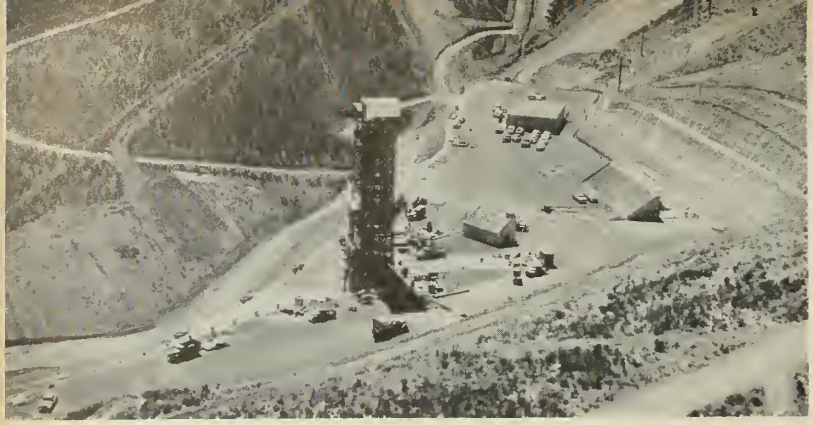
SPECIFIC DATA:

MANUFACTURER: Douglas Aircraft Co.
Mission: surface-to-surface IRBM
RANGE: 1500 mi.
VELOCITY: Mach 10
GUIDANCE: radio-inertial by AC Spark with assistance from Bell Telephone Labs
POWERPLANT: (1) NAA LPR (135,000 lbs.)
STATUS: prototype firings ($67.5m for continued development)
REMARKS: Intermediate range ballistic missile; nose cone—GE; warhead—Sandia Corp.

THOR engine under test? The canyons rock with the thunder of captive power. This Rocketdyne test stand is high in the Santa Susana Mountains, 35 miles from Los Angeles.



First official photos of Atlas test base. Atlas missile systems are checked out in this test tower in Sycamore Canyon, a secluded military reservation N.E. of San Diego.

U.S. Air Force's

ATLAS

The WS-107 *Atlas* is the first of the most ambitious line of missiles yet attempted—the Inter-Continental Ballistic Missile, ICBM. It is officially described as being in pilot production at Convair's Astronautics Division at San Diego, Calif. The missile is now in the test flight stage, being fired from Patrick AFB, Fla. Components and systems test other than engine run-up is conducted at Convair's special facility on the ocean side of Point Loma, San Diego Bay, Calif.

Convair Div. of General Dynamics Corp. initiated work on the *Atlas* project as far back as 1947. With Air Force funds, it developed and fired several models of the MX-774 liquid-propelled missile to determine the feasibility of a gimballed motor. During the lean days of the late 1940's, it carried the project with its own funds.

It was not until about 1953 that the feasibility of an ICBM became clear. The U.S. succeeded in detonating a true hydrogen bomb (in contrast to a hydrogen *device*), demonstrating that a warhead of titanic power could be wrapped up in the relatively small confines of an ICBM's nose section. This at once had the effect of sharply diminishing the ICBM's size as well as broadening its permissible circular error probability to limits deemed attainable with guidance equipment within the state of the art.

A second "technological breakthrough" was the discovery by the National Advisory Committee for Aeronautics that a blunt nose cone could reject 90% or more of the re-entry heat to the atmosphere by setting up a strong shock wave. This substantially alleviated cooling problems and cleared the way for the Air Force's present $1 billion a year ballistic missile effort.

No photos have yet been officially released on the *Atlas,* but several bits of information have been gleaned during the past several months regarding its probable configuration. It is understood the weapon utilizes three North American liquid-propellant engines—two boosters of about 120,000 pounds thrust and a sustainer motor of 140,000 pounds. The boosters and presumably their turbopumps and tankage are jettisonable when they burn out.

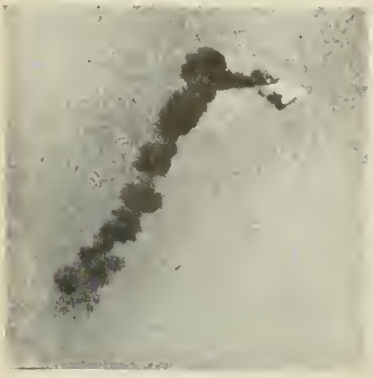
Also, the wide publicity given the precise date and time of the highly secret first firing of the *Atlas* configuration resulted in several hundred people being on hand about the land perimeter of Cape Canaveral, many of them photographers with the best in long lense equipment.

On this first firing, the 5,000-mile missile went between 5,000 and 10,000 feet before it was intentionally detonated by the range safety officer. From the appearance of the missile in flight, this apparently is what happened: The twin boosters fired properly until the missile reached between 5,000 and 8,000 feet. Then one of the liquid rocket engines apparently suffered a failure in its LOX supply. The flame went from a crisp clean yellow to a dirty orange. Black smoke belched forth. Loss of power in one of the paired engines caused a violent yaw. The missile made at least two efforts to correct for this before it was detonated.

Quite a number of pictures were taken of the missile during this period and have been published. Study of them reveals that surrounding the engine nozzles is a flare to provide directional stability. The missile has no fins as such. The pictures also reveal that the missile was not fired with its final nose cone, but utilized a fairly conventional low-drag-to-weight ratio shape instead.

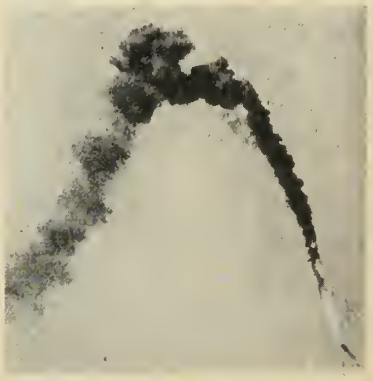
The actual nose cone, rather than being sharply tapered and pointed as shown, will be very blunt with a heavy metal base probably coated with laminated plastic. It is scheduled to be attached to later test models.

Length of the *Atlas* is something

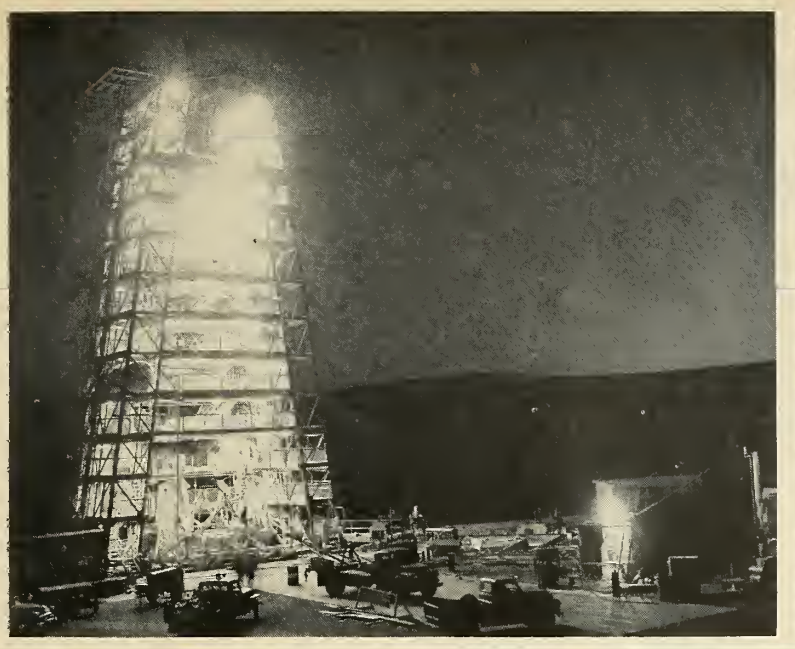


Prototype of the Atlas ICBM was fired from Patrick AFB at Cape Caneveral last month.

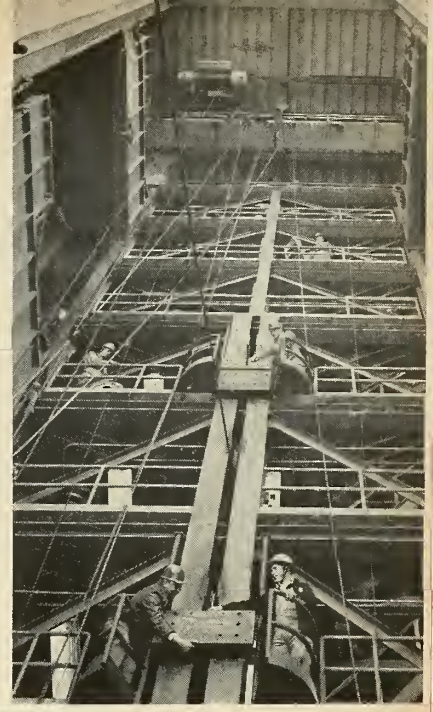
A mass of flames and spiraling at 10,000 feet the Atlas ICBM leaves a trail of black smoke.



The Patrick AFB range safety officer exploded the missile because one engine failed.



Sycamore is one of three facilities where Convair, Division of General Dynamics Corp. is testing the Atlas missile. Component testing is conducted on Point Loma in San Diego.



Systems checkouts are conducted in this huge tower at Convair's San Diego facility.

under 100 feet, and take-off weight is probably more than 200,000 pounds. Its maximum range is 5,500 miles and its apogee is about 800 miles. It will attain speeds of approximately 15,000 mph upon its re-entry into the atmosphere. To test re-entry problems with full-scale nose cones, the Air Force is using the Lockheed three-stage X-17, powered by Thiokol *Sergeant* and *Recruit* solid-propellant motors. Speeds of about 9,000 miles per hour have been achieved with this device, equal to about one-quarter of the re-entry energy of an ICBM.

Just when the *Atlas* is expected to be ready for operational use has never been disclosed publicly, but it is certain that it will be sometime after 1960 and probably later than the operational date now expected for the *Thor-Jupiter* IRBM.

Probably the most crucial problem with the *Atlas* at the present time is guidance accuracy. Most officials expect this will prove to be the toughest headache of all, and many companies have been brought into this phase of the program to work on alternate solutions. (See *Titan*, p. 162) Hinging on the answer to this question is the timetable for reduction of the Air Force's fleet of manned bombers.

Commented one Air Force wag: 'I foresee two broad periods in the ICBM program. In the first period, we can probably be sure of missing Western Europe and hitting Russia. In the second period, we can guarantee strikes within reasonable distances of specific targets. The trouble is, I can't tell you how long that first period will last, and so, I can't say when we will be able to de-emphasize manned bombers."

• • •

SPECIFIC DATA:

MANUFACTURER: Convair Astronautics (San Diego)
MISSION: surface-to-surface ICBM
RANGE: 5500 mi.
SPEED: Mach 15
WEIGHT: over 90 tons, take-off
LENGTH: 70 ft.
DIAMETER: body 8 ft. 6 in.; flare, 12 ft.
GUIDANCE: original AC Spark radio-inertial system cancelled; now inertial system by Arma ($1.1 mi. contract) assisted by the Bell Telephone Labs (ground control)
POWERPLANT: (1) NAA LPR sustainer (100,000 lbs.)
(2) NAA LPR boosters (135,000 lbs. ea.)
ALTITUDE: 800 mi. peak trajectory
STATUS: Flight Test
REMARKS: intercontinental ballistic missile auxiliary power-AMF; thermonuclear warhead-Sandia Corp.; nose cone and re-entry body-GE.

Special trailer was built to transport the Atlas ICBM missile from San Diego to Patrick Air Force Base. Second Atlas firing is understood to be scheduled for next month.

U.S. Air Force's TITAN

The *Titan* (WS-107) Intercontinental Ballistic Missile is an alternate approach to the ICBM problem. The missile's airframe is under development by The Martin Co. in a new $20 million facility near Denver, Colo.

Aerojet-General Corp. is developing *Titan's* propulsion system. According to a recent speech by Dan Kimball, president of Aerojet, the company is working on a propulsion system for a long-range ballistic missile which includes a first-stage rocket engine of 300,000 pounds thrust at sea level, and a seven-stage engine of 60,000 pounds thrust at sea level. These engines are undoubtedly intended for *Titan*.

In configuration, the *Titan* would appear to be a tandem, two-stage missile like the Army's *Nike* or the Navy's *Terrier*. First stage would carry the weapon up to altitude before the second stage motor is ignited, as distinguished from the *Atlas* system in which all three motors are fired simultaneously on the ground.

Development of the *Titan* was ordered late in 1955 when it was decided to put the USAF ICBM program on something approaching a "crash" basis. The Martin weapon does not duplicate the Convair *Atlas*, although many of its components are common to both systems. In discussing the decision to go ahead with a second ICBM program, former Air Force Secretary Donald Quarles said last year:

"This plan enables us to conduct simultaneous development of two operational missiles, representing different technical approaches, at an estimated increase of only 10% of the cost of developing a single configuration. The decision to pursue two different approaches was prompted by the desire to assure earliest possible success in our ICBM effort."

Actually, the airframes and propulsion systems of the *Atlas* and the *Titan* appear to be so distinctly different that it is unlikely that these can be regarded as interchangeable. This may not be true of the nose cones under development for the two missiles, and it certainly is not true for the various guidance systems. Both the Special Projects Department of General Electric Co., Philadelphia, and the Research Div. of Avco Manufacturing Corp., Everett, Mass., are working on nose cones for the two missiles.

A total of seven contractors are working on guidance for the USAF ballistic missile program, but the Air Force still has not linked individual contractors to individual ballistic projects. They include: Heavy Military Electronics Div. of GE, Syracuse, N.Y.; American Bosch Arma Corp., Garden City, N.Y.; A.C. Spark Plug Div. of General Motors Corp., Milwaukee; Burroughs Corp., Paoli, Pa.; Univac Div. of Sperry-Rand Corp., St. Paul, Minn., and the Instrumentation Laboratory of the Massachusetts Institute of Technology.

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

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

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

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

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

Two missile firms, Associated Products Corp. of Pomona, Calif. and Hallamore is also subcontractor to conbair in the *Atlas* project.

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

Burroughs Corp. holds contracts for data processing equipment in the ground control equipment for the IRBM/ICBM program. Fruehauf Trailer Co., Los Angeles plant, is building special *Thor* truck-trailers under a $15-million subcontract from Douglas.

But these are only a few of the 200 subcontractors active to date in the ICBM and IRBM in the programs.

Four static test stands are being completed at Martin's Titan facility near Denver, Colo.

The roster of the unnamed, obviously even more impressive by its numbers alone, remains to unfold.

Defense Secretary Charles Wilson recently voiced a somewhat cryptic comment about the ICBM program. Discussing the two weapons, he remarked to a Senate Committee: "The one we think is best" is probably "farther behind." Developmentwise, the *Titan* is behind the *Atlas,* so Wilson may have been expressing a preference for the former weapon system.

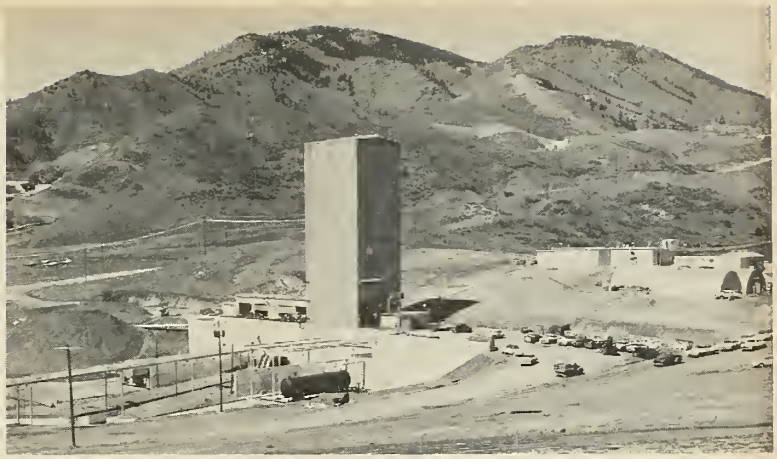
The initial USAF *Titan* development contract, totaling $358 million, has reshaped the geographic organization of the Martin Co. The *Titan* program, centered in the new $10-million facility here, is already in its manufacturing stage.

As a result, a $2-million plant expansion is in the mill. Present employment of 2,500 is expected to reach 5,000 next year. Company officials say building of a landing strip is planned to expedite delivery of parts and for transporting military and civilian people to the site.

The *Titan* program now is broken down into eight departmentalized functions which perform specialized responsibilities in successfully completing the project. Several of these are well underway.

The propulsion section, which has the responsibility for the engine installation, its propellant feed system and its satisfactory marriage to the airframe, is working closely with Aerojet, planning first engine tests at the Denver site.

The airframe section has the responsibility for the design of the structure, the orientation of the various systems within the structure and the general configuration of the missile. This work is in the mill.



Martin's Titan intercontinental ballistic missile effort is in a far more advanced stage than was expected a year ago. Some design conceptions from the Atlas have been incorporated.

The guidance and control section has the responsibility for the analysis, design, development and installation of all of the control equipment which will help the vehicle maintain a stable flight attitude at all times and the integration for guidance within the entire system. Little is known of guidance progress, but it must be assumed that it is as advanced as the *Atlas* guidance.

The ground support and equipment section, which has the responsibility of supplying all the necessary equipment required to launch the vehicle, is well ahead in its overall planning. In all, the *Titan* program is well advanced, and, needless to say, Air Force officials are pleased with the progress.

SPECIFIC DATA:

MANUFACTURER: Martin Co.

MISSION: surface-to-surface ICBM

RANGE: 5,500 mi.

SPEED: Mach 15

WEIGHT: 200,000 lbs. plus

HEIGHT: (est) 100 ft. plus

GUIDANCE. ARMA inertial

POWERPLANT: 1st stage-Aerojet LPR (300,000 lbs.)
2nd stage—Reaction Motors LPR (60,000 lbs.)

GROUND CONTROL: radio ground guidance by Bell Telephone Labs

PROPULSION:
Booster: 300,000 lbs. thrust Aerojet LP motor
Sustainer: 60,000 lbs. thrust Aerojet LP motor

STATUS: component development; $358m in January for continued development

REMARKS:
ICBM, Nose cone-AVCO
warhead-Sandia Corp.

Martin expects to employ 5,000 people at its Denver facility by the end of the year. Most construction work has been completed.

Aerojet's giant-size engines for Titan have been successfully developed and will be at the Denver site for test shortly.

MISCELLANEOUS MISSILES

DING-DONG MB-1 (Bird Dog High-Card)

The *Ding-Dong* MB-1 was the first air-to-air missile to have an atomic warhead. Developed for the Air Force by Douglas Aircraft Co. it was reportedly flight tested with an atomic nose during the May 1957 AEC atomic firings. Liquid and solid propellant versions are under development although the liquid propellant model was the first conceived. Atomic warheads for air-to-air missiles were tested in the spring of 1955 to provide basic information on the missile requirements. Design for the *Ding-Dong* was initiated in 1956.

SPECIFIC DATA:
MANUFACTURER: Douglas
MISSION: air-to-air
GUIDANCE: Hughes
POWERPLANT: NAA LPR (latest version has SPR)
STATUS: reactivation of an earlier Douglas project; in late development or early production
REMARKS: air-to-air interceptor missile, atomic warhead; TINGALING is ballistic spotting version.

GREEN QUAIL

Green Quail is an air-to-surface diversion missile understood to be a member of the *Corvus* family. Missile is believed in late stage of development with first flights expected in early 1958.

SPECIFIC DATA:
MANUFACTURER: McDonnell Aircraft
MISSION: air-to-surface diversionary
GUIDANCE: Sommers Gyroscope
STATUS: late development

DUCK

An air-to-air missile in the research and development stage designed as armament for our long-range and supersonic bombers. The role of this missile as a BDM weapon has not been confirmed at this time. Fairchild is reported as the prime contractor for this Air Force missile.

GOOSE

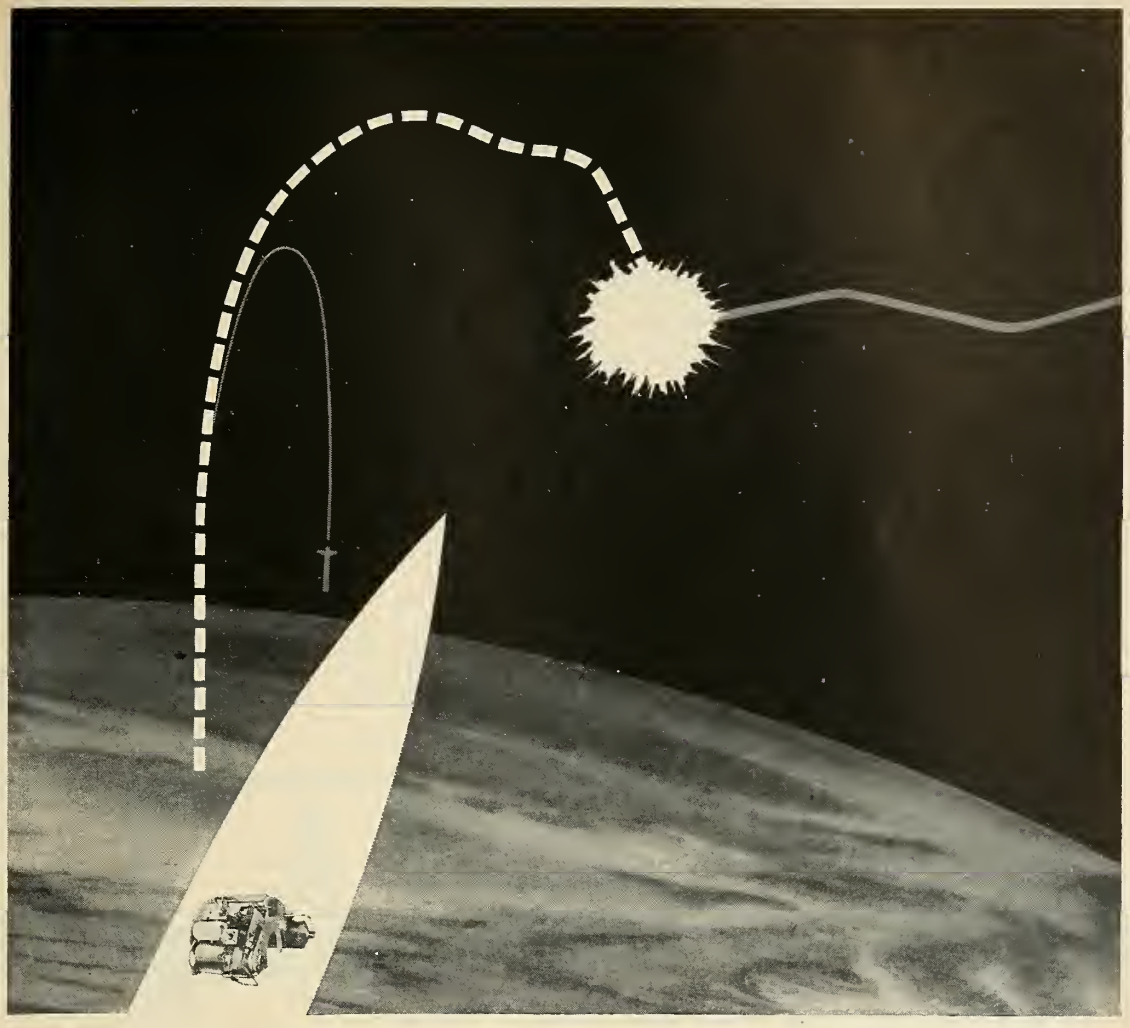
An air-to-air bird in the development and production stage manufactured by Fairchild as a diversionary drone. Launched from a bomber, the *Goose* was designed to decoy intercepting planes or missiles from bomber strike force, i.e., B-52 or B-58 atomic carriers. This turbo-jet aerodynamic cruise missile will probably be operated similarly to the *Rascal* air-to-surface missile. The B-58 *Hustler* has been mentioned as the carrier for the *Goose* and *Duck*.

SPECIFIC DATA:
MANUFACTURER: Fairchild Aircraft
MISSION: air-to-air diversionary
LENGTH: 20 ft. (est)
VELOCITY: Mach 1.25
SPAN: 13 ft. (est)
GUIDANCE: Fairchild radio command
POWERPLANT: Fairchild J-83 or GE J-85
ALTITUDE: 100,000 ft.
LAUNCHER: mother plane
FLIGHT CONTROL: Kollsman
STATUS: production

WS-126A WS-132A

The WS-126A is reported to be under the systems engineering management of Cornell Aeronautical Labs, DE Johnson City. Bell Telephone, Hughes and Raytheon have been engaged in the design and development of a bomber defense missile (WS-126A) for the B-52. Recent indications, however, are that the project has been de-emphasized although it remains a critical AF requirement. It is anticipated that the project will be kept alive.

The WS-132A was to have been the bomber defense missile for the WS-110A. Two development teams (GE/-McDonnell and Republic/Westinghouse) were working on this missile until work was suspended by an AF stop order issued in November 1956. Arma is believed to be still working on a competitive system.



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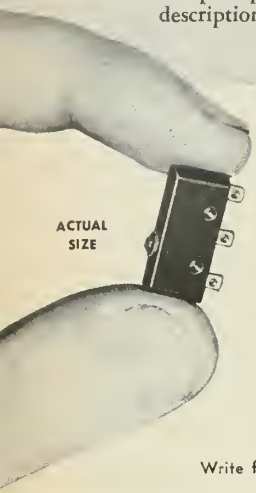

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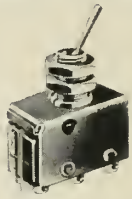
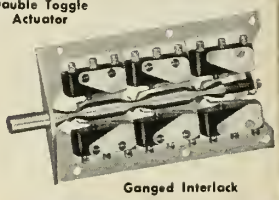

Double Toggle Actuator


Roller Leaf Actua


Leaf Actuator


Extension Leaf Actuator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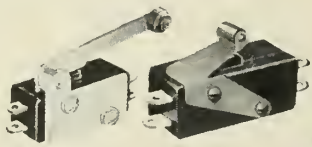
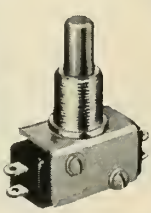
Vrite for Data Sheet STY-7


Roller Lever Actuator — Roller Actuator

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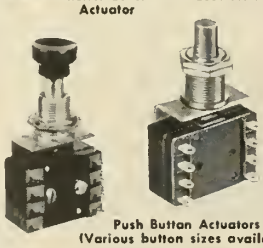
Roller Leaf Actuator


Roller Lever Actuator


Leaf Actuator


Extension Leaf Actuator


Push Button Actuators (Various button sizes available)

HERMETICALLY-SEALED DOUBLE-POLE SWITCH

Write for Data Sheet HJY-7


Type J2-4


Toggle Actuator for J2-4

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Space Medicine

by Hubertus Strughold, MD., PhD.

An important research area in space medicine is the study of the toxicity of rocket propellants—fuels as well as oxidizers. This is a kind of preventive medicine. Basically, the injuries may be caused by chemical reactions with body tissue or by thermal burns, such as those caused by liquified propellants at very low temperatures.

The areas of attack are usually the skin, the eyes, the respiratory tract, and the digestive tract. Protective measures must be taken—special clothing, face shields, etc. The problem of propellant toxicity concerns both crew and ground personnel, and pertinent instructions are important for both.

Ozone is used as an oxidizer in rocket propulsion and is also found in higher concentrations in the atmosphere between 60,000 and 140,000 feet (the ozonosphere). Recently ozone has attracted special medical interest. Dr. H. G. Clamann of the School of Aviation Medicine at Randolph AFB, Tex., in cooperation with Armour Research of Chicago, has carried out experiments in an ozone chamber to determine human tolerance to the gas.

The high altitude balloon flight of Capt. J. W. Kittinger on 3 June was a test in the balloon program of Maj. David G. Simons of the Aeromedical Field Laboratory at Holloman AFB, N. M. From the standpoint of human physiology the altitude reached by Kittinger—96,000 feet—can be considered equivalent to the vacuum of space.

The true nature of the so-called boiling of body fluids above 63,000 feet has been discussed in a paper by Capt. Julian E. Ward, Jr., (J. Av. Med., Vol. 27, pp. 429-439, Oct. 1956). This low-pressure, low-temperature vaporization is a physical process, and does not include chemical reactions in the tissues as in the boiling of food during which protein coagulates. For this reason, the author suggests that a new term "ebullism" (derived from *ebullare:* to form bubbles) should be applied to the phenomenon. The term "boiling" is misleading and should be discouraged, especially in the press. The boiling of body fluids at altitude is actually an unhindered, profuse vaporization.

At the annual meeting of the Aeromedical Association in Denver May 6 to 8, Dr. Alberto Hurtado gave the Louis H. Bauer Lecture on "Natural Acclimatization to High Altitudes." Dr. Hurtado is Research Director of the Institute of Andean Biology at Lima, Peru. It is the only place where acclimatization studies are continuously carried out at altitudes as high as 15,000 feet. The subjects are natives and visiting researchers.

At the same meeting, Prof. R. Margaria, Director of the Physiological Institute at the University of Milan, Italy, reported on experiments in which he immersed fish in water, placed them on a centrifuge, and subjected them to 1500 g for periods up to 10 minutes. They survived for more than twenty-four hours after this extremely high gravitational stress. Frogs survived after exposure on the centrifuge to several hundred g while they were immersed in water.

On July 19 a symposium on Astronautics, organized jointly by the Royal Aeronautical Society, the British Interplanetary Society and the College of Aeronautics, will be held at Cranfield, England. Papers of interest in the field of Space Medicine will be given by Lt. Col. James P. Henry, Chief of the Biosciences Division, ARDC titled "Psychophysiological Hazards of Satellite Flight," and by H. G. Clamann, School of Aviation Medicine, on "Medical Problems in Bio-astronautics."

Missile Miscellany

Six months ago this page started out with a stated main purpose to make people think. Perhaps the clause should have been added: ". . . even if it has to make them mad to do it." Sometimes it's the only way.

With this semiversary note, this page hears: That AF has made at least two efforts to provide sufficient financial incentive to induce private companies to buy away Wernher von Braun Army missile team; that AF recently attempted to cut off Jupiter without a cent of fiscal 1958 R&D money but was foiled by Defense Secretary Wilson; also that AF, rather than famed missile-maker Douglas Aircraft, should take blame for Thor fiasco—for scheduling the impossible and then saying: "Hurry!" With all this, plus interesting timing of Air Force Magazine's "Great Missile Hoax" vis-a-vis Army Jupiter's 1500 mile shot vis-a-vis AF Atlas' 8000 foot misfire, seems like there might be room for another magazine, called Missile Politics, to tell John Q where his missile tax money is really going.

Now to a Russian Admiral admiring Bomarc exhibit on Armed Forces Day who asked: "Can this be used for anti-submarine work?" On the same missile, a query tossed out the other evening: "Why doesn't it have a competitor?" And a quip circulating Washington: "It's going to take a fourth stage engine just to get Vanguard through the red tape!"

But speaking of serious projects, AF's TV-carrying Big Brother satellite may be running ahead of schedule, spurred on by anti-missile missile need to know instant enemy ICBM is fired. Tip-off may be delivery to AF in nine months of a one kilowatt hydrogen-oxygen fuel cell that needs no heat sink; can operate at temperatures from −175 to 350°C at zero gravity with 5-lb./kwh or less weight-to-power ratio and at least 30-day operating life. Proving you never know where missile knowhow's going to pop up next, spheres of Haveg high-temperature material fitted with Diversey-machined molybdenum will measure for the first time ever the molten cores of the world's eleven major active volcanoes at rate of one a year. National Geographic Society's to pay and plans first shot this year in Peru.

Totally unclassified discussion the other morning of problems of getting anti-missile missile high enough soon enough brought this conclusion: Must be solid propellant for instant readiness—these suggestions: by-pass duct a solid propellant motor to add air mass to rocket efflux; core intermediate stage into solid fuel ramjet; afterburn in secondary nozzle behind conventional solid propellant motor (all these designed to put atmosphere to work) —and this forecast: Startling AMM developments within months.

Why doesn't American Rocket Society set up a missile launching base where tomorrow's space-flight engineers, today's amateur missileers can safely static test and fire their hardware? This page bets manpower-hungry missile industry would foot bill if ARS administered. Insurance is no excuse. Lloyd's in London will bet for or against anything.

Now jumping from pad-to-pad—Navy's "second Admiral Rickover" (for missiles, that is), Robert C. Truax, is reportedly on his way back to Washington to head up Polaris Fleet Ballistic Missile program. About time . . . Shades of Swedish sub-seeking seals, U.S. Navy at end of World War II seriously contemplated use of hungry homing pigeons for guiding missiles . . . Credit to a radio disc jockey who quipped: "Nuclear warheads now come in three sizes: small, large and 'where did everybody go?' " . . . This unfortunately apt goal in electronics gear design: To make it idiot-proof . . . Employment at Redstone Arsenal and ABMA's Guided Missile School is highest ever at over 14,400 . . . And a serious report that man may place his finger on the moon by Christmas . . .

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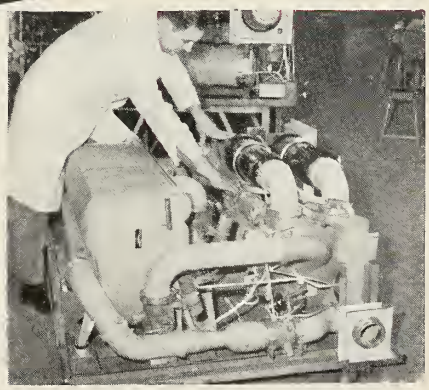

Stratos' Model GEA120-1 air conditioning system being prepared for production test.

To Probe Tomorrow

Photography by
R. M. LaMar and E. Hull

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reveal new sciences. These colors of tomorrow
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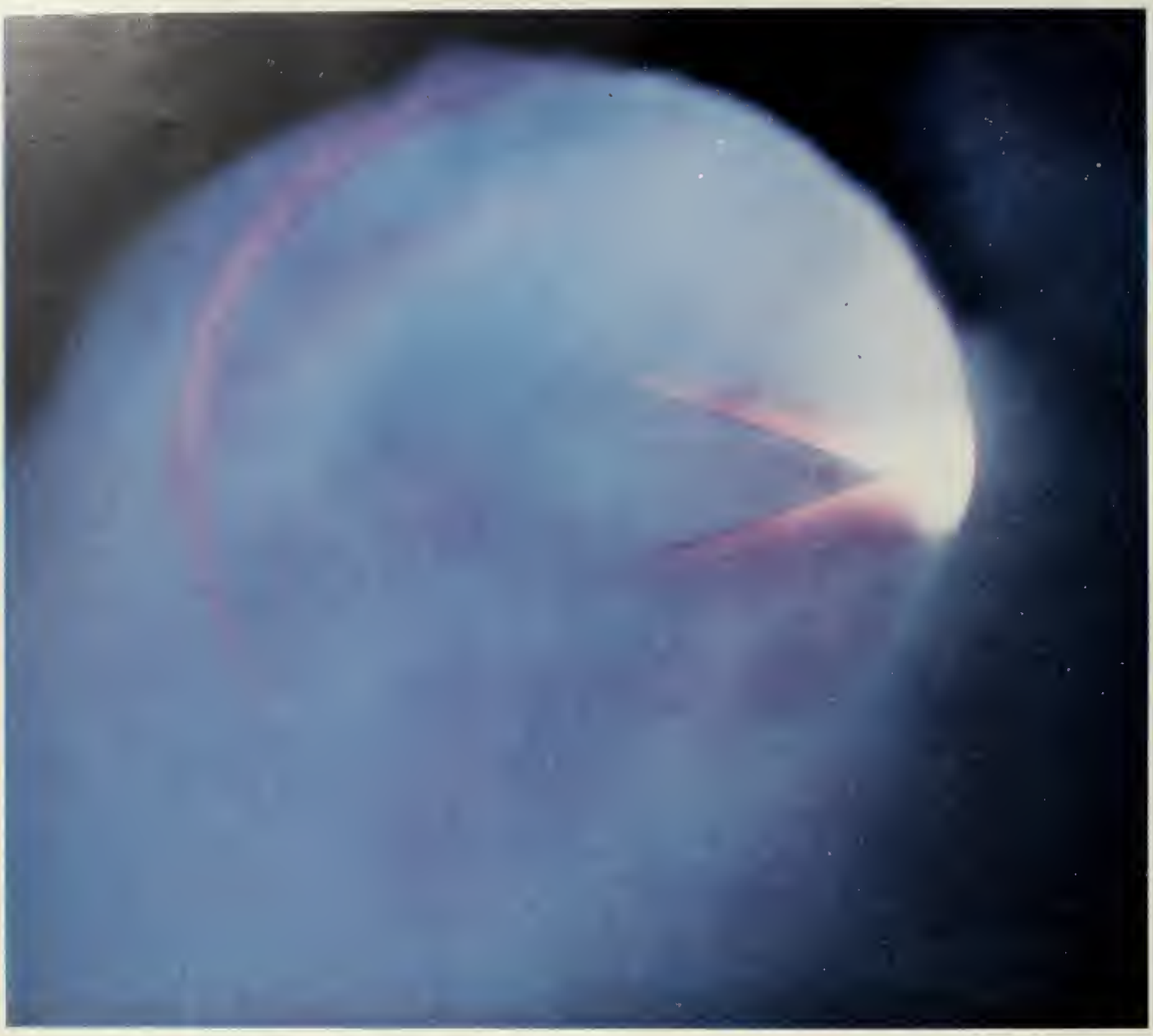
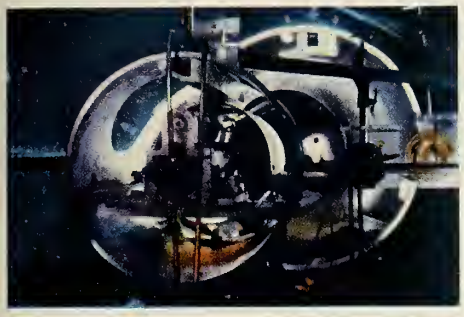
an original purpose to study the aerodynamic
materials problems of hypersonic flight. Alre
however, Dr. Leo Steg (above), the lab's e
getic young director, admits that not even he
define the limits of these tools that probe the
known. The dull thud of a shock tube bursting
diaphragm, the devil's spectrum of a plasma je
these are the sounds and colors of escape, Mars
bit, return and reentry, of research in a new

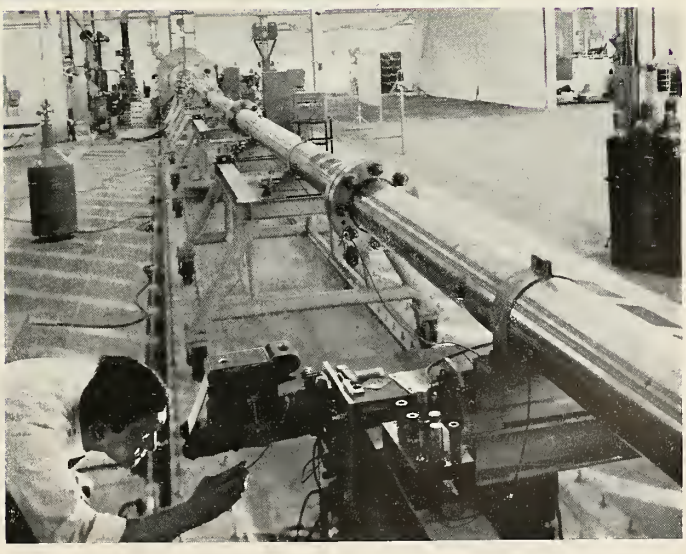
Like a ring-sight zeroing in on the future, the carbon arc-powered solar furnace above can concentrate 2700°C heat in the test area. To the far left, opposite, a compressed asbestos test cone glows, flares and disintegrates under the 12,000°C plasma blast from a water stabilized arc. Moving right, the next two pictures show the same jet with a graphite expansion nozzle in place. AF Office of Scientific Research's Col. Wm. O. Davis says such a stream of ionized particles exhausting through magnetic coils may soon provide basic ion propulsion know-how. Next, a copper sample waits its turn; in an instant glows red; then melts, spalls and vaporizes in tell-tale copper green. This arc, a joint MOSD—Chicago Midway Laboratories development initiated by GE's Dr. B. Levine, uses a half-inch electrode and 200 kw of DC power. Water swirling in the plastic annulus cools the unit, confines the arc and is vaporized and ionized into a plasma. The GE MOSD lab also boasts a liquid nitrogen stabilized arc using a one-half inch electrode and 200 kw. Possible later versions requiring several thousands of kw will offer versitility and a wider range of test conditions—tens of thousands of degrees centigrade and extremely high hypersonic velocities.



Not man's first assault on Saturn's ammonia atmosphere, but the moment of ignition of GE MOSD's liquid nitrogen "steam" as it pours from the test chamber. Even though liquid nitrogen's temperature is —195°C, the unit promises temperatures up to 12,000° C and more closely simulated atmospheric conditions. These arcs provide heat transfer rates on the order of 500 BTU per square foot per second. The surface temperature of the sun is approximately 6500°. In charge of developing this unit are Drs. John McGinn and Harold Wachman (white shirt). Note the heavy frost on the lead lines and swirl chamber. This equipment can provide test conditions for seconds or minutes, depending only on the length of the electrode. Note also, in the before-and-after shot, the beating a brass nose cone took from heat and blast in just a few seconds.

Mr. Jesse Metzger, MOSD's solar furnace researcher, sweats it out between heat source and target to explain a new technique to Aeroscience's associates (left to right): Dr. Wallace Warren, Dr. Wm. C. King, Jr., Mr. James Reid, Dr. Leo Steg, Dr. Harold Wachman, Dr. Joseph Farber and Mr. Clifford Mannal. Actually, the name Aeroscience will probably be discovered to be a misnomer. The potentials of some of these tools has been described as "fantastic." It seems certain that their contribution to man's knowledge of the basic state of his universal environment will far exceed the current confining limits of this definition.





A bit hot for marshmellows, solar furnace has melted its way through a one-eighth inch thick sheet of stainless steel (top). Again looking into the white-hot heart of this inexpensive laboratory tool, a lucite test sample melts from its probe in a few seconds. And to the right center, an epoxy resin slug glows red hot in scientist's tongs. Slug has been removed before destruction in order to evaluate rate of deterioration and changes in material's chemical and physical properties under high heating. To the right, MOSD's most expensive Aeroscience research tool now in place is this six-inch diameter shock tunnel. Still building up to full power, it has already produced Mach 10 shock waves. A unique feature of this installation is the expansion throat at the far end, permitting study of large-scale models. Contemplated for addition to the array is an electric arc discharge accelerator, theoretically capable of model velocities in the hyper-hypersonic range—beyond the realm of known requirements.

"QUARTERMASTER IN THE SKY

Now, critical Air Force supplies cross the sk in greater bulk—with greater speed— via Lockheed's new C-130 Military Transpo

To produce the all-important C-130 empennage, Lockheed called on Avco-Crosle The result: empennages of consistent quality perfect interchangeability. Avco-Crosley's long experience with all methods of airframe tooling guarantees positive fidelity to design

Complete airframe capabilities at Crosley include: contour honeycombing, metal bonding, and chemical milling processes.

A fully staffed structural design group, part of a 300-engineer Aircraft Component Production Department, gives Crosley complete capabilities in design engineering, tooling and fabrication of aircraft structures

Crosley offers complete facilities for research, development, and production of:

Aircraft Structures	**Ordnance Systems**
Air Weapons Systems	**Missile Systems**
Air Traffic Control Systems	**Communications Systems**
Ground Radar Systems	**Industrial Electronics**

Avco Manufacturing Corporation, Crosley Division, Dept. AS, 1329 Arlington St Cincinnati 25, Ohio.

ENGINEERS WANTED: For top-flight men, Crosley offers unusual opportunities to explore new scientific frontiers that lead to outstanding and rewarding careers. Write Vice President of Engineering at Avco-Crosle

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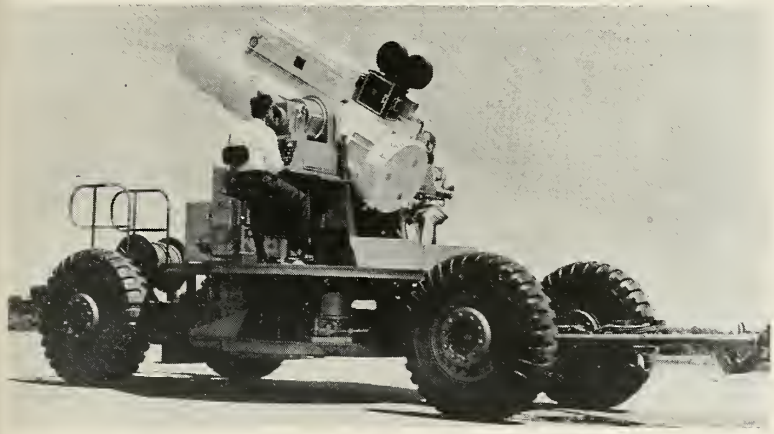
defense and industrial products

NEW MISSILE PRODUCTS

MISSILE TRACKING SYSTEM



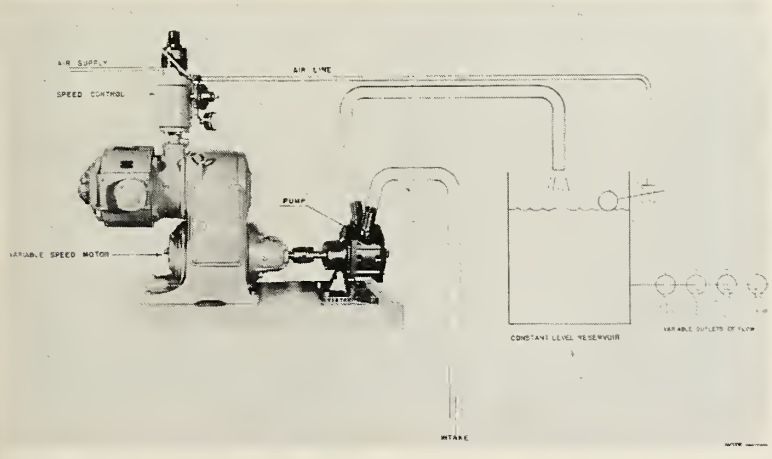
First completely mobile optical tracking system, capable of photographing an object 2″ x 7″ at an altitude of 4 miles, has been delivered to the Air Research & Development Command. System will soon undergo range evaluation tests at ARDC's Armament Center, Eglin AFB, Fla.

Called Telescopic Photographic Recorder (TPR), the 6-ton system will be used to photograph the flight history of missiles, aircraft and bombs. It will record documentary information such as altitude, spin rates and correlated time data. TPR was designed and built by the Perkin-Elmer Corp.

TPR can be readily moved to any desirable site and can be operated either remotely or by operators. It consists of a 9′ long, 100″ focal length reflecting telescope equipped with 70 mm motion picture camera, two sighting scopes, controls, electronic and hydraulic equipment. Primary telescope is a 3-in-1 system.

Circle No. 207 on Subscriber Service Card.

PUMP-MOTOR SET



Variable flow rate pump-motor set designed specifically for pilot plant, laboratory or process work where controlled and varying rates of flow of corrosive fluids and abrasive slurries are required is being marketed by Vanton Pump & Equipment Corp.

The pump is driven by a variable speed source so that a relatively linear relationship between speed and output can be obtained. This offers a practical and exact way of varying the rate of flow.

The sensing and controlling portion of the system is an air signal operating at an instrument pressure of 3 psi to 15 psi. The signal pressure controls the power air through an amplifier, thus controlling the rpm of the pump drive.

Pump has no stuffing boxes or shaft seals and the fluid conveyed is isolated to contact only materials used in the flexi-liner and body block.

Circle No. 265 on Subscriber Service Card.

FLAME-RETARDANT LAMINATE

A new flame-retardant glass epoxy laminate, featuring excellent flame and heat resistant properties, has been developed by Continental-Diamond Fibre Corp. When removed from flame laminate will not continue to burn because of self-extinguishing characteristics.

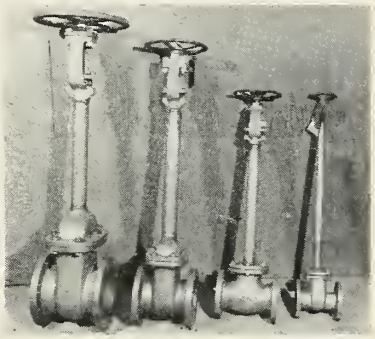
Laminate can be used continuously at temperatures up to 300°F. Above this mark it can be used intermittently. Available in plain form for power applications and metal-clad form for printed circuitry. Can be obtained in sheets ranging from .010″ to 1″ in thickness.

Circle No. 200 on Subscriber Service Card.

STAINLESS STEEL VALVES

Cooper Alloy Corp. has developed a line of stainless steel gate and globe valves for handling liquid oxygen and other extremely low temperature liquids.

Valves which operate at around —300°F and pressures of 150 psi to



600 psi are designed with extended bonnets to permit the use of heavy insulation between the operating mechanism and the pipe line. This serves to prevent heat pick-up into the valve and its contents and to allow free movement of the operating mechanism.

Furnished with Teflon chevron packing, valves are available in both gate and globe designs from ½″ to 12″.

Circle No. 218 on Subscriber Service Card.

NUCLEAR ELECTRIC TIMERS

A small, lightweight electric timer suitable for use in time delays, missile destructors, pilot ejection systems, alarm systems, and warheads uses a nuclear battery as its power source.

Called Betachron, the unit was developed by the Moos Division of Universal Winding Co., Inc. The timer has a shelf and use life of over 25 yrs. and is capable of operating reliably over wide ranges of temperatures, acceleration and vibration. Suitable for use in missile systems where time delays from microseconds to 40 hrs. are required with an accuracy of ±3%.

Timer is capable of delivering energy pulses up to 250,000 ergs, is supplied and encapsulated in a metal case with standard connectors at the output. Heart of timer is nuclear battery which converts nuclear energy directly into electrical energy.

Circle No. 202 on Subscriber Service Card.

CONSTANT DAMPING GYRO

A new rate gyro, Type JRT, has been developed by the Boston Division of Minneapolis-Honeywell. Instrument measures absolute rates of rotation in inertial space. Damping is electro-mechanically controlled to maintain a constant damping ratio over the entire operating temperature range of —65°F to 175°F.

The rate gyro is designed specifically for flight control of long-range missiles and for instrumentation in missiles and aircraft where ambient temperatures are not controlled and at the same time where

low threshold, minimum hysteresis, excellent linearity, high natural frequency and ruggedness are essential.

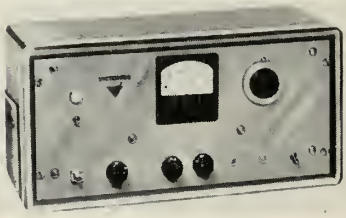
Features include: excellent linearity, 25% of full scale; low hysteresis, less than .1% of full scale; low threshold, less than .01°/sec; microsyn pickoff, variable reluctance type providing infinite resolution and high signal-to-noise ratio; full scale rate, up to 1,000°/sec; full scale output, up to 12v; withstands 100g shock, 15g to 2,000 cps vibrations; size 2 7/64" diameter, 4 5 16" long; weighs 2 lbs.

Circle No. 209 on Subscriber Service Card.

COUNT RATE METER

A logarithmic count rate meter build to the latest ORNL specification Q-1454-B is being produced by the Victoreen Instrument Co.

Based on the Cooke-Yarborough circuit, Model 727 is a wide-range instrument for use with all types of radiation



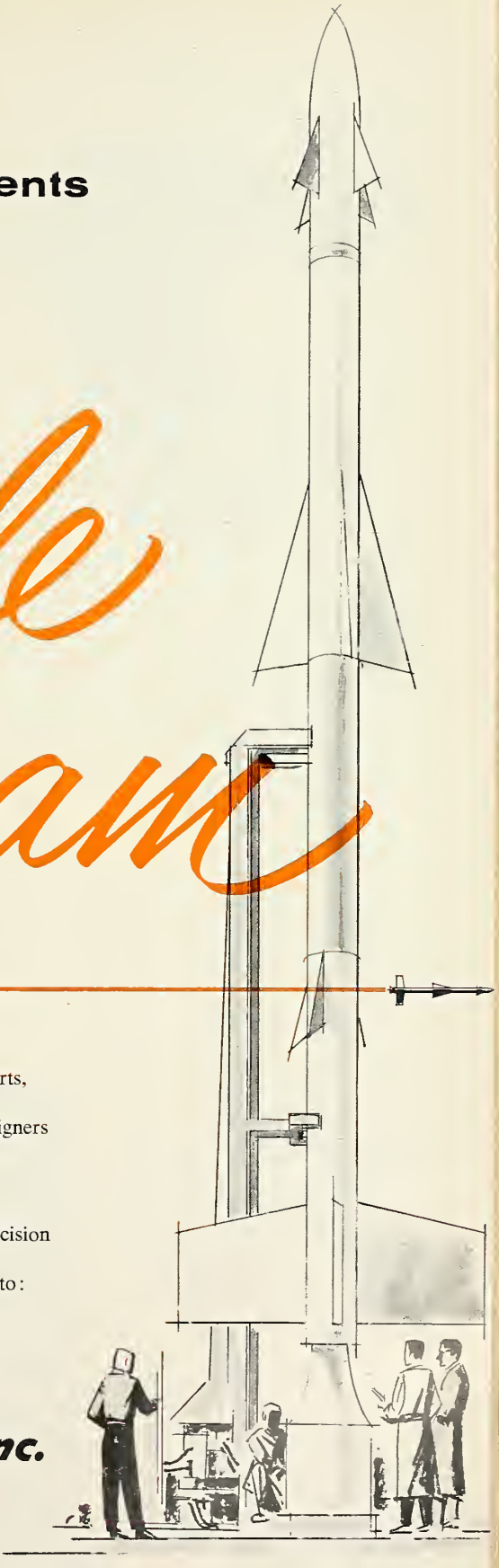
detectors. Applications include gamma monitoring with scintillation counter, beta-gamma monitoring with Geiger counter, and gamma ray spectrometry.

Meter eliminates need for manual or electrical switching as is required in linear-type rate meters. Range is from 10

Leader in Jet Components

can help speed your

Missile Program



Experience gained in producing over 100,000,000 forged parts, stainless steel weldments, and assemblies for all jet engine manufacturers is available now to designers and manufacturers of missiles.

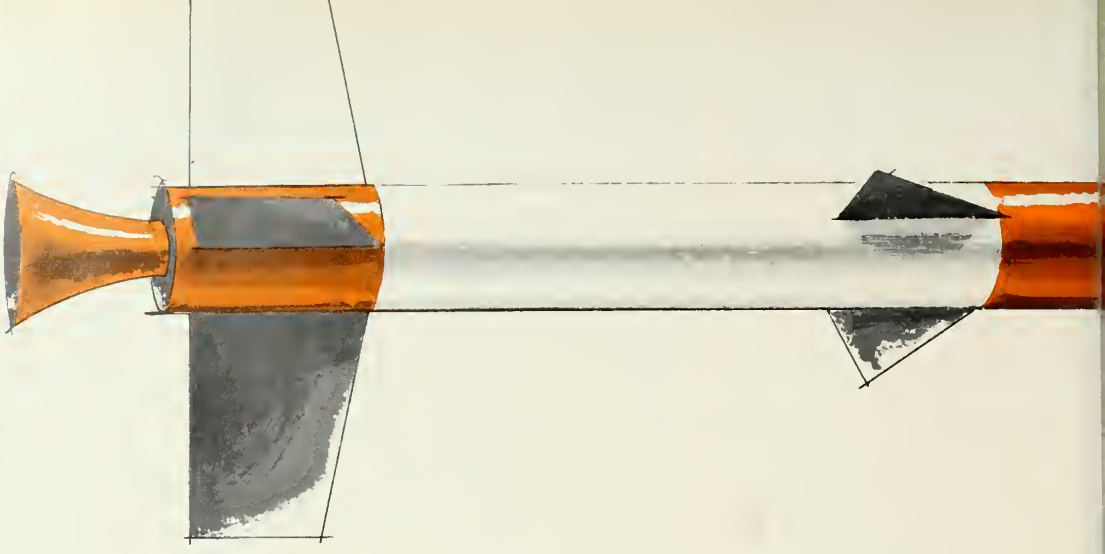
Let us discuss your projects and your needs with you now. Your missile can then have the benefit of what the Jet Division has developed for the jet-engine industry . . . precision forgings, high-temperature alloys, resistance-welded stainless steel assemblies. Write or phone today to:

MISSILE PROJECTS DEPARTMENT

JET DIVISION

Thompson Products, Inc.

CLEVELAND 17, OHIO



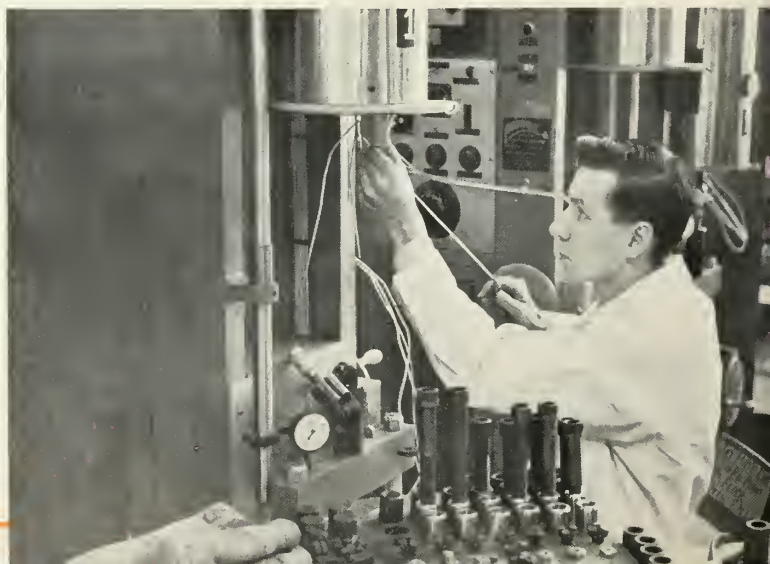
for your missile program...

complete engineering and test facilities to augment your manpower

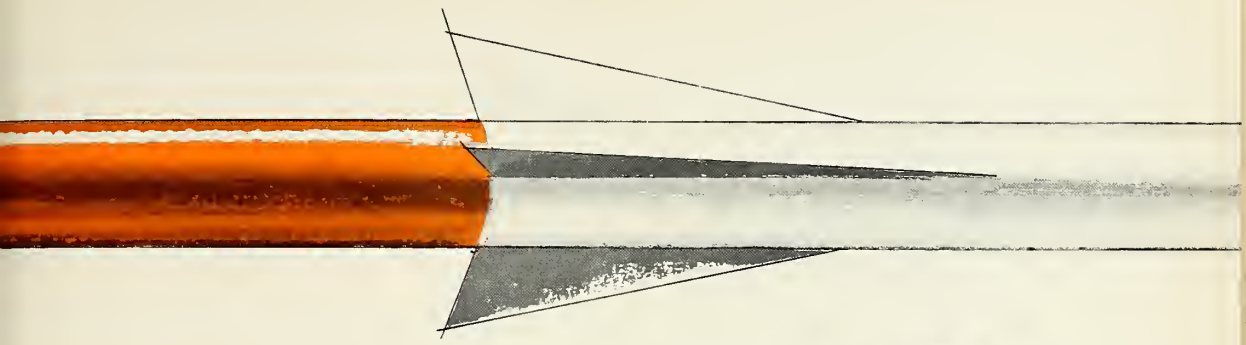
The men at the Jet Division who helped develop forgings and stainless steel weldments for jet engines are ready now to work with missile engineers on projects using their experience and talents.

You can use their services in the development of air-frames, tanks, and other structural components of missiles. You can also use their experience with metals at high temperatures in the design of your missile power-plants and skin-surface components.

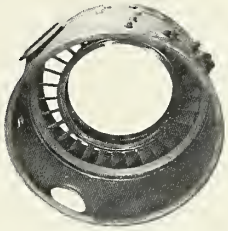
A Jet Division engineer will be glad to call at your convenience to discuss your projects, timetables, and requirements.



Tensile tests at elevated temperatures are run an variaus allays in Jet Divisian labs ta determine their strengths under missile equivalent aperating canditions.



for your missile program...



weldments in stainless and high-alloy steel and titanium made to your specifications

High-precision weldments that combine careful forming, all types of welding, and accurate placement of bosses and holes, can be designed and produced for your missile at the Jet Division.

Our experience in the production of titanium, high-alloy and stainless steel components for jet engines can give you a head start on your missile projects. Special Jet Division techniques of welding and stress-relieving provide maximum strength at minimum weight in metals that can resist the operating temperatures and stresses of missiles.

Let us discuss your weldment and machining requirements and show you how Jet Division engineering and production can quickly augment your own facilities.

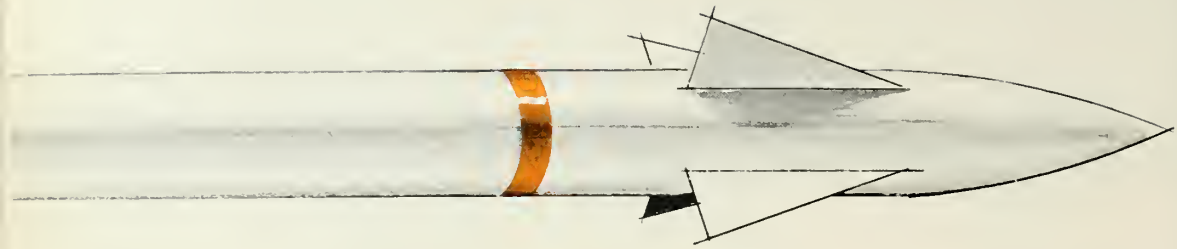
MISSILE PROJECTS DEPARTMENT

JET DIVISION

Thompson Products, Inc.

CLEVELAND 17, OHIO

Special welding procedures and jigs are used in welding service-stressed stainless and alloy steel components into a finished structure at the Jet Division.



for your missile program...

Forgings made to closest tolerances for high-temperature service

Starting in 1944, the Jet Division was the first manufacturer of high-precision forgings for jet aircraft engines.

More forged parts of titanium, stainless and high-alloy steels for engines of every manufacturer have been made by the Jet Division than by any other producer.

Every jet engine manufacturer uses Jet Division forged parts.

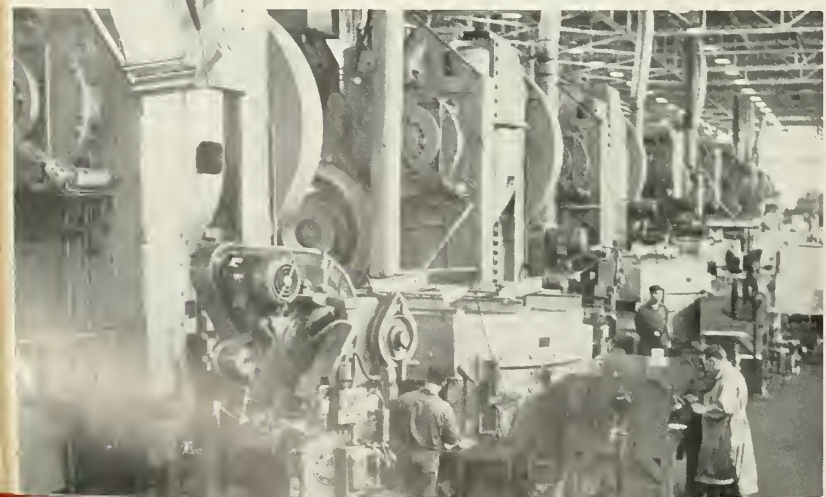
Forged to extremely close tolerances and contours, precision parts produced by the Jet Division often require no costly machining before assembly. Their use in your missile can speed delivery, reduce finishing time, eliminate capital plant investment.

Complete machining and test facilities are also available for your missile subcontract work.

Our sales engineers will gladly discuss your missile project requirements at your convenience.

WRITE FOR FREE BOOKLET

The complete engineering and manufacturing facilities of the Jet Division are described in Booklet MI-57. Write on your company letterhead for a copy.



MISSILE PROJECTS DEPARTMEN

JET DIVISION

Thompson Products, Inc.

CLEVELAND 17, OHIO

Bottery of forging presses up to 4000-ton capaci produces precision ports in titonium, stoinless, or olloy steels ot the Jet Division's press-forging sho

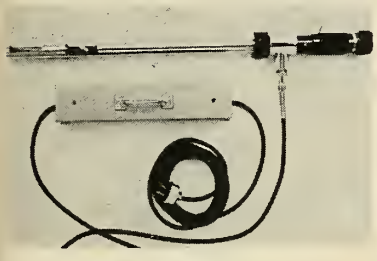
to 1 million counts per minute in 5 decades on a single scale. Accuracy is within ±2% over the entire decade and is better than ±1% in the vicinity of the calibration point. Drift is less than 1% in 24 hours.

Meter operates on 150 vac, 60 cycles, draws 135 watts. Relay pack panel is 8¾" x 19", weighs 60 lbs.

Circle No. 206 on Subscriber Service Card.

MIRROR BORESCOPE

Borescope developed by Lenox Instrument Co. permits complete internal inspection of tanks, vessels, combustion chambers and other equipment by means of an adjustable mirror which can be controlled by a hand-wheel to permit scanning from restrospective through right



angle to forward oblique.

Large field of view offered by instrument makes it easier to detect flaws, pits, cracks or deterioration to assure perfection in manufacturing and maintenance. Borescope gives magnification of 10 power, a field of vision of 9" in diameter at a distance of 24", and has a viewing head with 13/16" diameter 100 watt lamp.

Circle No. 212 on Subscriber Service Card.

ENVIRONMENTAL EQUIPMENT

Labline, Inc. is producing a line of Environ-Cabs to simulate temperature and humidity conditions over a range of 20% to 95% relative humidity and temperatures from 40°F to 200°F, in four sizes—10, 20, 30 and 40 cu. ft.

Environ-Cabs are suitable for laboratories and plants where such tests must be run. Features are double-wall cabinets with interiors and exteriors of 1808 stain-

less steel, insulated with Fiberglas, perforated diffuser walls for uniform air flow, dual blowers, dual hydraulic thermostats for temperature control, silicone door gaskets, adjustable shelves.

Humidity pan with heaters and automatic water level supplies the necessary humidity conditioners. Where required,

automatic temperature recorders, controllers and programmers may be installed. Thermopane observation windows, terminal boards for elecrtical testing, penetrations for pipes, wires, etc., are optional.

Circle No. 204 on Subscriber Service Card.

MINIATURE SWITCHES

Airtron, Inc. has developed a miniature waveguide switch for applications requiring minimum size and weight. Switch provides rapid switching of signals from any one of three positions to either of the remaining two and will not change to another position upon failure of power supply.

Electrical characteristics of the 1" x .5"-size unit includes a frequency range of 8,500 to 9,600 mc/sec with a maximum VSWR of 1.10 and minimum isola-

tion of 40 db. Maximum switching time is .25 sec. for 240° operation and .15 sec. for 120° operation. The universal switch operates at 3 amperes maximum at 28 vdc nominal and employs R.F. and pressurized fittings built into the switch, giving up to 20 lbs. of pressurization throughout.

Available in Xs and X_L band series, switches are of rotary channel type using a circular bend in the rotor and a broadband internal choke design.

Circle No. 210 on Subscriber Service Card.

MAGNETIC COUNTER

Abrahms Instrument Corp. is marketing improved models of their 3- and 4-digit magnetic counters for use in aircraft and missile applications.

Available in additive or subtractive types with manual reset wheels, the counters record pulses accurately up to 1,200

counts per minute. Actuated electromagnetically, counters can be connected in vacuum tube plate circuits or operated by any contacting device.

A variety of mounting methods is possible and units can be supplied with

or without panel mount cases.

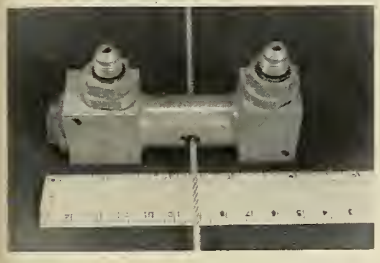
Snap-door on front of case allows convenient resetting. Counters available for all common voltages from 6 to 110 vdc. Three-figure counter measures ⅞" x ⅞" x 2", weighs 2 oz.

Circle No. 216 on Subscriber Service Card.

CABLE CUTTER

A ballistically-operated cable cutter with self-contained cartridges has been developed by Stanley Aviation Corp. Triggered by low incoming gas pressure, the unit contains two independently fired cartridges, either of which produces sufficient force to sever a ⅛" steel cable.

Weight is .45 lbs., unit measures, 4" x 1" x 2¼". Device is applicable to



any system requiring instantaneous, reliable cutting of cables, wires, tubes or rods.

Other models are designed to operate from mechanical or electrical signals, rather than pressure input, and provide for variation in mounting position, cable orientation and changes in angular relation of input connections.

Circle No. 219 on Subscriber Service Card.

EYE-WASH FOUNTAIN

A portable emergency eye-wash fountain, for instant eye first aid where normal water supplies are not available, is being manufactured by Haws Drinking Faucet Co.

Model 8950 is designed for use by crews working in remote areas. The corrosion-proof stainless steel tank has a carrying strap and holds three gallons of water instantly avialable to flood the eyes and wash away dangerous substances or particles. Specially designed fountain heads project water into the eyes with a soft, flushing stream.

Pressure is build up within the tank by means of the large pump handle. Pressure maintained for an 8-hr. period. Weight is about 40 lbs. loaded, 15 lbs. empty.

Circle No. 217 on Subscriber Service Cord.

PROGRAMMER COUNTER

Precision-made devise turns on and off test apparatus whose limits are sensed by strain guages, thermocouples or other transducers that have a maximum output not exceeding 100 mvdc. Instrument has been developed by Spar Engineering & Development, Inc.

Unit eliminates need for manual control of test cycling and simplifies setting up of equipment each time test is to be run. The Spar program counter is said to be a stable, precision mv electronic relay having adjustable energizing and release thresholds and DPDT 15 amp contacts. Its two, adjustable, stable thresholds provide for precise selection of

AIRCRAFT COSTING MILLIONS . . .

BOEING PHOTO

. . . ARE PROTECTED BY THE B&H JETCAL® ANALYZER

Two of the most important factors that affect jet engine life, efficiency, and safe operation are *Exhaust Gas Temperature (EGT)* and *Engine Speed (RPM)*. Excess heat will reduce "bucket" life as much as 50% and low EGT materially reduces efficiency and thrust. Any of such conditions will make operation of the aircraft both costly and dangerous. The *JETCAL Analyzer predetermines* accuracy of the EGT and (interrelatedly) Tachometer systems and isolates errors if they exist.

The *JETCAL* ANALYZES JET ENGINES 10 WAYS:

1) The JETCAL Analyzer *functionally* tests EGT thermocouple circuit of a jet aircraft or pilotless aircraft missile for error *without running the engine or disconnecting any wiring*. GUARANTEED ACCURACY is ±4°C. at engine test temperature.

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

3) Checks thermocouples within the harness for continuity.

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

5) Checks resistance of the Exhaust Gas Temperature system.

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

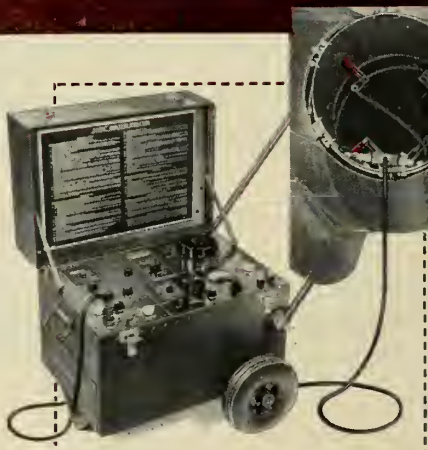
7) Checks EGT Indicators (in or out of the aircraft).

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

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

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

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



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

(functionolly, without running the engine)

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

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

B & H INSTRUMENT CO., INC.

3479 West Vickery Blvd. • Fort Worth 7, Texas

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upper and lower operating limits and a counter, which may be of the reset type, registers each cycle.

Instrument operates on 110 vac.

Circle No. 20S on Subscriber Service Card.

TANTALYTIC CAPACITORS

New "King Size" high temperature tantalytic capacitors for low voltage direct current capacitors with high microfarad values in a small space have been added to General Electric's Capacitor Department line. Three rectangular case sizes with similar base dimensions of 1.316" by 0.75" are being produced.

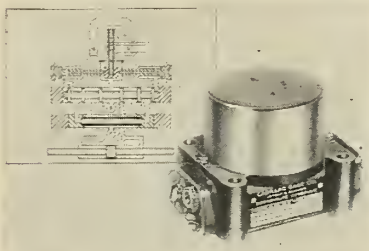
Heights vary from 1.375" to 2.5" with typical capacities of 1000 mico-

farads at 30 volts to 100 microfarads at 20 volts. The capacitors are rated for 1000 hours operation at 125°C with not more than 20 percent loss from 25°C capacitance after the 1000 hour period.

Circle No. 225 on Subscriber Service Card.

ELECTRO-HYDRAULIC VALVES

A new series of Electro-Hydraulic Servo valves, known as the FC200 series,



has been developed by Cadillac Gage Co. Series is comprised of three models.

Valves represent a marked departure from previous design concepts and are capable of functioning reliably under the rigorous operating and ambient conditions encountered in modern high performance aircraft and missiles. They utilize a closed loop hydraulic control circuit to position the output stage and are of a completely balanced push-pull construction.

No springs are incorporated in the design. The valves have a minimum of moving parts, incorporate a single large capacity filter element to protect the control stage, and are of "dry coil" design.

Circle No. 238 on Subscriber Service Card.

HIGH SPEED CAMERA

Fastex high speed motion-picture and oscillographic camera and a 16 mm projector and a motion picture missile camera have been developed by Wollensak Optical Co.

Fastex-WF-17 combination high speed motion picture and oscillographic camera was designed to record both mechanical and electrical data on the same film. It is particularly useful where studies of short duration are required. Camera takes 100' daylight loading spools, has speed ranges from 150 to 8,000 pictures per second, and can be used for either picture or oscilloscopic recording independently.

The projector was developed for the study and analysis of subjects filmed by high speed cameras. Films can be pro-

jected without flicker as slowly as 2 frames-per-second. In addition, normal speed of 16 frames-per-second, frame by frame or still picture may be shown.

The Fastair high speed missile camera, in addition to its rugged construction capable of withstanding high g loads,

severe vibration, impact and shock, will accept 50′ and 100′ daylight loading magazines. This feature eliminates one of the photographer's major problems in location work.

Circle No. 259 on Subscriber Service Card.

MAGNETIC COUNTER

Model MCRP-700 by Photocon Research Products is a compact, high-speed, precision counter developed to add or

subtract electrical pulses with optional microswitch control at zero level—featuring electrical reset to any predetermined number.

The high-speed lightweight armature, which actuates the counting mechanism, is dynamically balanced to provide accurate counting under severe vibrations.

The MCRP-700 can be furnished as a three, four, or five digit counter with any combination of add, subtract, and microswitch control at zero level.

Circle No. 249 on Subscriber Service Card.

PRESSURE CONTROLLER

Bellofram Type air gauging manostat is said to give precise downstream pressure control over wide supply pressure variations. It does not drift with time or with periodic shutdowns. It remains precisely stable through tempera-

ture changes as well as supply or flow variations.

Manufactured by Bellofram Products Corp., the manostat utilizes an extremely high gain servo system with main valve action controlled by a pilot nozzle which in turn is activated by slight pressure variances. Instantaneous adjustment

of controlled pressure is assured by the small relative movement required between the pilot valve and its seat in order to initiate great changes in main valve action.

To eliminate exhaust valve "pick-up" on dead-end service and initial drop-off, pilot pressure is bled directly to atmosphere rather than downstream.

Manostat's entire measuring element, including the pilot valve, embodies highly elastic metallic parts having practically no hysteresis or permanent deformation under any working conditions.

Resolution is one-part-in-10,000 of range, and repeatibility is usually less than one in 5,000 of range.

Available in ranges of 2-25 and 3-36 psi in 1.8" and ¼" pipe sizes.

Circle No. 264 on Subscriber Service Card.

SAMPLING SWITCH

A precision switch having a hermetically sealed case for high altitude mili-

tary and commercial applications has been developed by General Devices, Inc.

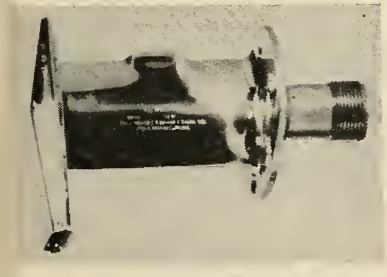
The switch has up to two poles with 30 non-shorting channels per pole. It is driven by either 28 vdc motor with a governor, arc-suppressor and a R.F. filter or a 115 v, single phase, 400 cps hysteresis synchronous motor.

Dimensions are 2.75" x 4.94" x 3.87". Typical applications include high altitude telemetry systems, multi-channel data systems, error indicating systems, etc.

Circle No. 247 on Subscriber Service Card.

TEMPERATURE PROBE

Rosemount Engineering Co. claims its Model 102 is the fastest total temperature



probe designed specifically for flight test applications. Time constant for the probe is less than 25 milliseconds under most conditions of operation.

The 102 exhibits extremely small recovery errors, namely, less than .1% of the absolute temperature for supersonic flight, and even less for subsonic flight.

Design of the unit protects the element from flying particles. This is done by removal of internal boundary layer air, thereby avoiding the usual upstream particle deflector which is slow in response and contributes a slow transient into the response of ordinary "fast" designs, the company reports.

This design eliminates all but the finest water droplets. Further testing is expected to show dry adaabatic readings in rain.

Model 102 probe has 50 ohm platinum resistance thermometer element, and has excellent uniformity of calibration. The element may be easily replaced and repaired at low cost. The element also has long electrical leakage paths for minimum dependence or dampness.

Circle No. 237 on Subscriber Service Card.

HEAT TREATABLE ELECTRODE

Eutectic Welding Alloys Corp. has developed a fully heat treatable all-position electrode formulated specifically for fabrication of chrome-moly steel and other high tensile alloy steels.

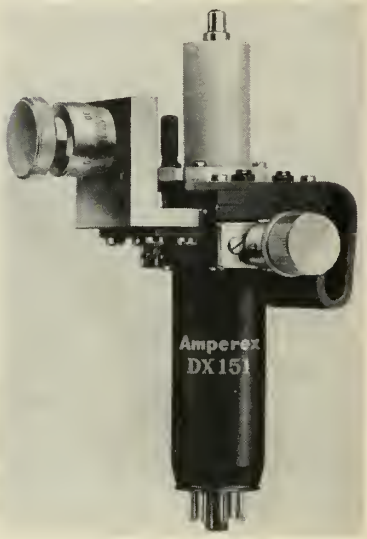
Featuring ease of application regardless of current or position, "Low Amp" EutecTrode 71 ac-dc is designed mainly for low alloy steels, particularly the 4130, 4140 and 8630 grades. Deposits have similar heat treating characteristics as the base metal.

The electrode has a deposited tensile strength of 100,000 psi. Deposits are fully heat treatable. Specific uses for spatter and clag interference-free Eutectrode 71 ac-dc include fabrication of tanks, containers and vessels for high pressure work.

Circle No. 243 on Subscriber Service Card.

KLYSTRON

A new 4mm klystron tunable over a range of 6 kmc from 65.5 to 77.5 kmc



has been announced by Amperex Electronic Corp. The DX151 waveguide-output reflex klystron has an output of 40 milliwatts at band center and 10 milliwatts across the band.

Oxide coated cathodes are used and operate at 2 to 4 amps per square centimeter and are said to give long life. Heater power needed is 0.4 amperes at 10 volts ac or dc. Electrostatic focusing is used.

Circle No. 228 on Subscriber Service Card.

SNAP-ACTION SWITCH

Milli-Switch Corp. has developed a hermetically-sealed high-amperage snap-action switch which is said to insure reliability and performance because of a one-piece spring.

Model BHA-HS has an electrical rating of 10 amperes at 30 vdc resistive, 8 amperes at 30 vdc inductive and 10 amperes at 125 vac. Temperature range is —67°F to 268°F; operating force, 30 oz. maximum to 4 oz. minimum release force; vibrations, 55 to 4,000 cycles per sec.; shock, 75g.

Contacts are fine silver, 24 karat gold-plated; terminals are screw type 24 karat gold-plated over silver plate. Altitude to 100,000 ft.; life is 250,000 cycles minimum mechanical. The mounting bracket is corrosion resistant.

Circle No. 252 on Subscriber Service Card.

TEFLON HOOK-UP WIRE

Made to MIL-W-16878B and meeting all requirements of this specification, Amphenol high temperature Teflon Hook-Up Wire is being marketed by Amphenol Electronics Corp.

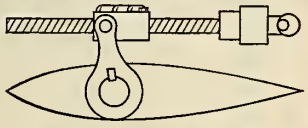
Types E and EE and a variety of colors and gauges are represented in the line.

Amphenol reports the following features: ease of processing in automatic stripping machines because of concentricity of Teflon insulation over tightly

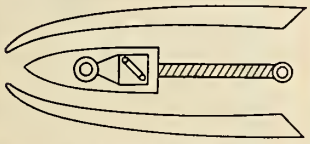
FAIL-SAFE ACTUATION

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

TYPICAL APPLICATIONS

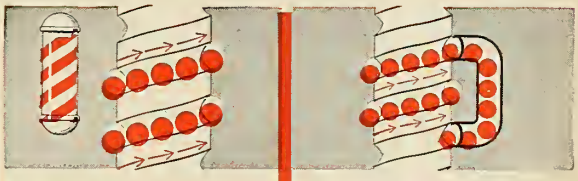


Control surface actuators



Nose cone positioners

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



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

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

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

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

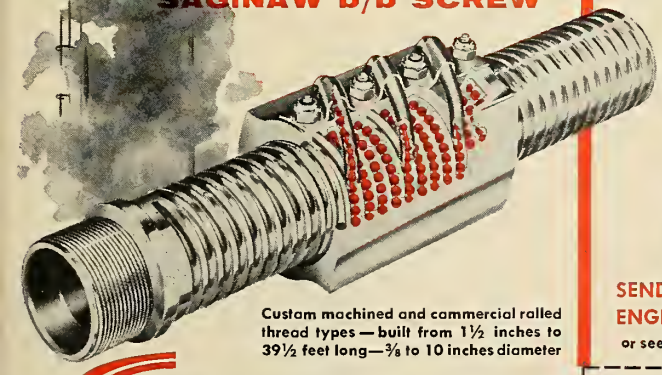
3 PRECISE POSITIONING. Machine-ground Saginaw b/b Screws offer a great advantage over hydraulics or pneumatics because a component can be positioned at a predetermined point with precision. Tolerances on position are held within .0006 in./ft. of travel.

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

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

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

SAGINAW b/b SCREW



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

SAGINAW b/b SPLINE

Averages 40 times lower friction coefficient than sliding splines

Radically increases efficiency of transmitting or restraining high torque loads; built from 3 inches to 10 feet long, ⅜ to 6 inches diameter

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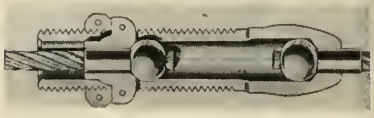
stranded wire; ease of tinning because of minimum of 40 micro-inches silver-plating on all wires; assured reliability because of 100% inspection of every foot produced, including 11 major quality checks.

Circle No. 251 on Subscriber Service Card.

SHORT TURNBUCKLE

A short turnbuckle which exceeds standard tensile and fatigue strength requirements has been developed by Vio-Shan Manufacturing Co.

One-third as long as the standard AN short turnbuckle, the new one, called



Cabuckle, has constant length for any adjustment. It can be installed and adjusted readily with standard tools, eliminates cable twist, and can be lock-wired.

Cabuckle assembly has three components: slotted sleeve with rolled external threads, a forged cross-piece, and a hex nut. One cable end is attached to the sleeve, the other to the cross-piece. Cable tension is adjusted by advancing the nut on the sleeve and the amount of available adjustment is visible at all times.

Voi-Shan, division of the Pheoll Manufacturing Co., is licensed by North American Aviation Co. to develop and manufacture Cabuckle, NAA designed Cabuckle to meet a space-limit problem in the flight control system for the F-100 fighter-bomber.

Circle No. 257 on Subscriber Service Card.

OXY-ACETYLENE REGULATORS

A new line of "Jet-Flow" oxygen and acetylene regulators for gas welding has been developed by Marquette Manufacturing Co.

The new regulators are offered in several price ranges and in many sizes, both single and two-stage. New design contains only four working parts, assuring long life and maintenance-free operation. Each regulator in the new line is "proof tested" in the factory under actual operating pressures to assure perfect operation.

Circle No. 236 on Subscriber Service Card.

PYROMETRY CIRCUIT SWITCHES

Thermo Electric Co., Inc. has developed a line of key-type selector switches

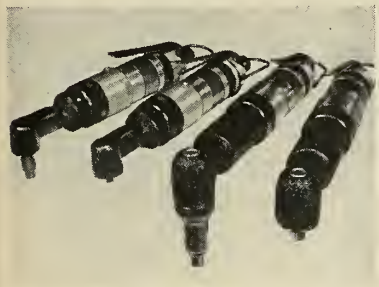
for connecting sensing elements to indicators, recorders or other instruments. Two-position and three position key switches with various pole arrangements are available.

Cases containing the switches are moisture-proof and dust tight and suitable for wall or panel mounting. Case capacities range from 12 to 144 points for both thermocouples and resistance bulbs.

Circle No. 231 on Subscriber Service Card.

ANGLE ATTACHMENTS

A line of angle attachments, designed to simplify production fastening in close



quarters and hard-to-reach places, has been developed by Gardner-Denver Co.

Four attachments, for use with the recently developed line of Keller Tool air drivers, are heavy or light duty angle screw drivers and nut setters.

Newly designed Keller No. 2 air motors power both the 12G-2 series screw drivers and the 16G-2 series nut setters. These air motors, it is reported, provide more speed, increased power, low noise level and low maintenance.

Circle No. 245 on Subscriber Service Card.

WOVEN ELECTRIC HEATERS

Thin enough to fit into cramped instrument spaces, flexible enough to be bent around sharp corners, and availability in practically any physical shape are claimed to be advantages of a new group of heaters that permit wide design of flexibility in adapting electric heat.

Designated Pre-Fab Laminated Woven Electric Heaters, they are custom-made by Pre-Fab Heater Division, Chromalox, Inc.

Heaters may be insulated with silicone-rubber, Neoprene, natural rubber and synthetic rubber. Maximum heater surface temperatures are 150°F with natural or synthetic rubbers, 167°F with Neoprene, and 350°F with silicone-rubber insulation. They may be applied with adhesives and by bonding and clamping. Leads may be insulated with silicone, Teflon, neoprene or rubber, depending on the construction of the heated sections.

Widths of the Pre-Fab heaters range from 3/8" to 24", while maximum length

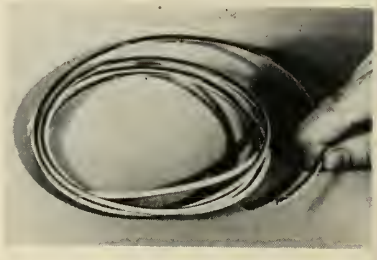
is 24". Thickness is determined by wire size and insulation; minimum is .020".

Wattages range from fractional up to 15 watts per sq. in., while higher watt densities may be built in if heat take-away rate is sufficient to keep temperature of insulation below the breakdown point. Voltages are 6, 12, 24, 48 and up to 230 v. and also 440 v for special applications.

Circle No. 239 an Subscriber Service Card.

STRIPED TEFLON TUBING

Pennsylvania Fluorocarbon Co., Inc. is marketing Teflon tubing with axial stripes of any color to make it easier to

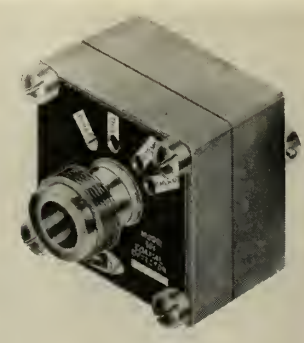


identify process lines, electrical and electronic leads. Available in any size, the tubing has good dielectric strength (500 to 1,000 v/mil); lowest dielectric constant (2.0) and dissipation factor (0.0002) of any solid dielectric; no change of electrical properties with temperature or frequency.

Circle No. 220 on Subscriber Service Card.

COAXIAL DETECTOR

A new coaxial detector mount for bolometers and thermistors of the mica



disc type which requires no tuning and covers the frequency range of 500 to 10,000 mc. has been developed by Narda Corp.

The new mount, Model 561, uses a unique arrangement of the locating pin

K.O. PUNCH...

from Army Ballistic Missile Agency

This is the REDSTONE missile . . . a real knockout for anyone who tries to get tough with Uncle Sam.

Reynolds Aluminum Fabricating Service, as both a prime and subcontractor, is proud to work with the Army Ballistic Missile Agency in the development and production of these missiles . . . our Army's new K.O. punch. Reynolds is proud to work with the scientists, the engineers and the more than 3,500 civilian and military personnel of the A.B.M.A.—one of the activities located at the Redstone Arsenal.

Reynolds offers to this field production redesign, an engineering staff experienced in the development of highly specialized jigs and fixtures, welding techniques, optical inspection equipment, use of X-ray facilities and—the latest in aluminum developments and applications.

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plus a "locator" coded nameplate which is a functional part of the instrument that makes it possible to change elements rapidly and to determine quickly which type of element is in the detector and its bias requirements.

Circle No. 232 on Subscriber Service Card.

TRANSISTOR TRANSFORMERS

Seven new types of transistor transformers have been added to the United Transformer Corp's line of ultra-miniature DO-T units. The units weigh one-

tenth ounce and are fully hermetically sealed to MIL-T-27A specifications.

Included in the new group are 500 milliwatt types designed for pushpull transistor to 600 ohm line operation, a chopper input transformer, transistor interstage transformer, and a line-to-line matching transformer.

Circle No. 222 on Subscriber Service Card.

SILICONE RESIN

Dow Corning Corp. has developed a silicone resin that is said to establish new performance standards for high-temperature protective coatings. Identified as Dow Corning 808 resin, it provides greater gloss retention after long exposure to high temperature than was previously possible.

Typical formulation pigmented with titanium dioxide and thinned with xylene, retains its original 84% gloss rating after 100 hrs. at 482°F. When subjected to 572°F for 400 hrs, or to 482°F for over 2,500 hrs., its gloss rating drops to 70%.

Circle No. 201 on Subscriber Service Card.

FABRIC SEALS

Fuel-resistant, fabric-covered and fabric-reinforced seals for —65°F to 400°F applications are being produced by The Connecticut Hard Rubber Co. using LS-53, Dow Corning's new Fluoro-silicone rubber.

The fabric-covered seals provide high tear and abrasion resistance. The LS-53 fluoro-silicone rubber remains resilient, resists swelling and destruction by aviation

fuel and synthetic oils, even at extreme temperatures.

While the LS-53 fluoro-silicone rubber costs considerable more than ordinary silicone rubber, fabric-covered or fabric-reinforced seal constructions provide the most practical and economical use of the rubber.

The seals, custom made to meet customer design requirements, are already being produced for aircraft uses.

Circle No. 254 on Subscriber Service Card.

DIGITAL-ANALOG CONVERTER

A Multiverter for analog to digital and digital to analog conversion has been

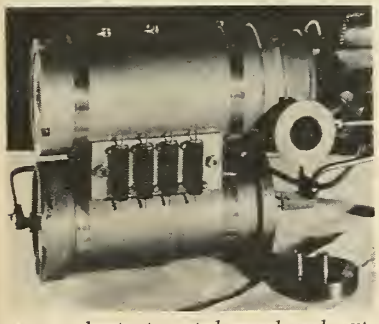
developed by Packard-Bell Computer Corp. subsidiary Packard-Bell Electronics Corp. Conversions are said to be provided at better than 0.01% and at speeds in excess of 15,000 per sec. for analog to digital and 300,000 per sec. for digital to analog conversion.

The unit is completely transistorized. It is claimed to be the first commercially available converter of its type that permits multiplication and division in the process of conversion.

Circle No. 230 on Subscriber Service Card.

POWER UNIT

General Electric Co. has produced a fully self-contained electric and hydraulic auxiliary power unit for missiles. It



can accelerate to rated speed and output within half a second.

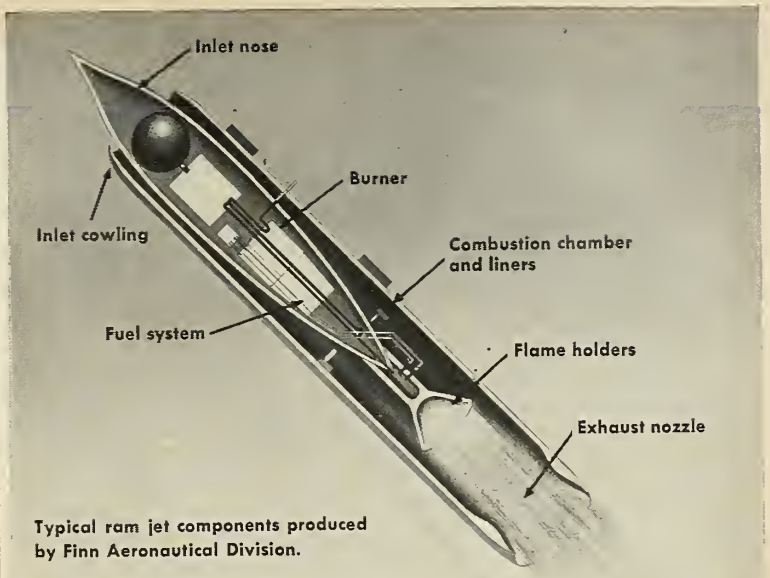
The compact, turbine-drive unit consists of several modular components for versatility and flexibility of outputs and can supply electric power, hydraulic power, or both with ratings from 1.5 hp to 10 hp.

Circle No. 248 on Subscriber Service Card.

BALANCE UNIT

Ten 4-arm strain gauge bridge or resistive type pickups may be calibrated individually or simultaneously with a rack-mounted balance unit manufactured by Consolidated Avionics Corp.

Designed for large-scale instrumentation systems, Model 228 employs individual plug-in calibration resistors



Typical ram jet components produced by Finn Aeronautical Division.

which are inserted from the front through a hinged door on the panel. Precision 10-turn balance and sensitivity potentiometers are provided with knurled finger locks for

maintaining desired settings. Toggle switches permit individual transducer calibration, or all transducers may be calibrated by a remote contact closure.

Individual or common voltage supplies of 0 to 30 v may be used. The system is designed for 4-arm resistive transducers of 120 ohms or more.

Model 228 supplements the manufacturers line of airborne calibration systems which are available in 16, 26 and 36 channel models.

Circle No. 262 on Subscriber Service Card.

SQUARE CR TUBE

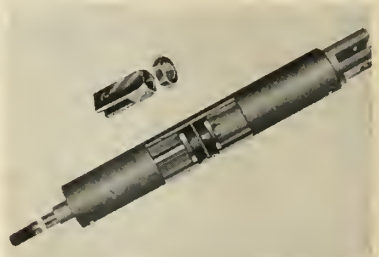
Electronic Tube Corp. has announced a new 3½" square-face Type 41HAP

single-gun electrostatic focus and deflection cathode ray tube. Overall length is 11⅛". Traces are held within 1 degree of each other and deflection factor is held to within 10%. A low current gun is used.

Circle No. 229 on Subscriber Service Card.

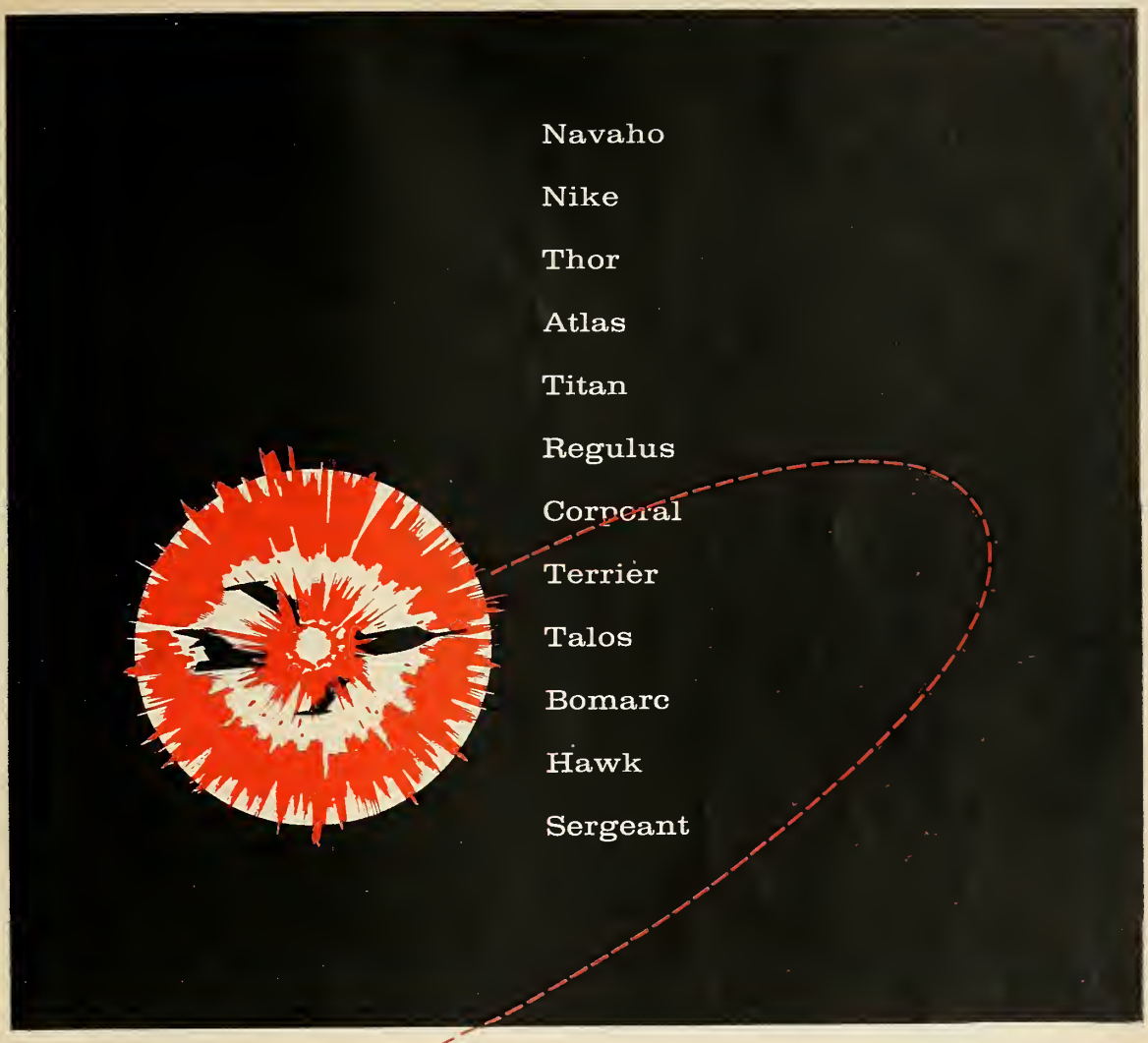
CYLINDERS

Two lines of cylinders, known as types AN and BN are being manufactured by the A. K. Allen Co. Both models feature a fork-type rear head for mounting, stainless steel rods, Nylined bearings, high tensile aluminum heads, honed brass or steel tubing treated for corrosion re-



sistance, and a choice of fixed or adjustable cushions for either end or both.

The bore sizes available are: ⅞", 1⅛", 1½", 2" 2½", 3" and 4". Type



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hydraulic systems for missile handling and launching . . .

Name an important missile. Chances are that Vickers equipment or "know-how" played a part in its success. Every one of the missiles listed above, for example, depends on Vickers hydraulic units for some phase of surface handling, launching or testing.

Latest development is a completely integrated hydraulic system that brings true automation to missile handling. At the push of a button, missiles automatically flow from storage rack to final firing position.

There are important reasons for Vickers' success in heavy ordnance work. Long experience in this specialized field is one. Another is the fact that Vickers has the most comprehensive line of hydraulic equipment.

Hydraulics itself has unique advantages. On a recent project, a 100-horsepower transmission offered the ideal solution because of: —

High torque to inertia ratio — the pump end can be stroked from zero to maximum displacement in less than 30 milliseconds.

High power gain — a milliwatt input easily controls hundreds of horsepower.

Very narrow deadband — narrower than any other high horsepower drive.

High horsepower to weight ratio.

For one source convenience and one source responsibility, bring all your hydraulic problems to Vickers.

VICKERS INCORPORATED
DIVISION OF SPERRY RAND CORPORATION

Marine and Ordnance Department
Waterbury 20, Conn.

BN cylinders use cups for the piston head seals instead of the O-ring packing used in type AN. Double packing for the rod gland is also provided on the Type B. All cylinders are available as double acting or single acting spring return.

Circle No. 256 on Subscriber Service Card.

FILTER AND BLOWER

Packaged blowers are available in several sizes to utilize minimum of panel height in electronic rack from McLean Engineering Laboratories. Filter and blower section was designed to protrude

in the normally unused base section of the rack since blower is normally the bottom component of a relay rack. Models 2P408 and 2Q408 require 5¼2 on panel height but have performance of models requiring more height. Unit will dissipate a 1.5 kw heat load with an air temperature rise of 10°C.

Circle No. 211 on Subscriber Service Card.

ULTRASONIC GENERATOR

Ultra-regulated low voltage dc power supply developed by Optimized Devices, Inc. utilizes an ultrasonic carrier sys-

tem to achieve optimum performance consistent with light weight, compactness, and efficiency. This supply, which can produce 0 to 7 v at up to 1.5 amperes, is said to be superior to batteries in almost all applications.

Typical uses are for strain gauges,

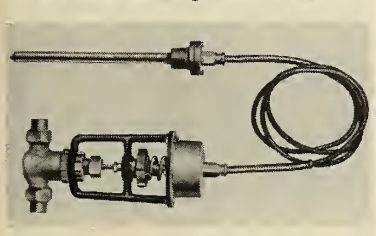
dc filaments, transistors, precision electroplating, bias supply, and for a precision laboratory reference even under load.

A number of feedback loops and corrective networks combine to keep the output voltage virtually independent of line and load fluctuations. Regulation is complete even down to O v. Negative voltage feedback is included for low drift, low noise, and low output impedance. Adjustable current feedback is included to reduce the output impedance to O ohms. The adjustment can also provide a negative resistance characteristic to compensate for lead length.

Circle No. 246 on Subscriber Service Card.

TEMPERATURE REGULATORS

Watts Regulator Co. has a new line of single seated temperature regulators for automatic flow regulation of liquids or



steam. These self-operating regulators are of two types—direct acting and reverse acting.

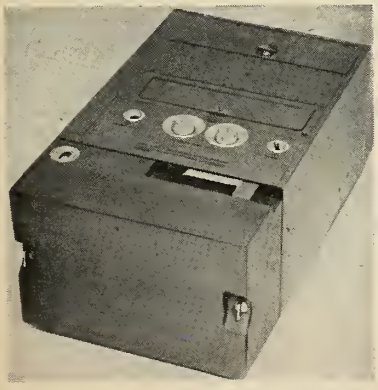
Direct acting regulators maintain the liquid temperature by controlling the heating source. They are available in sizes ½″ to 1½″ inclusive. Reverse acting regulators maintain the liquid temperature by controlling the cooling source. They are available in sizes ½″ to 1″.

Both types are easily adjustable for temperature control within 40°F operating range within 100°F and 240°F. They feature overheating protection and rugged bronze body construction with replaceable stainless steel seats.

Circle No. 235 on Subscriber Service Card.

HIGH-TEMPERATURE OSCILLOGRAPH

A new recording oscillograph developed for flight testing at high temperatures is now available from Consolidated



Electrodynamics Corp. The Type 5-112 is able to operate from —65°F to 250°F at altitudes to 120,000 feet.

The unit is explosion-proof and features a crash resistant magazine with

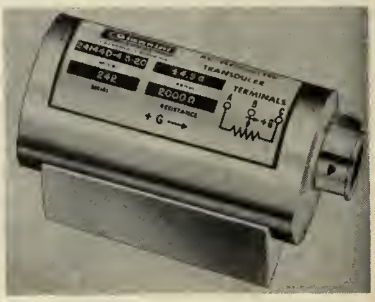
a safety shutter that automatically closes when the magazine is removed from the oscillograph.

Up to 26 channels can be recorded at writing speeds in excess of 12,000 inches per second. The unit occupies less than one cubic foot of space. Twelve discrete record speeds give a range of 0.047 to 96 inches per second. A jump-speed system allows the operator to pre-select jump speed ratios of 8:1, 4:1, or 2:1.

Circle No. 223 on Subscriber Service Card.

AXIAL ACCELEROMETER

A new line of axial accelerometers that feature extremely low cross-talk of



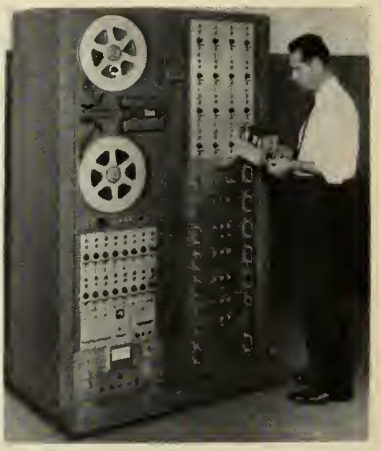
0.01g/g max. and low threshold has been developed by G. M. Giannini & Co., Inc. The units sense linear acceleration by a spring supported linear ballbushing mounted mass that moves along a shaft.

Output that is linear with acceleration is supplied by high resolution potentiometer pickoffs. Instruments are available with ranges of ±1g to ±40g with undamped natural frequencies from 7.8 to 54 cps.

Circle No. 227 on Subscriber Service Card.

MAGNETIC TAPE RECORDING

A bandwidth of 300 kc is featured in American Electronics Corp's new series 3000 multi-channel magnetic tape



recording system. Made by the Recordata Division of American Electronics, the system accommodates reel sizes to 14" and a single switch selects one of six standard speeds up to 60"/sec.

Module housings provide plug-in facilities for amplifiers and permit instant selection of direct FM or PDM recording or playback combinations.

Circle No. 224 on Subscriber Service Card.

TOP HAND

...on a test stand

Absolute tight shut-off reliability safety • long life

ANNICO SEAT SEAL

Absolute shut-off dependability and safety is assured with ANNICO TEFSEAL SEATS, proven in severe fuel, chemical and gas services at pressures to 10,000 psi.

ANNIN...*most widely used remote shut-off valves for control of liquid propellants*

ANNIN's ten years of experience in the design and development of valves for rocket and missile ground installations has resulted in a new valve concept which has been *proven-in-service* for remote, manual and throttling applications. ANNIN's complete line is now available for pressures to 10,000 psi and temperatures from –400°F to 1600°F. Write for catalog 1500-C containing data on ANNIN valve bodies, operators and special design features.

ANNIN *Control* **VALVES**

THE ANNIN COMPANY
DIVISION OF THE ANNIN CORPORATION
6570 Telegraph Road, Los Angeles 22, California

INDUSTRY SPOTLIGHT

By Norman L. Baker

Bell Aircraft Acquires Land for Research Center

BUFFALO—Bell Aircraft Corporation recently announced the acquisition of 350 acres of land near Pembroke on the New York State Thruway as a site for its new Lawrence D. Bell Research Center.

Two other significant developments were also revealed as part of Bell's program of consolidating its Niagara Frontier operations. They are:

1) Early completion of negotiations for a modern central warehouse on property purchased last year adjacent to the Wheatfield Plant.

2) Occupancy within 45 days of the new Electronic Data Processing Center now being finished at the Wheatfield Plant.

"With completion of the Research Center's first unit and occupancy of the new data Center, Bell Aircraft Corporation will own properties and equipment in the Niagara Frontier area valued at more than $34 million," President Leston Faneuf said.

"This does not include the new warehouse, which will be built by outside interests and leased back to Bell, nor the 12 government-owned or private properties now under lease to Bell," he continued.

"While we have been reducing our employment owing to changed Department of Defense requirements, we believe that construction of these new facilities, as well as other plans for the future, is concrete evidence of our corporate program to continue Bell Aircraft as a significant factor in the economic growth of the Niagara Frontier."

The site for the Research Center is located 1½ miles east of Pembroke on the Ontario section of the Thruway, near the junction of Routes 5 and 77 and was selected after several other sites had been investigated.

Initial expenditure for the research building will be $1 million. The first unit will be a hypersonic wind tunnel, capable of handling the highest speed ranges. This will be followed by a laboratory for heat studies and all services and facilities of the center will be available to other manufacturers.

Dr. Everett T. Welmers, formerly Bell's chief of dynamics, has been named director of the Research Center and is coordinating plans for the Center's design and construction, which will start this year.

A new $750,000 building will house the Electronic Data Processing Center, first occupancy to begin in August. The Data Center will handle all the computing in support of Bell's technical programs, including those of the Niagara Frontier Divisions, the Research Center and the Bell Helicopter Corporation in Fort Worth, Tex.

In addition to processing technical data, the facility will also maintain accounting records, provide manufacturing and financial records and a wide variety of other services and information for supervision and management. Eventually, it will also furnish similar data to Bell's wholly-owned subsidiaries.

The warehouse site is located north of the Wheatfield Plant on Walmore Rd. and adjoins Bell's railroad siding. The building will be approximately 250,000 square feet. Bell will occupy the facility on a lease-back arrangement. Construction is expected to be started within 60 days.

"The Data Center and the warehousing building are essential in our program of consolidation and cost savings," Faneuf explained.

"We have had computer operations in a number of departments and warehousing scattered in a number of locations throughout the Niagara Frontier. A centralized location for both functions will prove more efficient, more economical."

Aluminum Co. of America Develops New Impellers

Aluminum Company of America has developed "premium strength" high-speed aluminum impellers that have survived testing during which they were whirled at nearly three times the speed of sound.

The impellers, primarily intended for missile use, receive their high strength qualities through carefully controlled foundry practices and the fact that impurities are controlled to a new minimum, according to Alcoa officials. Iron content, for example is held to 0.2% in the improved alloys.

The alloy most used in the high-speed rotating parts is 355-T6—5% silicon, 1.3% copper, .5% magnesium, and the remainder aluminum and normal impurities. T6 designates solution heat treatment followed by artificial aging.

Alcoa has been spinning aluminum components for aircraft engine superchargers, propellers, jet engine turbines and torque converters since 1940, but the 2,000 mph speeds have not been common until recent development of the high-strength alloys.

During testing, parts are rotated in a "whirl pit" until they fly to pieces. Reassembled, the parts reveal valuable

information to test engineers.

"Non-destructive" testing is done by coating the part with a brittle, lacquer-like substance and whirling it at speeds just short of the destruction point. Cracks in the coating show high stress areas.

Some parts have been spun without rupturing at peripheral velocities of 3,000 ft./sec.

Among the applications of the high-strength alloys in missiles are important structural castings for Douglas

Impeller mounted on test arbor at Alcoa laboratory. Part will be spun until it flies to pieces in "whirl pit."

Aircraft Co. Alcoa's high-strength casting process and Alloy A356-T61 give them some of the highest properties ever cast, according to a company official. In one case maximum tensile and yield strengths are 47.1 and 36.9 psi, elongation is 9%.

Lockheed Builds Lab For Missile Antennas

Lockheed Aircraft Corp.'s Missile System Division is building a facility for the design and testing of advanced missile antennas and radar devices.

Electronics experts and the division's antenna propagation department will be housed in the 10,000-sq.-ft. building at Sunnyvale, Calif. The site is located about a mile from present buildings at the division to minimize interference and improve accuracy of measurement in the study of radiation and propagation phenomena of electromagnetic waves.

Electronics Specialties Sales up 50% in '57

Electronics Specialties Co. sales this year are about 50% ahead of a year ago, according to William H. Burgess, president. Shipments for April and May ran above $400,000 monthly and the backlog is over $3 million.

ROCKET POWER PROGRESS REPORT

Atomic Radiation for Rocket Testing

by Alfred Cohen

Assistant Project Engineer in the Instrumentation Section of the RMI Test Department, Mr. Cohen is investigating new concepts for acquiring, reducing and evaluating test data. After graduating in mechanical engineering from City College of New York, he worked as a civilian test engineer for the Navy. Mr. Cohen came to Reaction Motors in 1954 as a Test Department Instrumentation Engineer.

Although the rocket engine in theory is an extremely simple powerplant, its development is a highly critical art. Successful operation of an engine depends upon the solution of many unique problems and the accurate measurement of unusual variables. One of the problems we encountered at RMI was the measurement of the corrosive effects of a new high energy rocket propellant, a problem we solved through the use of atomic radiation.

In determining the corrosive effects of propellants, it is essential that the sensing element employed does not come into direct contact with the propellant being tested. The propellant would rapidly damage or destroy most measuring equipment. In addition, the tolerance of the tests does not permit additional contamination from other foreign bodies.

We approached the problem on the basis that the density variation of the propellant could be the measure of its degree of corrosion upon the component materials with which it had been in contact . . . and the denser the material being tested, the less radiation would pass through it. We decided, therefore, to use the penetrating power of radiation as the tool to measure density variation.

To conduct the tests, a radioactive source and a detector for radiation were located so that the propellant being measured lay in a container between the two. The radioactive source emits gamma rays which penetrate through the propellant and its container. That part of the radiation that gets through the propellant and its container strikes the detector.

The detector contains a filling gas which is forcibly ionized when bombarded by atomic radiation. The energy of ionization is converted directly into electrical energy. Thus, an increase in the density of the propellant reduces the radiation field intensity at the detector, and results in a decreased generated signal.

However, accurate measurement of this energy is difficult because the generated signal is very low (in the magnitude of 1×10^{-13} amperes). To overcome this, an instrumentation system was specially developed to transmit, amplify and record this data.

The signal is transmitted to the amplifier by a special shielded cable that eliminates the effects of noise and other disturbances. Data is recorded by a Null system of measurement, using a ten-inch strip chart recorder. The recorder is calibrated to give full deflection for a density change equivalent to one tenth of a pound per cubic foot.

As a result of the data acquired by this test program, the research scientists have been able to improve the propellants to a point where they are both safe and highy desirable for use as rocket fuels.

This project is typical of one of the ways in which RMI Test Department supports the applied research, development and production projects associated with advanced rocket powerplants. All projects pass through this department, from the evaluation of components and fuels to the static "hot testing" of the entire engine system for an aircraft or missile before delivery.

The Test Department is staffed by a team of specialists highly qualified in mechanics, electronics, chemistry, and instrumentation. This team is constantly working to provide the most accurate possible test results and also to develop new equipment and methods that will allow for even more accurate information in the future. And—because this team is constantly expanding—we are always anxious to talk with top-rated engineers and technicians who are interested in test work.

4986

If you desire one or more reprints of Mr. Cohen's article, or would like to receive further information about employment at RMI, write to our Information Services Coordinator. Reaction Motors, Inc., 16 Ford Road, Denville, N. J.

Power for Progress

THE BIRD
THAT'S ATTRACTED TO STRANGERS

Audubon never observed it—this new species that won't tolerate intruders in the sky, tracks them down, destroys them.

Raytheon has pioneered in the development of electronic missile guidance systems for more than a decade. A technical milestone was reached when the Navy's experimental Lark, equipped with a Raytheon guidance system, achieved history's first destruction of an aircraft by a guided missile.

Today Raytheon, alone among electronics companies, is prime contractor for two missiles of advanced design: the air-to-air Sparrow III for the Navy, the ground-to-air Hawk for the Army. Here, once again, Raytheon's "Excellence in Electronics" is contributing to the security of the nation.

RAYTHEON

RAYTHEON MANUFACTURING COMPAN
Waltham 54, Massachusetts

RADIO, TV & MICROWAVE TUBES—TRANSISTORS—MILITARY & COMMERCIAL EQUIPM

West Coast Industry

By Fred S. Hunter

Scope of the Marquardt Aircraft Co. facilities at Ogden. Utah. where it will produce the ramjet engines for the Boeing *Bomarc* missile for the Air Force, is illustrated by fact that the total investment may reach $30 million within five years. Cost of constructing and equipping the production plant on a 66-acre tract adjacent to the Ogden Municipal Airport—shared 50-50 by Marquardt and the Air Force—will come to $10 million.

The Air Force is footing the $13.5 million bill for the test facility on a 2100-acre site at Little Mountain. Marquardt hopes this test facility will be completed by 1959. Until then it will ship Ogden-produced engines to California to be tested at its Van Nuys facility. Marquardt employment in Ogden will reach 500 to 600 by the end of this year. Ultimately Utah employment is expected to total about 3000.

•

Instead of television, North American Aviation uses ejectable, recoverable, missile-borne film cameras for color motion picture coverage of the XSM-64 in Florida. NAA's Missile Development Division designed a six-camera system to provide a variety of engineering data and documentary coverage from "on board" for the Air Force. Two of these camera packages were devised to be ejected during flight and parachuted into the sea on completion of their photographic job. They are recovered through a radio signal transmitted by each floating unit and detectable by an airplane at a distance of about 35 miles. Direction also is indicated.

A "T-boat" receives directions from the airplane to guide it into the area where its own radio receiver can locate the units at a range of about 1½ miles. Location is further aided by use of a visible dye marker solution on the surface of the water.

•

Lockheed's Missile Systems Division is using a power brake—ordinarily used to bend heavy metal—to chop out tapered and twisted 10-inch aluminum spacers. They are achieving greater uniformity than by the hand method. Two dies are used is the process. The brake can be adjusted to produce spacers with a twist ranging from 17 to 22 degrees. The new process does in four hours what had previously taken 80 hours, and does it more precisely.

•

Apprenticeship program being started by Hughes Aircraft Co.'s Tucson plant this summer is aimed at turning out 32 trained machinists, 25 electronic technicians and 10 tool-and-die makers during first four years. Program is jointly administered by Hughes and the International Association of Machinists.

•

Delays in ground equipment caused postponement of the test firing of the *Atlas* . . . Researchers are showing more and more concern over the low level of support being given to basic research in comparison to the large amounts of money being poured into applied and developmental work . . . Convair Cove is the name given to the new 52-acre housing project for Convair technical personnel at Cocoa Beach, Fla.

Grand Central Makes Major Reorganization

Grand Central Rocket Co. has announced a major shifting in its project management organization. Willem Schaafsma, formerly director of engineering, is director of projects with a staff of five project managers. They are Angus Scott, D. H. Eccles, Rod Andrus, Wilbur Hartzell and Harold Bartel.

Scott is Schaafsma's assistant. Hartzell is senior engineer on the third stage of project *Vanguard.*

Republic to Study High-Temp Hydraulics

Republic Aviation Corp. has been awarded an Air Force contract for the study and design of a 1,000°F hydraulic system.

The contract includes mock-up of the system and associated components such as seals, pumps, material filters, electro-hydraulic valves, tube fittings, electrical wiring and test equipment. Republic also will study and develop high-temperature hydraulic fluids for this system.

ACF Forms Division For Advanced Products

ACF Industries, Inc., has formed a new Advanced Products Division which will specialize in pressed-metal items, special weldments, aircraft and missile components and other products. Division will contain personnel and facilities at ACF's St. Charles, Mo., and Milton, Pa.

Lockheed Gets X-7 Contract Extension

Lockheed Aircraft Corp. has received a $14.5 million Air Force contract for continuation of its X-7 ramjet engine test vehicle project. The new contract will extend the program into mid-1958.

The X-7 is used to check ramjets in supersonic runs at Holloman Air Development Center, N. Mex.

Westinghouse to Design, Build *Polaris* Systems

Westinghouse Electric Corp. will design and manufacture experimental seagoing handling and launching systems for Navy's *Polaris* ballistic missiles. Work will be done at the Sunnyvale, Calif., plant.

Program will involve a series of experimental systems leading ulti-

mately to a submarine launching for *Polaris*. Contract is with Bureau of Ordnance.

Richard N. Parkin, manager of the long-term missile launching and handling project at Sunnyvale and company coordinator, has recruited a staff of engineers and supporting technicians to work in a restricted area at the plant site.

Bristol Opens Three Branch Facilities

The Bristol Co. has recently opened two new branch factories and repair laboratories and relocated its Pittsburgh, Pa., district office.

Branches opened are at Houston and Los Angeles. The Pittsburgh office has moved to 2250 Noblestown Road and a new building housing sales and service staffs for industrial instruments for recording, controlling, and telemetering, electronic components, and pressure actuated aircraft devices.

Overtime Cut Reduces Ryan Payroll

Ryan Aeronautical Co. estimates payroll reduction resulting from the Department of Defense directive cutting out overtime will be about $120,000 a month.

The figure is based on an average four-week period of overtime work on the KC-135 and *Firebee* projects.

Sperry Rand Builds Florida Facility

Sperry Rand Corp. is building a $2 million facility at Clearwater, Fla., for development of advanced radar instrumentation. First building to go up will be a 75,000-sq.-ft. laboratory for Sperry's newly organized Electronics Division. Operations are scheduled to begin late this year.

Gyroscope Assembled Under Microscope

Microscope aids technicians at AC Spark Plug Division of General Motors assemble parts of a gyroscope for use in missiles. Work is done under plastic shields in special air-conditioned rooms to make certain gyro is free of dust.

Chance Vought Files Debenture Issue

Chance Vought Aircraft, Inc., has filed a Security and Exchange Commission registration statement covering proposed issue of $12.5 million of convertible subordinated debentures. This

marks the first public financing of the firm since it became independent of United Aircraft in 1954.

Funds will be used to reduce bank loans incurred to finance increased inventories and accounts receivable. Debentures will be convertible into common stock through July 1, 1967. Harriman & Ripley & Co. heads the underwriting group.

Litton Sales up 90% For 1st Nine Months

Litton Industries realized sales of $20,372,000 for the first nine months of the current fiscal year, a 90% increase or the comparable period last year, according to Charles B. Thornton, president.

Profits of $1,154,236 for the period which ended April 30, were an 85% increase over last year. Earnings per share were $1.10 on the $1,-154,236 outstanding. Backlog April 30 was $44 million, a new high.

DFI Completes Test Program for *Redstone*

Designers for Industry, Inc., has completed four pieces of testing equipment for the *Redstone* rocket missile under sub-contract to the Chrysler Corp. Equipment tests guidance mechanism and other components of missile during production and just prior to launching, DFI officials said.

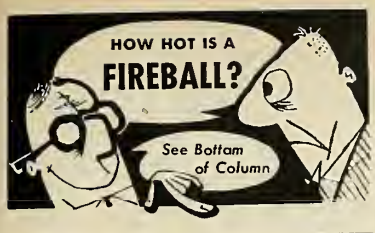
NAA Gets Subcontract For *Titan* Equipment

North American Aviation's Los Angeles Division has received a subcontract from The Martin Co. to build ground equipment for the *Titan* missile, Work will begin immediately on the transtainer units used to transport the big missile on the ground.

Oregon Firm Casting Titanium, Zirconium

Oregon Metallurgical Corp. is producing titanium and zirconium castings in a 100-lb. capacity consumable electrode furnace.

Since the metals in the liquid state react with every known element except



argon and helium, the mold itself must be contained in the melting furnace. Water cooled copper and graphite molds have been successfully used and castings of 125,000 psi tensile strength produced.

Castings will soon be available in pure titanium, zirconium or alloyed with aluminum, vanadium, tin, chromium, manganese, molybdenum and other alloys.

Coleman Increases Board Membership

Coleman Engineering Co. Board of Directors has been increased from seven to nine members. New seats are filled by E. A. Gardner, vice president and general manager of the company, and James Beattie, president of Photographic Products, Inc., Anaheim, Calif., a Coleman subsidiary.

ARDC Lets $81,000 Contract For Plan

Air Research and Development Command has awarded a contract to Porter, Urquhart, McCreary and O'Brien of Los Angeles to prepare a master plan for its missile training center at Camp Cooke, Calif.

industry briefs

BARNEY CONTROLS INC. will integrate marketing activities of all divisions and product lines into a new marketing department headed by Edward A. Johnson as vice president for marketing.

OLIN MATHIESON CHEMICAL CORP., Aluminum Division has opened its first Olin Aluminum office in the U. S. at Atlanta. Office will be used as sales headquarters for Southern states.

AMERICAN ELECTRONICS, INC., American Laboratories Division, has broken ground for a new environmental test laboratory at Fullerton, Calif. Completion is slated for August.

DARCO INDUSTRIES, INC., has acquired controlling interest in the Demo-Haines Tool Corp. Darco will produce 9½-lb. Demo electric hammer at El Segundo. Company is designer and manufacturer of aircraft and missiles parts and equipment.

BELOCK INSTRUMENT CORP. has broken ground for its Engineering Center at College Point, Queens, N. Y. R&D center will contain 30,000 sq. ft. for engineering facilities.

WALDALE RESEARCH CO., INC., has moved from Las Vegas to El Monte, Calif. Firm is manufacturing electric and high temperature strain measuring devices.

INDUCTION MOTORS CORP. reports consolidated net sales of $2,489,945 for 1956. Figure includes six months operations of the company's new PSP Engineering Division. Net income for year was $127,364 on 141,179 shares outstanding.

MARQUARDT AIRCRAFT CO., authorized a 2-for-1 stock split by payment of a 100% stock dividend July 1.

NORTH AMERICAN AVIATION'S Autonetics Division has set up an eastern Branch office in Washington, D. C. at Cafritz Bldg., 1625 I St. N.W. under Norman P. Hays, manager.

MARQUARDT AIRCRAFT CO. reports net earnings of $605,236 in 1956, an increase of 80% over 1955. Sales reached an all-time high of $23,110,441, up 104% over previous year. Backlog on February 24 stood at $55 million, including a number of USAF contracts for production of ramjet engines for Boeing *Bomarcs*.

ATLANTIC RESEARCH CORP. of Alexandria, Va. has acquired U.S. Flare Corp. & Associates of Pacoima and Saugus, Calif. and will operate latter under the same name as an affiliate. USF specializes in rocket ignition systems, missile tracking equipment, pyrotechnics and high-explosive ordnance items. Acquisition gives the combined organization a current annual volume exceeding $4 million and a staff of 325.

TRANSFER by North American Aviation of its missile test facility operations from Patrick AFB to Cape Canaveral Industries Area has been completed.

THE SIEGLER CORP., Electronics Division, has been awarded a rapid tax write-for missile systems facilities in the amount of $130,000 at 40% allowance.

SYLVANIA ELECTRIC PRODUCTS, INC. has started construction of a multi-million dollar, 100,000 sq. ft. R&D facility at Amherst, N. Y. for its Electronic Systems Division. Target for completion is February 1958.

METALS & CONTROLS CORP., will open a west coast design engineering facility this month. William Jones will head the Los Angeles laboratory and office staff as project engineer.

missile literature

WIRE SAMPLE CARD. Samples of high temperature insulations are offered on pocket-size sample cards. Typical samples are Teflon, silicone insulated magnet wires, lead wires, sleeving, tubing, shielded and jacketed cables. American Super-Temperature Wires, Inc.

Circle No. 100 on Subscriber Service Card.

DECIMAL-BINARY TABLES. Series of tables simplify conversion from decimal to binary numbers, or vice versa. Tables are compact, instructions concise. Measure 3½" x 8½". Barnes Engineering Co.

Circle No. 101 on Subscriber Service Card.

WAVEGUIDE PRESSURE WINDOWS. Brochure describes waveguide pressure windows, gives uses. Performance curves, outline dimensions, drawings, complete data given. Microwave Associates, Inc.

Circle No. 102 on Subscriber Service Card.

INSTRUMENT TRANSLATOR. Bulletin describes instrument translator which operates from ac or dc power source, integrates ac or dc sensors with ac or dc control mechanisms. Crescent Engineering & Research Co.

Circle No. 103 on Subscriber Service Card.

POWER RECTIFIERS. Set of 4 data sheets gives engineering information on full wave silicon rectifiers including electrical ratings, characteristic curves and dimensions. Sarkes Tarzien, Inc.

Circle No. 104 on Subscriber Service Card.

EPOXY ADHESIVES. Chart gives properties and other material information on epoxy adhesives for use in tooling, electrical, assembly and manufacturing of missiles. Furane Plastics, Inc.

Circle No. 105 on Subscriber Service Card.

TRIGULATOR. Illustrated 12-page brochure gives details on instrument which is said to save 90% of time spent in many mathematical problems. Complete data, sample problems given. Fitch Instruments, Inc.

Circle No. 106 on Subscriber Service Card.

MAGSLIPS. 60-page book gives designers all they need to know about magslips and synchros. Illustrated with photos, graphs, and circuit diagrams. History and development of magslips presented, has comprehensive subject index. Muirhead Instruments, Inc.

Circle No. 107 on Subscriber Service Card.

HAZARD FINDER. Safety check list in 8-page illustrated folder is guide to evaluation of hazard potential in plant or laboratory where flammable gases, vapors, dusts, liquids and other materials are handled. Crouse Hinds Co.

Circle No. 108 on Subscriber Service Card.

PHASE VOLTAGE CONVERTER. Data sheet gives all details of a rotating phase voltage converter suitable for testing sound track equipment. Kato Engineering Co.

Circle No. 109 on Subscriber Service Card.

SELF LOCKING NUTS. 36-page illustrated brochure gives weight, size temperature and material for miniaturized self-locking nuts for use in electronic units and missile equipment. Elastic Stop Nut Corp. of America.

Circle No. 110 on Subscriber Service Card.

TIMING MOTORS. Bulletin sheet contains details on three basic dc timing motors along with detailed explanation of construction and operation. A. W. Haydon Co.

Circle No. 111 on Subscriber Service Card.

SOLENOIDS. Basic types of solenoids for aircraft and missile applications contained in 4-page catalog. Tables provide data for both continuous and intermittent duty. Complete specifications of five types given. W. L. McMichael, Inc.

Circle No. 112 on Subscriber Service Card.

CORROSION TESTER. Illustrated 16-page brochure describes system for determining rates of corrosion. Instrument is available in two models for line or battery power sources. Labline, Inc.

Circle No. 113 on Subscriber Service Card.

FLEXIBLE HOSE. 8-page booklet describes flexible hose and ducts for variety of uses. Illustrations, data tables, applications, advantages listed. Flexaust Co.

Circle No. 118 on Subscriber Service Card.

Advertisers Index

Aerojet-General Corp.
Sub. General Tire & Rubber Co. 104
Aeronautical Machinists, Inc. 56
Aeronutronic Systems, Inc. 190
Aero Research Instrument Co., Inc. 188
Garrett Corp., The
AiResearch Mfg. Co. 72
American Cystoscope Makers, Inc. 186
American Machine & Foundry Co. 165
American Potash & Chemical Corp. 50
Ampex Corp. 85
Annin Co., The 201
Applied Science Corp. of Princeton 122
Aro Equipment Corp., The 55
Aro, Inc. 60
Austenal, Inc. 7
Avco Mfg. Corp.
Crosley Div. 174
B & H Instrument Co., Inc. 184
Morris Bean & Co. 192
Bell Aircraft Corp. 5
Bernco Engineering Corp. 52
Boeing Airplane Co. 61
Bristol Co., The
Aircraft Components Div. 211
British Industries Corp. 51
Brooks & Perkins, Inc. 66
Brush Beryllium Co., The 196
Brush Electronics Co. 32 & 33
Burroughs Corp. 15
Cambridge Corp. 35 to 40
Cannon Electric Co. 49
Century Electronics & Instruments, Inc. 185
Chrysler Corp. 191
Sigmond Cohn Corp. 65
Columbia Research Laboratories 210
Consolidated Electrodynamics Corp. 22 & 23, 186
Control Products, Inc. 182
CONVAIR,
A Div. of General Dynamics Corp. 214
Astronautics Div. 54
Frank R. Cook Co. 210
Cooper Development Corp. 4
Craig Systems, Inc. 200
Curtiss-Wright Corp. 29
Dalmo Victor Co. 194
Diversey Engineering Co. 10
Douglas Aircraft Co., Inc. 82
Dow Chemical Co., The 8
Eastern Industries, Inc. 213
Eckel Corp. 56
Eckel Valve Co. 21
Thos. A. Edison Industries, Inc.,
Instrument Div. 26, 88
Electrical Engrg. & Mfg. Corp. 62
Electrofilm Inc. 188
Electro-Mechanical Products 112
Electro-Snap Switch & Mfg. Co. 166
Fairchild Engine & Airplane Corp.,
Stratos Div. 169
J. W. Fecker, Inc. 199
Finn Aeronautical Div.,
T. R. Finn & Co., Inc. 195
Firestone Tire & Rubber Co., The,
Guided Missile Div. 80
Flexonics Corp. 108
Fluorocarbon Co., Inc. 210
Ford Instrument Co.,
Div.-Sperry Rand Corp. 12
Genisco, Inc. 113
Hallamore Electronics Co. 45
Harman Equipment Company 183
Hartwell Aviation Supply Co. 28
Harvey Aluminum 13
Haskel Engrg. & Supply Co. 167
A. W. Haydon Co., The 65
Hi-Shear Rivet Tool Co., The 6
Hoffman Semiconductor,
Div. Hoffman Electronics Corp. 25
Hofman Laboratories, Inc. 47
Johns Hopkins University Applied Physics Laboratory 21
Hunter Mfg. Co. 27
Ideal Chemical Products, Inc. 57
International Electronic Research Corp. 181
Jack & Heintz, Inc. 103
Janitrol Aircraft-Automotive Div.,
Surface Combustion Corp. 53
Jet Propulsion Laboratory,
A Div. of California Institute of Technology 120
Kato Engineering Co. 210
M. W. Kellogg Co., The 95
Kennametal, Inc. 205
Walter Kidde & Co., Inc.,
Aviation Div. 107
Lear, Inc. 19
Lenox Instrument Co. 183
Lockheed Aircraft Corp.,
Missile Systems Div. 14
Marman Div.,
Aeroquip Corp. 34
Marquardt Aircraft Co. 71
McDonnell Aircraft Corp. 70
Mepco, Inc. 51
Millrich Engrg. Corp. 47
Minneapolis-Honeywell Regulator Co.
Boston Division 99
M-H Division 187
Ordnance Division 24
Moog Valve Co., Inc. 43
Narmco Resins & Coatings Co. 58
North American Aviation
Rocketdyne Div. 67
Northrop Aircraft, Inc. 59
Ordnance Associates, Inc. 202
Pacific Automation Products, Inc. 64
Pacific Optical Corp. 48
Phillips Petroleum Co.,
Rocket Fuel Div. 18
Pyle-National Co., The 176
Raytheon Mfg. Co. 204
Reaction Motors, Inc. 203
Reynolds Metals Co.,
Industrial Parts Div. 193
Rheem Mfg. Co.
Electronics Div. 30
Douglas Roesch, Inc. 31
Rome Cable Corp. 79
Saginaw Steering Gear Div.
General Motors Corp. 189
Sanborn Co.,
Industrial Div. 110
Solar Aircraft Co. 116
Sperry Gyroscope Co.,
Div. Sperry Rand Corp. 42
Statham Laboratories 68
Sun Electric Corp. 3
Telechrome, Inc. 96
Teleflex, Inc. 46
Thompson Products, Inc.,
Jet Div. 177 to 180
U.S. Time Corp. 117
Utica Drop Forge & Tool Corp.,
Div. Kelsey Hayes Co. 100
Vickers Inc. 20
Vickers Inc.
Marine & Ordnance Dept. 197
Welsbach Corp. 198
Western Gear Corp. 9
E. B. Wiggins Oil Tool Co., Inc. 2
Franklin C. Wolfe Co. 16

EMPLOYMENT SECTION

Applied Science Corp. of Princeton 209
ARMA Div. American Bosch Arma 209
Bendix Aviation Corp.,
Guided Missile Div. 208
Minneapolis-Honeywell Reg. Co.,
Aeronautical Div. 206
Pesco Products Div.,
Borg-Warner Corp. 207
Telecomputing Corp. 207

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51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75
76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99

• Missile Literature
100 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121 122 123 124 125

• New Missile Products
200 201 202 203 204 205 206 207 208 209 210 211 212 213 214 215 216 217 218 219 220 221 222 223 224
225 226 227 228 229 230 231 232 233 234 235 236 237 238 239 240 241 242 243 244 245 246 247 248 249 250
251 252 253 254 255 256 257 258 259 260 261 262 263 264 265 266 267 268 269 270 271 272 273 274 275
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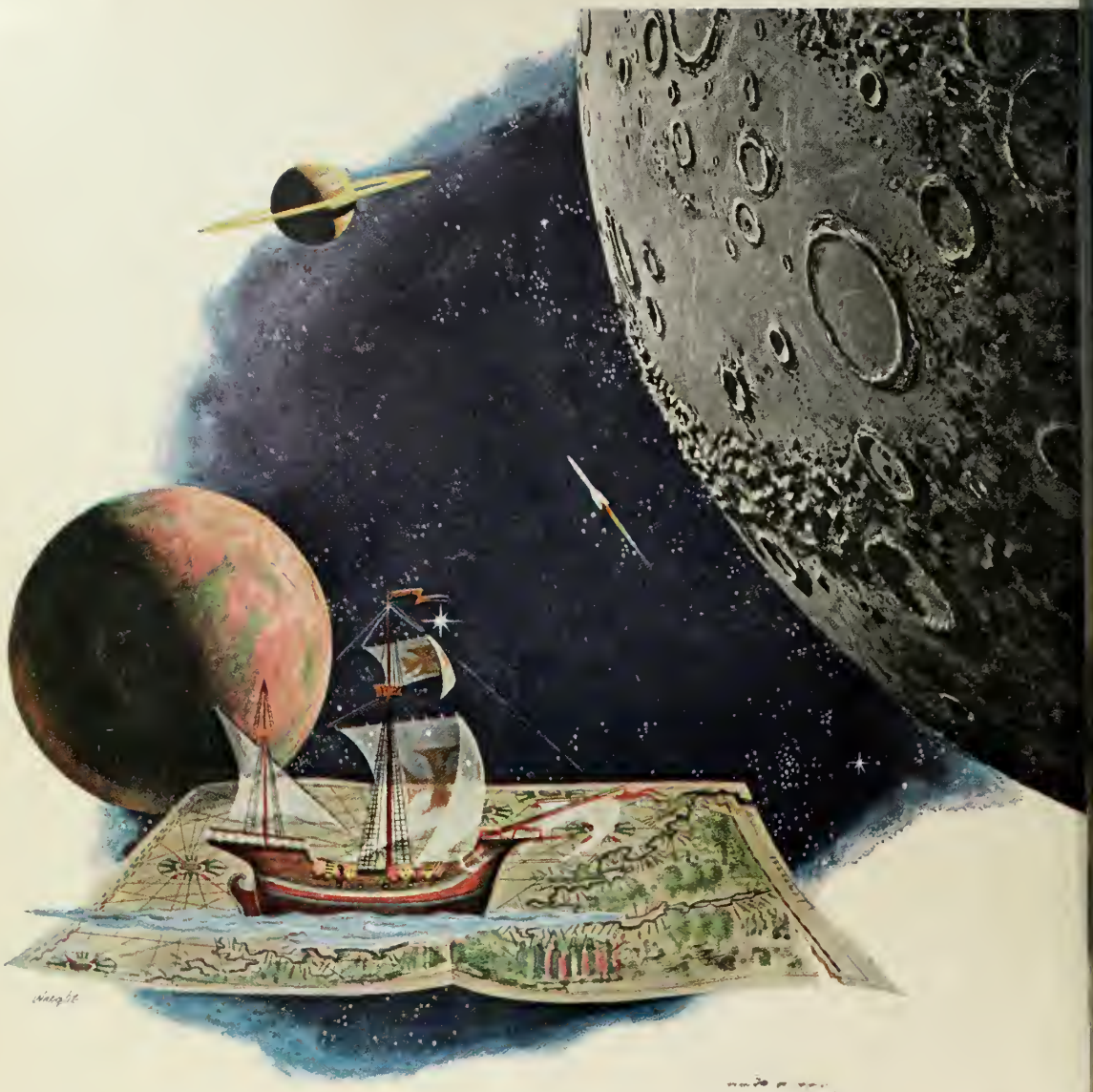

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