m/r MAY, 1957

missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS

AN AMERICAN AVIATION PUBLICATION

In This Issue:

MODERN TORPEDOES AND UNDERWATER MISSILES

engineers agree

Not on cigarette brands—
nor the shape of tomorrow's
rocket—but every day,
throughout the industry,
Engineers agree
on Wiggins Connectors.

Wiggins

The authority on connectors
Engineered for Reliability.

E. B. Wiggins Oil Tool Company, Inc.
3424 East Olympic Blvd., Los Angeles 23, Calif.

missiles and rockets

Magazine of World Astronautics

May, 1957 Volume II, No. 5

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

Subscription Rates:

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

Single copies $ .75

Subscription Service: All subscription orders, correspondence, and change of address should be sent to:
Geneva C. Kinnaird
Circulation Fulfillment Manager
Missiles and Rockets
1001 Vermont Avenue, N.W.
Washington 5, D.C.

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

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

REGIONAL OFFICES:

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

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

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

Cleveland: 1046 Hanna Bldg., 1422 Euclid Ave., Cleveland, Ohio. PRospect 1-2420. Douglas H. Boynton, regional advertising manager.

Dallas: 8924 Greenville Avenue, Dallas 6, Texas. Phone: EMerson 1-4507. Richard A. Worthington, regional advertising manager.

Detroit: 201 Stephenson Bldg., Detroit 2, Mich. Phone: TRinity 5-2555. Kenneth J. Wells, regional advertising manager.

Canada: Allin Associates, 12 Richmond Street, East, Toronto, Ontario. Phone: Empire 4-2001. Allin Associates, 1487 Mountain St., Suite 4, Montreal, Quebec.

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

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

Other American Aviation Publications:
American Aviation Magazine
American Aviation Daily
Official Airline Guide
(North American, World-Wide Editions)
World-Wide Aviation Directory
Who's Who in World Aviation
Air Traffic News
Airports
Aircraft Year Book
Aviation Facts and figures

PUBLISHING CORPORATION: Wayne W. Parrish, president; Leonard A. Eiserer, executive vice president and secretary-treasurer; William H. Pearson, vice president and director of advertising; Albert H. Stackpole, Eric Bramley, Robert H. Wood, Fred S. Hunter and Robert R. Parrish, vice presidents; Louis C. James, ass't secretary-treasurer.

WE START WITH PLASTIC SHEETS, END WITH STRATO DATA ANALYSIS

uilding the polyethylene balloon, s shown here, is part of General Iills balloon systems service. The full package" service, typical of ur thoroughness in other areas of ctivity, includes: design of vehicle nd instrumentation, manufacture nd flight planning—including ieteorological services, flight operations, telemetering, tracking and covery, and finally, analysis of llected data.

Manned strato-balloon flights probe the mysteries of space

This is the Navy Project Strato-Lab balloon that set a new altitude record in a recent ascent at Rapid City, S. D. The fact that Commanders M. D. Ross and M. L. Lewis rose to 76,000 feet, the highest man has flown in a balloon, was incidental. Of far more importance was their demonstration that a light, comparatively inexpensive polyethylene balloon, with a gondola carrying its own atmosphere, is a feasible means of carrying human observers above the present ceiling of sustained powered flight. Manned flights to altitudes of 100,000 feet or more are possible today.

Man has flown higher in a rocket plane, but only for seconds at a time. General Mills strato-balloons can remain at controlled altitudes for days if required. (Thus, "passengers" have time to make detailed observations.) They can also be used as launching stations to give rockets a "head start" into space.

Upper-air research is one of many areas being pioneered at General Mills. Possibly you can profit from our experience in this field—or from our research, development and production of electro-mechanical sub-systems and major assemblies for weapons defense, guidance and controls, and weapons testing. Send today for booklet with all the facts.

MECHANICAL DIVISION

General Mills

Minneapolis 13, Minnesota

REATIVE RESEARCH AND DEVELOPMENT + PRECISION ENGINEERING AND PRODUCTION

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.

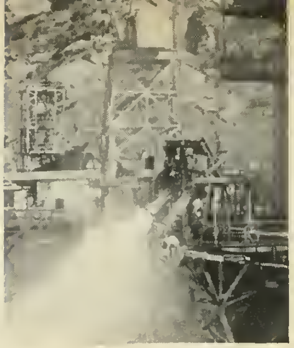
ANNIN... *most widely used remote shut-off valves for control of liquid propellants*

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

Circle No. 1 on Subscriber Service Card.



performance test

Brush Recording Systems at Rocketdyne, a Division of North American Aviation, Inc., directly record stress, acceleration, and acoustic values of rocket engines under test.

In all types of applications...

45,000 CHANNELS OF BRUS OSCILLOGRAPHS IN SERVICE

When selecting recording instrumentation for either military or industrial research and development, you want equipment that is proved by experience. Remember—there are more channels of Brush direct-writing oscillographs in use than all other makes combined.

This equipment offers the widest range of recording speeds available, to provide excellent readability for a wide range of signals. You have a choice of ink writing or electric writing, available in console, rack mounted or portable units.

The direct-writing frequency range, from d.c. to 100 cycles per second, covers the great majority of requirements for measurement of physical phenomena. Thus you can instantaneously record stress, strain, vibration, torque, force, and many electrical variables. Select *BRUSH* for equipment backed by unmatched experience.

complete frequency spectrum analysis for noise tests

With a Brush-Bruel & Kjaer Spectrum Recorder, a complete frequency spectrum analysis can be performed in a matter of seconds. This instrumentation operates *automatically*—thus saves hours of engineering time. And it presents recorded data in one-third octave steps—a form in which information is most meaningful and useful to noise reduction programs.

Shown at left is an aircraft test setup measuring loss in acoustic transmission through fuselage wall panels. This is one of scores of complete systems for sound, noise, or vibration analysis using Brush-Bruel & Kjaer equipment.

Templates make the *difference!*

The template you see above is being carefully shaped from blueprints by a Diversey master craftsman. When placed in position on a giant lathe a slender Follower will trace along the outline of the template, controlling a cutting tool which contour machines the turning component.

Many templates are needed for most missile hardware components. The new tracer techniques and precision templates of Diversey Engineering make new missile engineering designs feasible, which were thought impossible several years ago.

At Diversey Engineering you have the largest facilities exclusively devoted to your Guided Missile and Rocket Hardware problems. Contact us on your precision jobs.

SEND FOR THIS FREE BOOKLET

LEADERS IN CONTOUR MACHINING

Diversey ENGINEERING COMPANY

10257 FRANKLIN AVENUE • GLADSTONE 5-4737
FRANKLIN PARK, ILLINOIS • *A Suburb of Chicago*

FROM NOSE TO NOZZLE, FROM FIN TO FIN, CONTOUR TURNED PARTS—WITH PRECISION BUILT IN

missiles and rockets

Magazine of World Astronautics

WAYNE W. PARRISH, *Editor and Publisher*

ROBERT H. WOOD, *Editorial Director*

ERIK BERGAUST, *Managing Editor*

SEABROOK HULL, *Assistant Editor*

• •

Department Editors:

AERONAUTICAL ENGINEERING: William Beller
PROPULSION ENGINEERING: Alfred J. Zaehringer
ASTRONAUTICS: Hayward E. Canney, Frederick I. Ordway III
ELECTRONICS: Henry P. Steier
INTERNATIONAL, ASTRONAUTICS: Frederick C. Durant III
INTERNATIONAL, MISSILES: Anthony Vandyk
INDUSTRIAL: Joseph S. Murphy
MANUFACTURING: Fred S. Hunter

COPY EDITOR: Erica Cromley
ART DIRECTOR: William H. Martin
PRODUCTION MANAGER: John Walen
RESEARCH DIRECTOR: A. J. Newfield

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

LEONARD EISERER, *General Manager*

WILLIAM H. PEARSON, *Director of Advertising*

EDWARD D. MUHLFELD, *Asst. Director of Advertising*

LARRY BRETTNER, *Circulation Director*

ELSIE GRAY, *Advertising Service Manager*

Publishing Information: Published every month by American Aviation Publications, Inc., Washington, D.C. Printed at The Telegraph Press, Harrisburg, Pa. Second class mail privileges authorized at Washington, D.C., with additional entry at Harrisburg, Pennsylvania.

Another Industrial Challenge

After having been convinced by Rear Admiral Rawson Bennett that the torpedo was the first truly guided missile, our managing editor recently decided to look into the possibility of publishing articles on underwater warfare.

It soon became apparent, however, that today's torpedo and underwater missile systems embrace a whole new technological and strategic undersea warfare concept and that the advances to date called not for just an article or two, but an entire issue devoted to the subject.

This eye-opener of an issue, which was made possible through the kind cooperation of the Navy, of its Bureau of Ordnance and their efficient officers and civilians of the Office of Public Information and Security Review, clearly shows the importance of a continued and meticulous effort on the part of our Navy and industry's missile men to maintain a number one position in this field.

The reason for this is the Russian submarine threat. Naturally, Russia's answer to our overseas SAC bases is a vast missile-launching submarine fleet in addition to their long-range bombers. It is gratifying that our own Navy is aware of this, and that underwater early warning systems and sophisticated torpedoes and anti-submarine weapons are being studied and perfected.

When only ten years ago one would dare to suggest such a thing as launching a rocket from deep under the sea, even the most respected military strategists and engineers would brush the thought off with a condescending smile. Today, as this issue of m/r indicates, highly advanced underwater missiles of all kinds are being rushed through development and test.

With the advent of truly submersible atomic submarines that can cruise at high underwater speeds for weeks on end and with the growing practical knowledge of guided missiles of all types, the oceans assume a new strategic significance.

Water covers 71 per cent of the earth's surface. In places its depth exceeds 30,000 feet. It's a restless, moving thing that may stabilize the peace on earth; it is a world in hiding—one in which much of tomorrow's warfare may be conducted if major conflict arises.

One perfectly obvious aspect of the underwater missile science is the technological challenge it represents to our industry. It opens up a whole new field for designers, engineers and scientists. Our great missile manufacturers have new business opportunities, limited only by the vast defense system needed to keep our country safe against a huge fleet of deadly underwater platforms from which enemy missiles can be launched.

WAYNE W. PARRISH

SPERRY ANNOUNCES

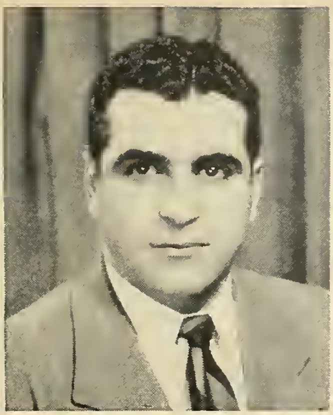
TWO NEW WEAPON SYSTEMS DIVISIONS

CARL G. HOLSCHUH, *President of Sperry Gyroscope Company.*

"In the years ahead, the nation's requirements for new and more efficient weapon systems, delivered at maximum speed and minimum cost, will impose greater demands on industry. For its part, Sperry is moving to meet these demands with the formation of our new Air and Surface Armament Divisions.

"Objective of this product-team realignment within the Sperry organization is to assure more advanced design, shorter lead times and lower costs in the development of weapon systems in these two categories. Each division, with its own engineering, manufacturing and contract organization, includes specialists in radar, fire control, gyroscopics, navigation, inertial guidance and all the allied sciences essential in the engineering of complex weapon systems."

C G Holschuh



SAMUEL AGABIAN has been appointed Manager of the Air Armament Division. Formerly works manager, Mr. Agabian is an Annapolis graduate and former Marine Corps officer. His work at Sperry has included responsibility for computing gunsights, bombsights, antiaircraft devices, radar and infrared developments.

AIR ARMAMENT

Air-to-air missiles and systems
Air-to-surface missiles
Airborne radars
Airborne beacons
Airborne electronic countermeasures
Bombing-navigation systems
Aircraft fire control radars
Airborne inertial systems

MYRON D. LOCKWOOD, manager of the Surface Armament Division, was formerly a systems engineering director. A World War II Lt. Col. of Artillery, and military-technical advisor at M.I.T., Mr. Lockwood has been associated with Sperry projects in underwater torpedo fire controls, guidance computers for missiles, antiaircraft control systems and inertial navigation equipment.

SURFACE ARMAMENT

Surface-to-surface missiles
Surface-to-air missiles
Ground and shipboard search radars
Ground and ship tracking radars
Battlefield surveillance equipment
Mortar and artillery locators
Land, ship and submarine fire control systems
Computers
Land and ship-based transmitters
Weapon direction systems
Ground and ship-based electronic countermeasures

SPERRY GYROSCOPE COMPANY
Great Neck, New York
DIVISION OF SPERRY RAND CORPORATION

features

news & trends

rocket engineering

guidance and control

industry spotlight

next issue:

NUCLEAR POWER AND ION PROPULSION

cover picture:

The Navy photo on the cover shows the business end of one of man's first guided missiles—the World War II torpedo. Whether sonar self-homing or guided by preset course coordinates, this beat its airborne cousins by a number of years. But, from being an under-mattress for the Navy's even-tempered submarine crewmen, this missile has come a long way, as this issue of m/r so well demonstrates.

columns

departments

photo credits:
U.S. Navy, pp. 41, 59, 60, 61, 64, 66, 71, 72, 75, 76, 77, 91, 113; Taggart, pp. 67, 68, 69; AiResearch, p. 78; E. Hull, pp. 88, 89, 159, 162; Whittaker Gyro pp. 100, 101, 104, 106; G. F. Wislicenus, p. 109; Nat'l Research Council, pp. 110, 113; Cameraman, Inc. p. 162; Robert Striar, pp. 160, 161.

when and where

MAY

Commercial Chemical Development Assn., Spring mtg., French Lick, Indiana, May 13-14.

IRE National Conference on Aeronautical Electronics, Biltmore Hotel, Dayton, Ohio, May 13-15.

Industrial Nuclear Technology Conference, sponsored by Armour Research Foundation & Nucleonics Magazine, Museum of Science & Industry, Chicago, May 14-16.

Jet Age Airport Conference, American Society of Civil Engineers, Park-Sheraton Hotel, New York City, May 15-17.

American Institute of Industrial Engineers, 8th annual conference & convention, Hotel Statler, New York City, May 16-18.

Armed Forces Communications & Electronics Assn. Convention, Sheraton-Park Hotel, Washington, D. C., May 20-22.

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

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

JUNE

First National Symposium on Production Techniques, sponsored by Washington Chapter of IRE, Willard Hotel, Wash., D. C., June 6-7.

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

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

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

Operations Research Conference, sponsored by Illinois Institute of Technology, IIT Campus, Chicago, Ill., June 12-14.

American Society for Testing Materials, annual mtg., Chalfonte-Haddon Hall, Atlantic City N. J., June 16-21.

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

IAS National Summer Meeting, Biltmore Hotel, Los Angeles, Calif., June 17-20.

Aviation Distributors & Manufacturers Assn., 29th mtg., The Broadmoor, Colorado Springs, Colo., June 23-25.

Federation Aeronautique Internationale, Palermo, Sicily, June 25-30.

JULY

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.

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

SEPTEMBER

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

OCTOBER

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

New facilities for new weapons

YOU ARE looking at the entrance to the new Honeywell Ordnance headquarters in Hopkins, a Minneapolis suburb.

These new facilities plus the engineering branch in Monrovia, Calif., the development lab in Seattle and a production plant in Minneapolis, will bring to over 372,000 sq. ft. the space devoted to development and production of *Customized* Weapons systems bearing the trademark of the Honeywell Ordnance Division.

These systems range from infrared detectors to stabilized platforms.

Experts in our Ordnance Division can draw upon a pool of over 30,000 skilled men and women in research, engineering, design and development, production and field service.

Standing behind them is over seventy years of engineering and production know-how.

If you require development work in the areas of missile equipment, fuzing, fire control, underwater ordnance or special products, Honeywell Ordnance Division would welcome your inquiry. Phone, wire or write to Honeywell Ordnance Division, Dept. MI-5-133, Hopkins, Minnesota.

Honeywell Customized Weapons Systems

Warheads; Infrared detectors and systems; Test, check-out and training devices; Transistor converters, inverters, rectifiers; Thermal batteries; Mechanical electro-mechanical and electronic fuzing; Sonar detection systems; fire control systems; Stabilized platforms.

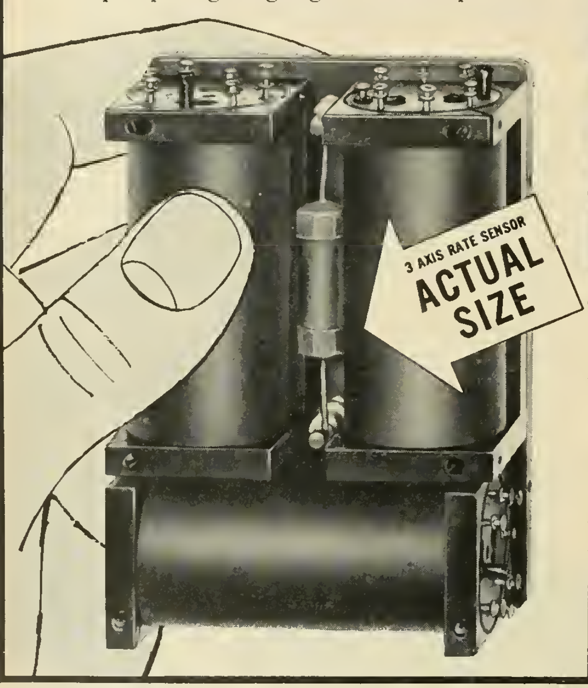
MINNEAPOLIS
Honeywell
H HONEYWELL **Ordnance Division**

In Control—with U. S. TIME GYROS

Poised on their launchers, the Navy's Terrier guided missiles.
Official U. S. Navy photograph.

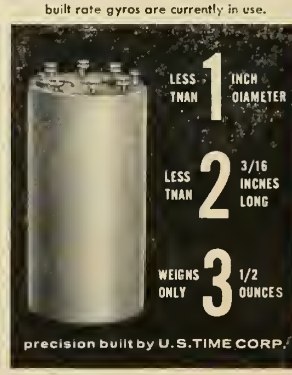
SUBMINIATURE!

Roll, pitch and yaw rate control gyros in one compact package weighing less than one pound!



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, subminiature gyros and gyro packages can be supplied in production quantities to satisfy your specific requirements.

More than seven thousand of these precision-built rate gyros are currently in use.



U.S. Time's Research Staff and facilities are engaged in research, design and development directed toward new products and optimization of the performance/weight ratio in the following fields of precision instrumentation.

• STABLE PLATFORMS • FLOATED INTEGRATING GYROS
• ACCELEROMETERS • RATE GYROS • 2 AXIS GYROS • DAMPER SYSTEMS
• INERTIAL INSTRUMENTATION • GUIDANCE SUB-SYSTEMS

A new edition of our technical data handbook available upon request.

THE UNITED STATES TIME CORPORATION

Manufacturing Plant: Waterbury, Conn., *Research and Development Division:* Irvington, N.Y.
Sales Offices: 500 Fifth Avenue, New York, OXford 5-5050
346 Tejon Place, Palos Verdes Estates, California, FRontier 5-9526

WORLD'S LARGEST MANUFACTURER OF WATCHES

letters

Disclaimer

To the Editor:

Regarding my Pentagon cleared article, "Spacepower," which you published in the April issue of MISSILES & ROCKETS, I would like to make the following comments for the benefit of you and your readers: . . . that due to my impending transfer of positions to the Martin Company from the Air Force, that any identification of my name with my present or former employer, carry a disclaimer "that my views do not reflect those of the Martin Company" or the Air Force.

Although I realize that it is an editor's prerogative to change titles and subtitles, your switch of my original subtitle: "An Analysis of Some Aspects of Space Doctrine" to "How the US Air Force Will Become the US Space Force," gave a new and different connotation to the real content of the article, which has caused me some embarrassment . . . Many readers of my article might assume that the *Vanguard* program, of which the Martin Company is the prime contractor and with which I am intimately connected, has political and military applications. The only purpose of the *Vanguard*—earth satellite program is a peaceful, scientific pursuit—to extend man's knowledge of the earth and its environs.

Donald Cox
The Martin Co.
Baltimore 3, Maryland

R-W Function Spelled Out

To the Editor:

. . . Enjoyed reading your excellent April issue; particularly the comprehensive roundup on Air Force long-range missile activities. We thought all portions were very adequately treated and were pleased to note that the role of The Ramo-Wooldridge Corp. was set forth in a very creditable and understandable fashion . . .

J. R. Lewis
Director, Public Relations
The Ramo-Wooldridge Corp.
5730 Arbor Vitae Street
Los Angeles 45, Calif.

Wants Servo Motors News

To the Editor:

Do you have a section for news items on servo motors and components?

A. B. Bradt
G-M Laboratories Inc.
4300 N. Knox Ave.
Chicago 41, Ill.

We are planning a forthcoming issue which will feature servo motors and related equipment.—Ed.

H. S. Rocket Courses?

To the Editor:

I was very interested in the letter by Leon Leonard of Seattle in the March issue, since I am associated with what is apparently a group similar to the one he describes. In my case the name is the Wakefield Rocket Society of Wakefield High School, Arlington, Virginia.

I very heartily agree with Mr. Leonard that high school student interest in Rocketry is being neglected and that this is a crucial phase of missile education. An account of our Society and its activities may give your readers an idea of what is being done and what can be done with this age group.

About three years ago George Pickard, a tenth grade student in the Arlington schools, decided to implement his growing interest in Rocketry. He gathered the nucleus of what eventually became the Wakefield Rocket Society . . . now in its second year.

Little was accomplished the first year, but this year's accomplishments were

interesting. Upon application, the group was accepted as an official Moonwatch team; work is now in progress on the construction of the observing station.

In cooperation with the University of Maryland, the group is building a cosmic ray recording station. Several visits have been made to local scientific installations; weekly meetings are "operation bootstrap" in missile education. Six of

the group ushered at the recent ARS convention. I must mention also that difficulties associated with actual launchings have led to the construction of a static test stand, and a program of experimentation with powder and liquid propellants is under way.

This is a good record of accomplishment and were such clubs not so important I would not go on to complain. Yet I feel I must, and my complaint is directed toward that same indifference Mr. Leonard mentions.

I was surprised to read that Mr. Leonard has received assistance from the Northwest Section of the ARS; the parent organization does not appear to have the perception of its Northwest branch. Our efforts to become associated in some way with the ARS have come to nothing.

Reason given is that the Society is afraid of incurring liability in case of accident. I cannot help but feel that this attitude is a tragic mistake; these boys are the scientists of tomorrow.

We must remember that our educational system depends upon people choosing their careers and not being ordered into them. The ARS should have an active program designed to interest capable students now in secondary school.

Other than Reed Research Inc. in Washington, D.C. we have had little success in attracting the attention or interest of industrial research organizations. At one time, Atlantic Research gave some evidences of interest but nothing has developed.

Several individuals have been very kind, but what we need is room for firing, equipment, and the advice of people more technically competent in this field than I.

In closing, I should like to predict that the number of rocket societies will grow in the next few years. The publicity given missile work makes growth inevitable. I hope this letter stimulates some group to step in and assume some of the responsibility practicing scientists owe to these student groups.

David W. Saltus
5433 Eighth Rd. S.
Arlington, Va.

Watch Your Language!

To the Editor:

Re your answer to Albert Parry in Letters April 1957—All I can say is:

Жиперс, Ватта Дерти Трык!

Also—where does the Lintz Basalt occur?

Kelly Choda
732 Ursula Street
Aurora 8, Colorado

It's a volcanic deposit. Lintz Basalt, in particular, comes from Germany.—Ed.

But Has It Been Cleared?

To the Editor:

Recently in cleaning out my desk, I came across the following, which may be of interest to your readers:

PROJECT VOGELHUNDT

"Firing of rockets, bombs, missiles, and projectiles in tests at NOTS are accomplished in tests of one kind or another. The conducting of a survey prior to the current reports period (1956) indicates that out of approximately more than 200,000 total rounds fired altogether per year and valued at some million and a quarter dollars, it is desirable for study purposes to recover about 20,000 having a total approximate value of about half a million dollars in all. However, further accumulation of data statisticswise showed that of these 20,000, only 10% were usually recovered and 90% had a strong recover incapability.

"Optical, auditory, and shock-sensitive devices developed this year have proved of but slight value either costwise or information-contentwise. Some detection methods are valued on the order of 20 times the material recovered.

"In 1956, however, it was noted that olfactory processes, at least in organic fields, are among the most sensitive of sensing devices. If the cost dollarswise of the search-and recovery processes could be reduced to a cost calculated centwise, by using scent-sensitive sensing equipment, it appeared sensible to develop and prove the technique which seemed sensational.

"Mechanical sensors were found impractical, but a careful study of current literature revealed that many varieties of organic sensors are available in large quantities and at low cost.

"After intensive study, it was found that one highly specialized organic sensor, the Bassett Male Aero Bark X3A was suitable as an olfactory detection unit, but that this unit would not operate without a corresponding sensitizing unit to sensitize the weapons before firing.

"Organic sensitizers need not be restricted to the Aero X3A; so several varieties were obtained, including Mastiff Female Yipe 6 and Setter Female Yipe 8. All apparently had equal sensitizing capability and were used in turn to sensitize missiles to be fired at the Randsburg Wash Range.

"Test projectiles were fired in groups of 40 because it was found that the Bassett Aero X3A became insensed after a period and had to be recharged.

"On three tests, in which 120 missiles were fired, the Aero X3A was stationed in a shelter near the anticipated target area. One hundred nineteen of these landed in the target area and were located by the Aero X3A in rapid succession. The average time for search and detection was 0.71 minutes. However, projectile No. 73 accidentally was fired at high gun elevation, and the projectile landed in the foothills of the Panamint Range. Operations had to be suspended because the Aero X3A left the field of operations at approximately more than 121.3 fps, and it was approximately one hour before the Helicopter Recovery Group was able to effect the capture of this sensing unit and return it to the operations area.

"It is the consensus that if some more effective means for stimulating the unspecialized sensitizing units can be devised, olfactory detection will provide an effective and economical means of recovering valuable test weapons after firing. Censing the projectiles before firing, the sensor could be more effective. It is also anticipated that the use of more than one Bassett Male Bark Aero X3A will considerably reduce the wear and tear on these units. It is also believed that the addition of one or more Bassett Female Yipe Aero X3A's will assure a constant supply of these valuable units."

John H. Wilson
Atlantic Research Corp.
Alexandria, Va.

Plaudits for Us

To the Editor:

I had the pleasure this week of being given a copy of your new magazine, Missiles & Rockets. A colonel who was attending our course of familiarization on Electronic Countermeasures thought that it might be a valuable source of information for our guided missiles lecture. We have really found this to be so.

We present this course every week to high ranking officers of all services, including the Royal Air Force and the Canadian Air Force . . .

R. Kevin Murray
Captain, USAF
OMR Box 69
Keesler AFB, Miss.

Fashions in the Sky?

To the Editor:

At the suggestion of the New York office of *American Aviation* Magazine, I am writing you to see if you can give me an approximate date for the launching of the New Earth Satellite. We understand that this will take place sometime during the summer.

It may seem strange for a retail store to be interested in such a highly scientific project, but we feel that it might be interesting to tie in some of our ad copy with the launching of the satellite.

Alison M. Beyea, Fashions
New York Office
Neiman-Marcus
1457 Broadway
New York 18, N. Y.

No date has been set yet. It depends on when the launching vehicle is in satisfactory condition. This may not be until the middle of 1958.—Ed.

Wants Red Missile Sources

To the Editor:

Your map on pages 40 and 41 of the February m/r, depicting the Soviet missile industry was very interesting. However, in the European Russia region the map was pictorial but confusing. Association of some symbols on the map with the nearest locality indicated conflict with information we already have on hand, some symbols were simply impossible to locate satisfactorily, etc.

Could you possibly furnish me with some of the specific information that was on hand when the map was drawn up, or indicate the sources and channels thru which the information was obtained?

It is thru the particular responsibilities and interests attached to my work as a Research Engineer in Missile Development Division of North American Aviation that I am interested in such information.

J. D. Harmon
11351 W. Olympic Blvd.
Los Angeles 64, Calif.

We cannot give our sources beyond saying that they consist of Governmental and private sources both in the U.S. and abroad.—Ed.

Emancipation Revisited

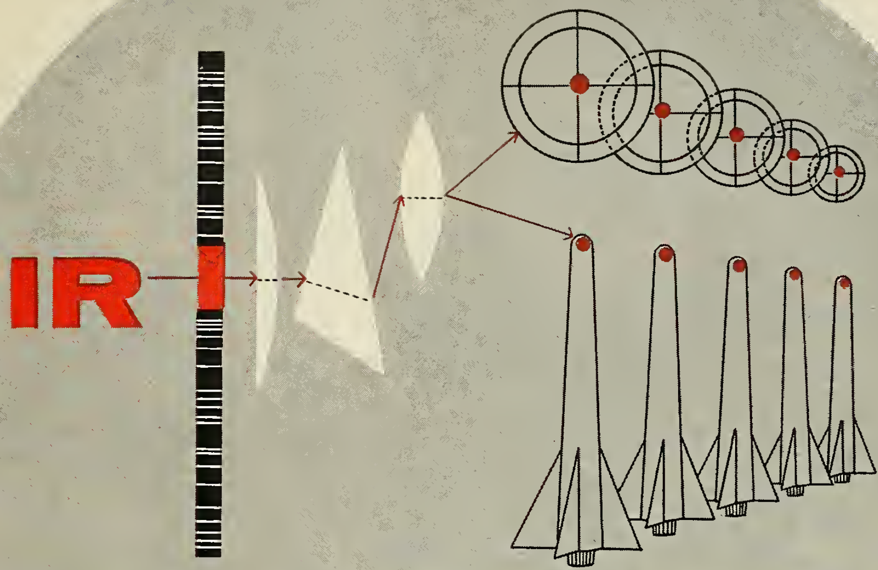
To the Editor:

This has been getting chuckles in Florida and San Diego.

I thought you might appreciate—

"GETUSABIRD ADDRESS"

"Four months and some weeks ago, our company brought forth to this base a new missile, conceived in haste and



INFRA-RED

1944...RESEARCH • 1956...MASS PRODUCTION

For 13 years Aerojet-General has pioneered the research and development of infra-red devices. *Now*, Aerojet and *Aerojet alone* has perfected the high-volume production of infra-red systems for:

GUIDANCE
WIDE-ANGLE SEARCH
AUTOMATIC TRACKING
GUNFIRE CONTROL

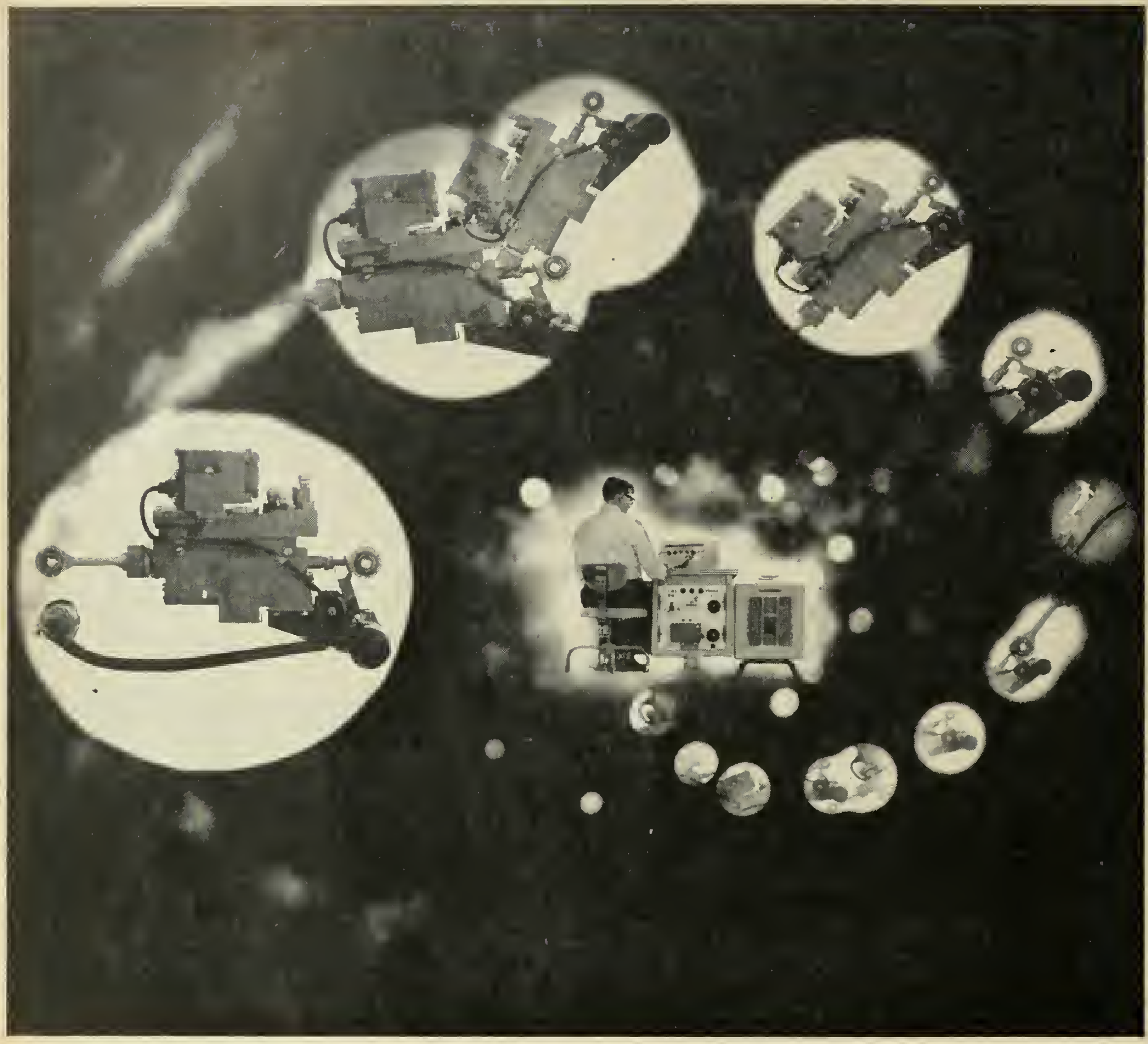
Aerojet-General CORPORATION

A Subsidiary of The General Tire & Rubber Company

THE GENERAL TIRE

AZUSA, CALIFORNIA
SACRAMENTO, CALIFORNIA

Electronics engineers...physicists...Aerojet invites you to pinpoint your own targets, "lock on" your own future... in the dynamic new field of infra-red.



dedicated to the proposition that all components are created equal.

"Now we are engaged in a great testing program, testing whether that component or any component so created and so designed can long endure.

"We are met on a great flight path of that program. We have dedicated a portion of that flight path for a final resting place for those missiles that here went down range, that this base might continue to exist.

"It is altogether fitting and proper that we can do this. But in a larger sense, we must test; we cannot rest; we must justify this program.

"The brave men, officers and contractors who have built their empires here, have justified it far above our poor power to add or detract.

"The people will little note, nor long remember what we say here, but they can never forget what we did here. It is for us, in Florida, rather to be dedicated here to the unfinished task which they, at San Diego, have thus thrust upon us.

"It is better for us to be here completing the diminishing tasks remaining before us: that from the public we take increased taxes for this cause for which they gave the last full measure of approval; that we here highly resolve that these taxpayers shall not have paid in vain; that this base, under ARDC, shall have a new birth of accomplishments: and that missiles of the contractor, by the contractor, and for the contractor shall be launched from this base."

W. G. Bennett
Convair-Astronautics
San Diego, Calif.

French Isopropylnitrate

To the Editor:

I note in Al Zaehringer's column "Propulsion Notes" in March m/r a reference to a method for producing isopropylnitrate, which has been devised by the French.

I would appreciate receiving any further information whatsoever you may have on this subject.

May I take this opportunity to say we find your journal extremely interesting and valuable in connection with our interest in monopropellants and fuel additives.

Harold A. Beatty
Technical Staff
Ethyl Corp.
Detroit, Mich.

It is in the mail.—Ed.

Russian Carbon?

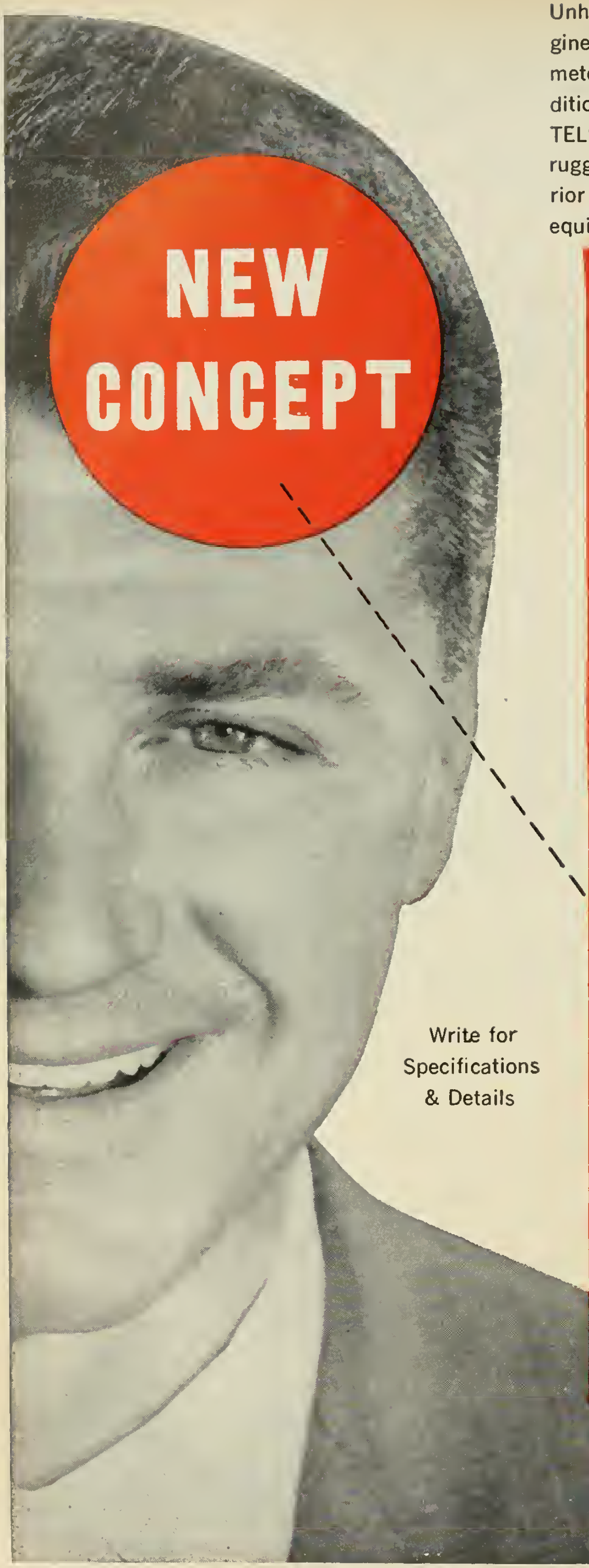
To the Editor:

I have just seen another Russian drawing on the earth satellite project.

It looks as if Mr. Dobrovolsky didn't make such an obvious copy of the Mouse as was done in the drawing that you reproduced last November. I don't know whether this latest Soviet satellite conception is the result of copying some other American design or represents some original Russian thinking on the subject.

Incidentally, this February, 1957, issue of Nauka i Zhizn also carries a five-page article by Varvarov titled "Artificial Earth Satellite." Included is a black-and-white drawing of a three-stage satellite launching rocket and sections on "Theoretical Premises", "Satellite Projects", "Methods of Launching the Satellite", "The Avanguard (Vanguard?) Project",

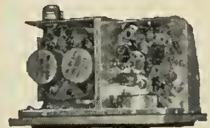
Circle No. 6 on Subscriber Service Card.



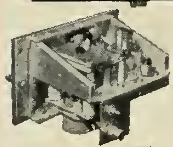
Unhampered by traditional thinking, TELECHROME engineers have developed an entirely new concept in telemetering equipment. Today's new environmental conditions and distances for missiles require new designs. TELECHROME units are unequalled in compactness, ruggedness* and dependability. Because of their superior qualities these highly efficient units are replacing equipment of other manufacture.

NEW CONCEPT

Direct FM Transmitters Crystal controlled 215-235 megacycles. ±25kc deviation.

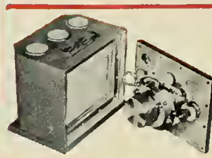


Model 1462—6″ x 4¼″ x 3¾″
50 to 80 Watts



Model 1463—5$^{19}/_{32}$″ x 3$^{13}/_{16}$″ x 4″
15 to 30 Watts

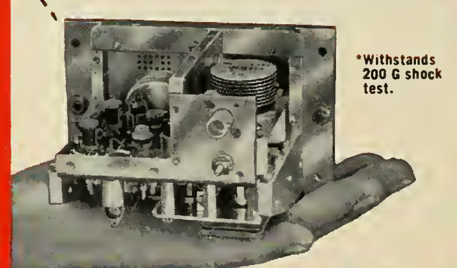
Model 1472—4″ x 1.5″ x 2.7″
2 Watts



Model 1460—5″ x 4⅝″ x 3$^{15}/_{16}$″
RF Amplifier
15 to 30 Watts

Model 800—4.5″ x 1.3″ x 1.4″

SUB-CARRIER OSCILLATOR. Deviation stability ±1% of band width. Deviation linearity less than 1% of band width under all conditions measured from a straight line drawn between end points.



*Withstands 200 G shock test.

Write for Specifications & Details

TELEMETERING TRANSMITTERS
HIGH POWER IN SMALL PACKAGES

TELECHROME INCORPORATED

The Nation's Leading Supplier of Color TV Equipment

28 RANICK DRIVE
AMITYVILLE, N. Y.
Lincoln 1-3600

See Our Interesting Exhibit Booth 1709

Circle No. 47 on Subscriber Service Card.

letters

"Use of Various Engines", "Will the Satellite Be Visible"? and "What Will the Satellite Do for Science"?

In an earlier issue of Nauka i Zhizn, V. V. Rozenblat, a Russian candidate of medical sciences, wrote a four-page article on the psychological problems of space flight. In all probability the problems discussed are pretty much the same as those you have written about: acceleration, strain, weightlessness, feeding the crew of a space ship, etc.

Chuck L. Adams
3330 Thirteenth St.
Boulder, Colo.

Is Gravity Constant?

To the Editor:

I would like to know your reference for the statement in "Missile Miscellany," of the March m/r, which says that "a gravity pendulum with a bismuth bob gains one beat in 17.432 by another pendulum of exactly the same oscillation length having a zinc bob." I would also like to know if the figure, 17.432, should not be 17,432. This sounds a little more reasonable.

Congratulations on a fine publication.

Richard E. Brown
41113 Menlo Dr.
Wichita 17, Kansas

The figure 17.432 as printed is correct, which means that the shift in period is quite rapid—Ed.

To the Editor:

In the February m/r "Missile Miscellany" section you state: "Has any one ever used modern theory to explain why the silicate, Lintz basalt, spontaneously generates heat at the rate of 2.38 x 10-4 calories per hour per gram; why *in free fall it won't accelerate at 980 centimeters per second?* It's not radioactivity, for uranium is 1500 times as active as Lintz basalt, generates only 7.2 x 10-5 cal/hr/gr."

In an attempt to get an explanation, this paragraph was shown to two physicists. Their reaction was to dispose of the problem by exclaiming, "Hogwash!". I am not inclined to dismiss this alleged phenomenon so lightly, but must admit that I am more than a little doubtful of the validity of the assertion regarding the acceleration of Lintz basalt in free fall.

I would, therefore, appreciate more detailed information on the subject, if at all possible. Also, I would very much like to know the source of your information.

C. C. Barnett
General Electric Co.
Missiles & Ordnance Systems Dept.
Philadelphia 4, Pa.

Our experience is that those who claim "hogwash" merely assume it, have never checked it. A letter is in the mail giving you complete references—Ed.

To the Editor:

It's interesting to see that you're stirring up the relativity time-contraction controversy sparked off over here by a letter from Prof. Dingle in "Nature," and continued both there and in "Discovery" by most of our "big guns" in relativity theory.

Lead v. bismuth pendulums—I sup-

pose someone has investigated the possibility of eddy-current damping from the Earth's magnetic field? If this, and the Lintz basalt phenomenon tie up together, we might get a real anti-gravity unit.

Astropsionics?

I'd like to comment on certain aspects of some of the serious articles, but I'm a bit scared of security—there have been instances of people being refused permission to use material in public lectures here in spite of it actually being published; that recent leak of "Sea Slug" also had security types going round in small circles, tho' what actually got out couldn't be of the least value to the Queen's enemies, as far as I can see. Still, I suppose that it's a question of principle.

P. H. Mabey
201 Bath Road
Cheltenham,
Gloucs., England

To the Editor:

. . . I have come across an article in your magazine which has stirred much interest. The article appeared in m/r, March 1957, page 113:

"Relatively also requires the equivalence of gravitic and inertial mass. If so, explain why a gravity pendulum with a bismuth bob gains one beat in 17.432 by another pendulum of exactly the same oscillation length having a zinc bob; and why torsion pendulums act similarly."

Can you please supply me with the source of your information?

Who made this discovery? If this is true, isn't g dependent on mass? . . .

Alfred F. Kudela
Senior Engineer,
Chrysler Corporation
P.O. Box 2628
Detroit 31, Mich.

This phenomenon may have some bearing on the theoretical g-mass relationship. More likely it has to do with diamagnetism. In any case it appears to be a phenomenon that's been looked into only a little. The reference is Journal of the American Physical Society, Volume XVIII, No. 2, page 125, a paper presented by Charles F. Brush.—Ed.

On Vanguard Switching

To the Editor:

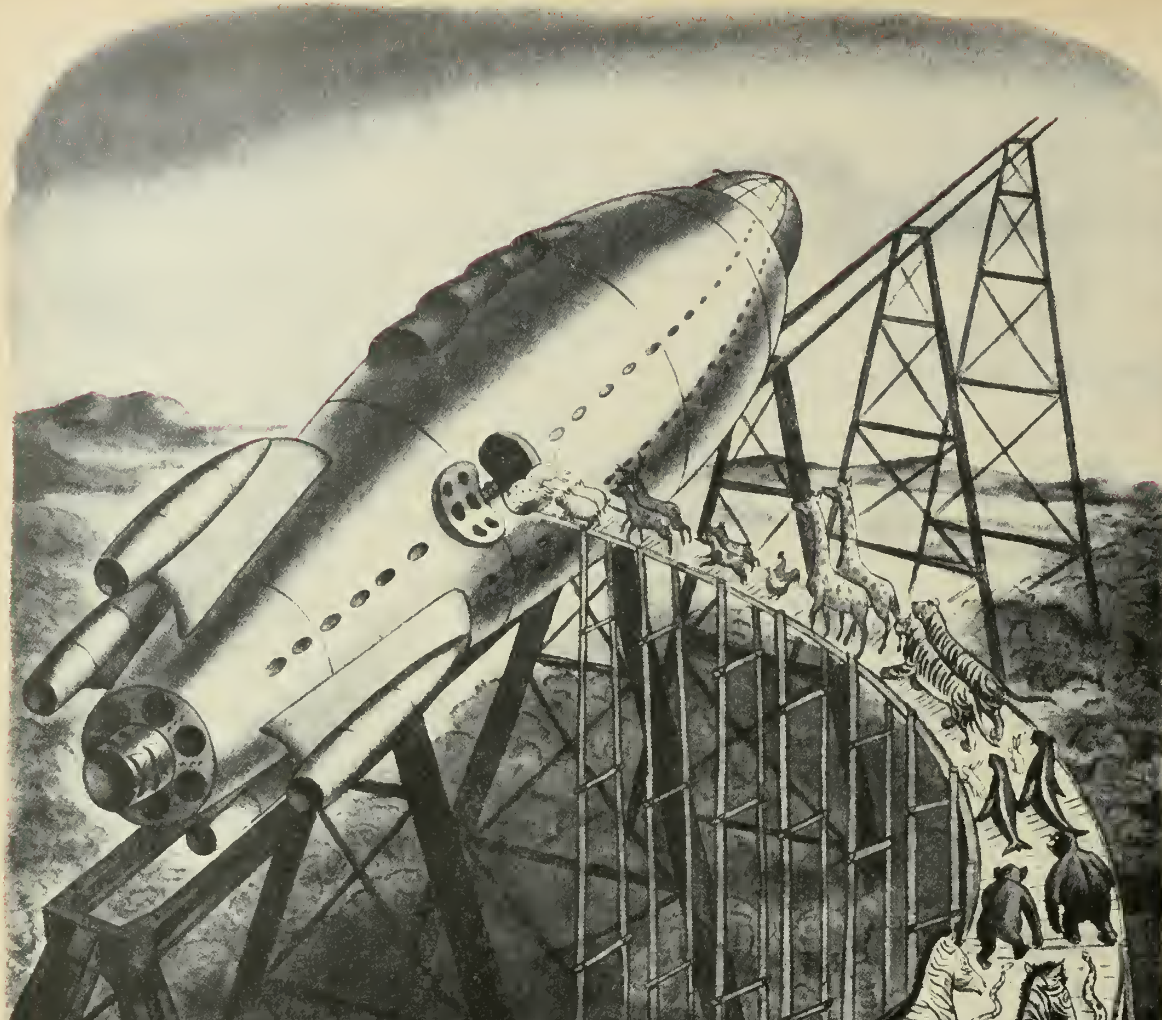
I am very interested in astronautics and m/r is the fulfillment of my dreams in the field.

In an article about the *Vanguard* Project, I saw that there was a sun-cell to reset a memory unit in the satellite once every circuit. What happens if the satellite is rotating on its axis more than once per circuit? Looks like the memory unit would erase information already stored, but not yet transmitted, and a great amount of information would be lost. Do you have any information on how this is being remedied, or is it?

Also where could I get an index for m/r and pictures of rockets, missiles, and planes.

Drew Evans
207 Taft Ave.
Wilmington 5, Del.

Vanguard's switches are programmed to act relative to its orbiting cycle. An m/r index will be published this fall. For pictures we suggest you try the public relations offices of companies involved—Ed.



FOR *almost* ANY MISSILE, ANYWHERE ...CREATIVE ENGINEERING BY CLEVELAND PNEUMATIC

Our Special Products Division designs and builds launching stands, test towers, ground-movement vehicles, and storage devices for *almost* any size missile, anywhere.

What do we know about ground-support devices for missiles?

Since 1924, Cleveland Pneumatic has been developing and building cushioning devices. Impact absorbers . . . structural units . . . for large and cumbersome loads.

Our ideas on ground-support vehicles and structures for missiles are firmly based on 33 years of experience.

May we call on you soon to discuss your missile and its ground-support requirements?

Your missile project ...and creative engineering

This new booklet outlines in detail the abilities and facilities of the Special Products Division. For your copy, write on your company letterhead to Cleveland Pneumatic Tool Co., Special Products Division, Cleveland 5, Ohio.

CLEVELAND PNEUMATIC

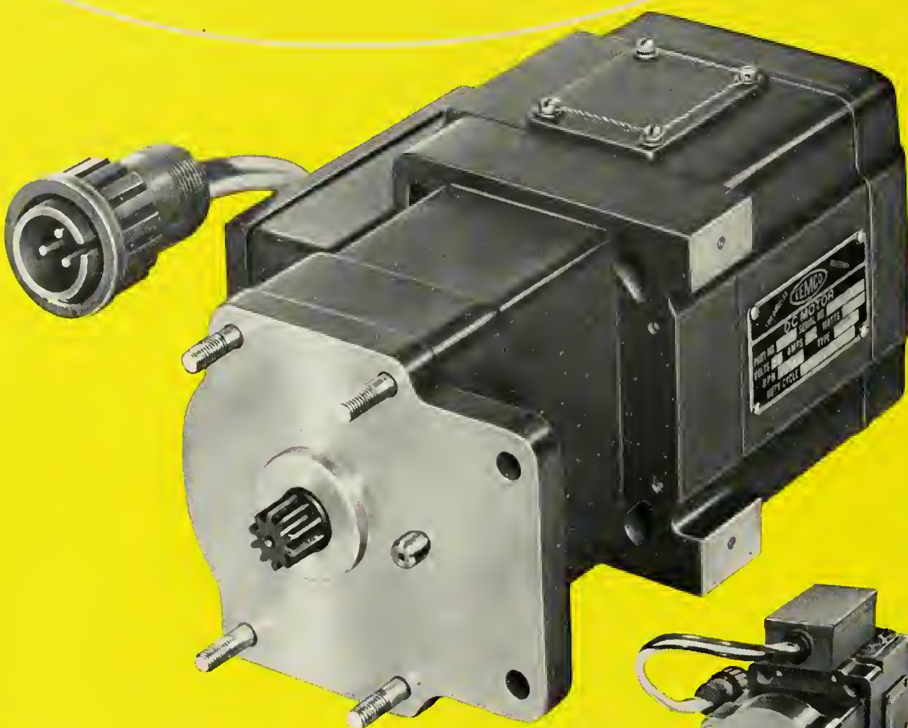
TOOL COMPANY • SPECIAL PRODUCTS DIVISION

Cleveland 5, Ohio

AGAIN . . . a new DC motor by

EEMCO

for another of our latest missiles

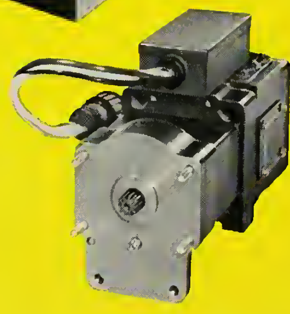


Unquestioned reliability under any condition of shock, acceleration and vibration is the prime requisite for all components in today's advanced missiles and rockets. A minor deficiency in but one, to any degree, can nullify completely the effectiveness of the weapon.

EEMCO Type D-927 DC motor is a component in one of our missiles that meets these rigid requirements. In fact, **EEMCO** motors and actuators are on the majority of the latest aerial weapons because of their unfailing performance.

The reason for such widespread recognition of **EEMCO** quality is that **EEMCO** has designed and manufactured custom motors and actuators for the aircraft industry for many years.

EEMCO is a specialist in this specialized field. It makes nothing else.



SPECIFICATIONS FOR TYPE D-927 DC MOTOR

Type: DC motor meeting Military Specifications MIL-8609
Speed: Continuous at 9900 rpm
Load: 0.5 HP
Terminal Voltage: 27 volts, 18 amps
Weight: 7.25 lbs. with 2-circuit noise filter for ungrounded system
Weight of Filter: 1 lb.

EEMCO **ELECTRICAL ENGINEERING & MANUFACTURING CORP.**

4612 West Jefferson Boulevard, Los Angeles 16, California—Telephone REpublic 3-0151

DESIGNERS AND PRODUCERS OF MOTORS, LINEAR AND ROTARY ACTUATORS . . . EXCLUSIVELY!

3-549

Undersea Warning System Underway

Chain of Low Frequency Sonar Devices Will Detect Enemy Subs

By Erik Bergaust

The United States Navy is understood to be conducting a program for what may turn out to be the most sophisticated defense weapons concept ever attempted. We are building an underwater early warning system similar in scope to the famous radar detection systems stretching across northern Canada. But the USAW (Underwater Security Advance Warning) concept is based upon highly advanced underwater sonar devices linked together in long chains at the ocean floor up and down our coasts. The system is designed to detect enemy submarines that may sneak up toward our shores. This system—as part of an anti-submarine system—is believed to be our most potent answer to Russia's vast submarine fleet, many units of which are designed to carry the 700 miles range *COMET* FBM or IRBM missile. Employing the submarine launching concept the Reds would be capable of hitting targets along our coasts as well as inland from launching positions less than 100 miles out at sea.

The underwater early warning system is top secret. No details whatsoever can be released, although it is understood that certain companies, such as American Cable & Radio, have submitted proposals and might have been awarded contracts at this time.

Our undersea warfare people are working under tighter security wrap than any other branch of the services. Little has been said about their many different weapons systems and their research and development, but a high-ranking Navy official has confirmed to m/r that work is progressing on the underwater early warning system. Said one Navy captain, when asked how many subs we could detect if Russia sent 500 of them toward our coasts: "Today we probably could only detect 10 per cent of them."

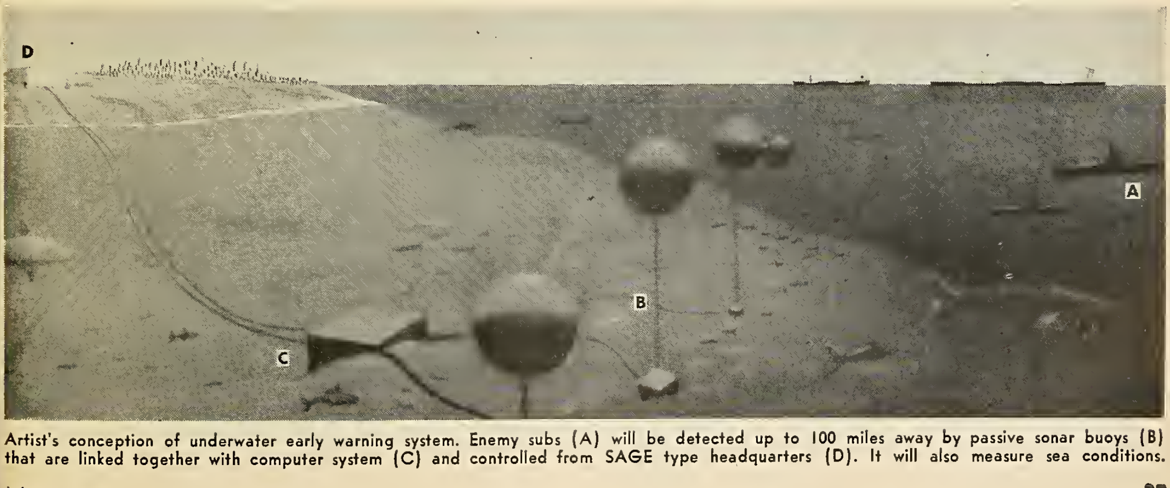
The future system will be much like a chain of Texas towers deep down in the sea. Chains of sonar buoys, operating on a passive basis, i.e. *listening* for enemy submarine noise, would be linked together. At certain intervals computors will calibrate the sound wave information and transmit it to a central defense headquarters, much like the SAGE system.

Underwater experts agree the underwater warning system can be made effective, since advancement in the field of low-frequency sonar has been substantial, and since it his been proven that ships can be detected by passive sonar as far off as 100 miles, perhaps even farther.

During the war sonar was developed to the extent that a convoy could be heard with ease at 40 miles distance. A large ship could be detected 70 to 80 miles away, and an underwater explosion could be heard more than 100 miles away.

Many of the major electronics companies in this country are working on advanced sonar devices for torpedoes and other underwater warfare purposes. And the interest in this science is growing.

Navy's need for improved sonar devices—for underwater early warning along our coasts and for shipborne



Artist's conception of underwater early warning system. Enemy subs (A) will be detected up to 100 miles away by passive sonar buoys (B) that are linked together with computer system (C) and controlled from SAGE type headquarters (D). It will also measure sea conditions.

sonar—is expected to influence the electronics industry noticeably in the next few years. Some experts have even considered the possibility of hooking up an underwater early warning system to automatically controlled detonation devices and self-launching missiles. This may belong to the distant future. But the immediate application of sonar as a straight detection system is imminent and feasible as well.

Engineers For Sonar Industry

Recently Cal-Tronics Corporation of Los Angeles awarded a scholarship to a high-school student for his sonar electronic exhibit, displayed at the Annual Science Fair at the Los Angeles County Museum.

The winner was judged by Cal-Tronics executives including Malik Robinson, vice president; Ralph Koerner, manager of engineering; Stanley Boyle, development engineer, and Robert Feland, Jr., sales manager of the firm which specializes in testing equipment for guided missiles, radar and fire control.

The scholarship was awarded to stimulate recruitment of engineers for the growing electronics and sonar industries.

Unique Sub Detection System

A recent AP dispatch from Sweden disclosed that the Swedes have been considering the use of seals to hunt down submarines.

"Yes. we tried it," a naval spokesman told, "and you needn't get flip about it. The seals cooperated but we couldn't handle the fish."

Seals were put in training during World War II at a Swedish naval base, where submarines were sent down with bundles of fresh herring attached. The seals went for the herring joyfully.

There were two snags in the project, as the Swedes saw it, which had to be overcome to make it workable.

One was to supply the seals with "war heads." Since a seal's body is pretty streamlined and slippery, a top secret order went out to the Royal Institute of Animal Medicine to devise a suitable plastic operation to take care of this difficulty. This idea was discarded in favor of an "explosive harness" of special design.

The project foundered on the second snag. Despite intense training, the seals looked with perfect distain upon any submarine without the herring bait.

60-Knot Missile Subs Planned

A major technological breakthrough in underwater warfare is under way. It consists basically of the development of an engineering ability to break the "cavitation" barrier, that hydrodynamic phenomenon that now proves as troublesome to underwater missile and submarine designers as the sound barrier was to aerodynamicists a scant dozen years ago.

Vice Admiral Charles B. Momsen, USN (Ret.) in m/r's *personal report* (page 88, this issue) states categorically that 60-knot submarines are bound to come. It is not idle speculation.

He is a central figure in the work towards high-speed underwater capabilties. Now a consultant for such firms as Electric Boat Division of General Dynamics Corp., Coleman Engineering Corp., Fairchild Aircraft and Engine Corp., Raytheon Manufacturing Corp. and U.S. Rubber Co., Adm. Momsen probably knows more of the limitations and potentials of undersea warfare than anyone else alive.

A number of privately financed research and development projects, taken collectively, add up to just such a vehicle. The most important single contribution to the 60-knot (and up) submarine will be designed for the elimination of cavitation—a low-pressure turbulent flow condition where gas bubbles form between the fluid medium and the skin of the vehicle. Elimination of cavitation plus the development of highly-polished underwater surfaces might cut high-speed drag 70 per cent.

Details of specifically who is working on the 60-knot submarine and in what capacity are classified, both for military security and for proprietary reasons. But an official announcement that the Navy is building such a vessel may come this year.

However, there are indications of what form it will take. First, it will probably be small and will be the most fully automated subsea craft ever launched. Its crew will probably consist of fewer than a dozen men. In that respect it will approach the airborne bomber in basic operational concept. Already, the revolutionary *Albacore* is "flown" with yoke, seat belts, etc. It performs a perfect needle-ball chandelle on rudder controls alone, obtaining the stability effect of dihedral by placing the center of buoyancy well above the center of gravity.

The 60-knot submarine will be nuclear propelled. Most importantly it will utilize a revolutionary system of hydrodynamic boundary layer control in order to maintain laminar flow throughout all speed ranges. It will have passive sonar gear with effective ranges reckoned in hundreds of miles.

It will be armed with reaction-propelled missiles with underwater speeds of 150-200 knots for anti-submarine (or surface ship) missions; with underwater-to-air anti-aircraft missiles; or, of course, the Fleet Ballistic Missile.

Increasingly, it will be necessary to design submarines for their special missions. Anti-submarine submarines will be like today's supersonic interceptor aircraft. Instead of carrying radar gear to detect and track their targets, they will be literally built around the finest sound detection gear possible. They will sit and listen in absolute silence for either the noise of an attacking submarine or a "bogey" report from USAW (Underwater Security Advanced Warning—Page 37, this issue). At this moment, the anti-sub submarine will either launch its missiles while at rest or streak off after its target, depending on the distance at which the detection was made.

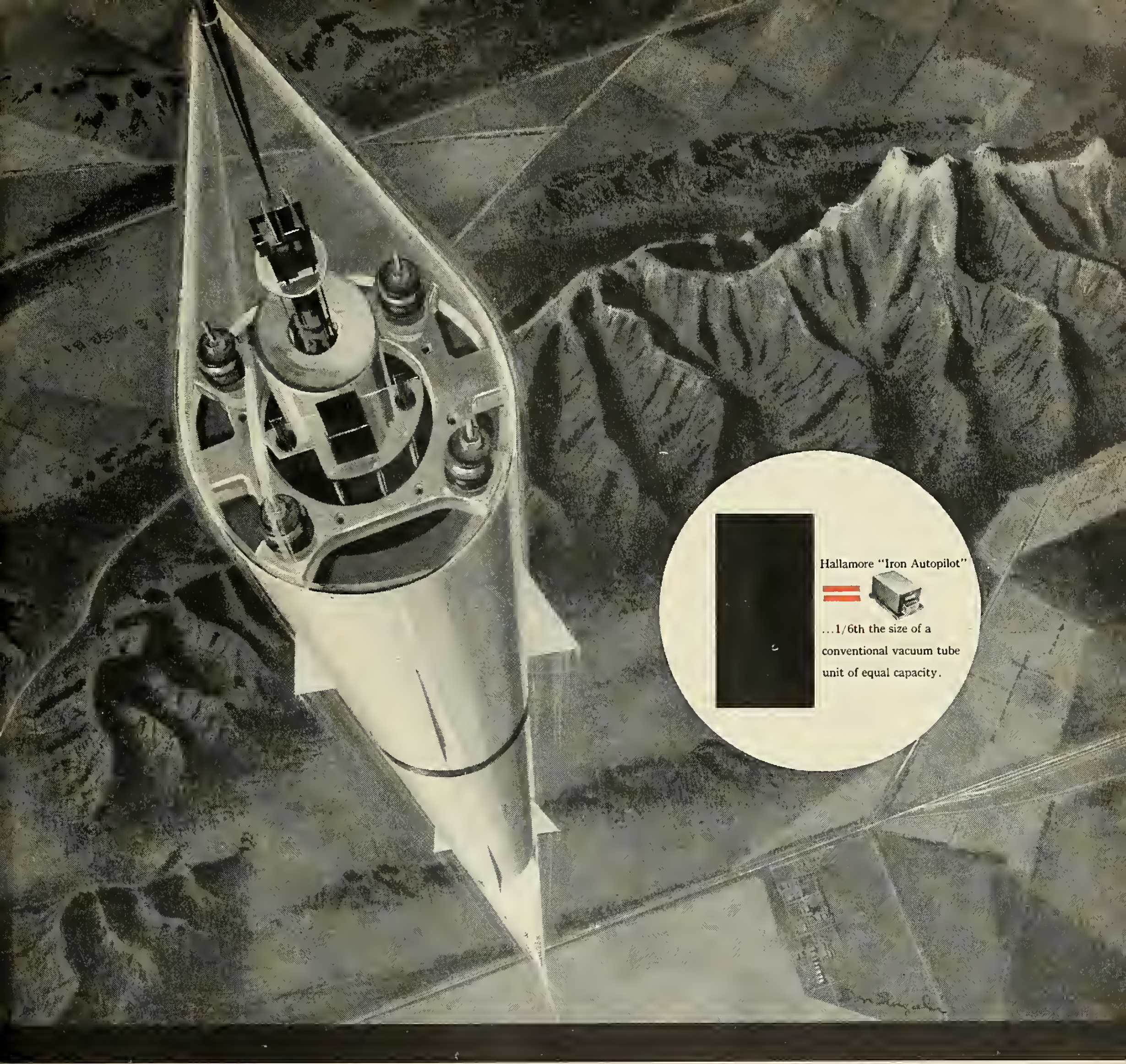
The strategic missile launching submarine, cradling a *Polaris* nest will have an assault capacity on the entire land mass of Russia. Lockheed Aircraft Corp., though admitting that early FBM's will have only a 1,500 mile range, has strongly hinted that 2,000-mile missiles will follow shortly thereafter. This will be the big bomber of the submarine fleet, loaded to the gills with underwater navigational and computing gear and boasting at least two nuclear reactor engines for both speed and endurance. It will not be dissimilar in size and propulsion to the *USS Triton*, a twin reactor-powered radar picket submarine now abuilding at Electric Boat's Newport, R. I., yards.

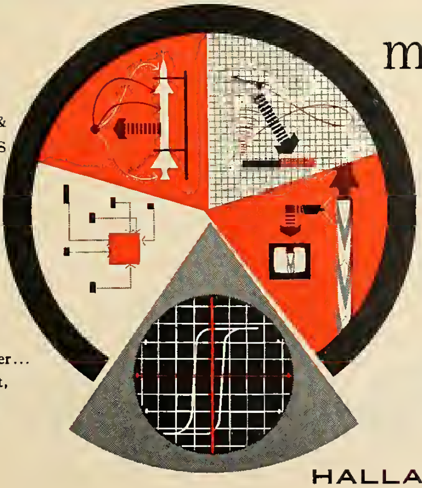
Other submarine configurations will include anti-aircraft vessels that range the seas, ready to fire either beam rider or self-homing missiles from underwater at attacking aircraft or missiles; a privateer-like vessel possessing extremely high speeds, a variety of armament and with a mission to seek targets of opportunity of all sorts; personnel transporters; possibly aircraft carriers; and cargo vessels.

In the later regard, U.S., British and Swedish work on towed underwater bulk cargo barges is significant.

The breakthrough to 60 knots for submarines will be just a beginning. Aerojet-General Corp. is working on advanced underwater propulsion for missiles. This knowhow would be applicable to submarines.

INEERS &
HNICIANS
ideal
ng
tions
a
mic,
ve
ization,
résumé
ief Engineer...
Brookhurst,
eim, Calif.





On-again, Off-again Missile Now On Schedule?

The now-it-will, now-it-won't missile, now, for the moment, will. The $39-million *Vanguard* now seems closer to being on schedule than it has in many months. In fact, with the recent successful firing of *Viking-14* with what is believed to be Grand Central Rocket Co.'s third stage *Vanguard* engine, the project may even be ahead of schedule.

The biggest question mark about when the U.S. would make its first "for keeps" effort to launch an artificial earth satellite has revolved recently around whether or not General Electric Co.'s first-stage engine would be successful. Early last month the press carried stories about how this phase of the project had been declared a failure, that Naval Research Laboratory might turn the Army Ballistic Missile Agency at Huntsville, Ala., for a first stage. The first three engines delivered by GE were, in fact, rejected as unsatisfactory. Now within a couple of weeks, this whole view has been reversed. The official word is that General Electric has solved its first-stage problems (reportedly, overheating) and that the engine is in the process of being accepted.

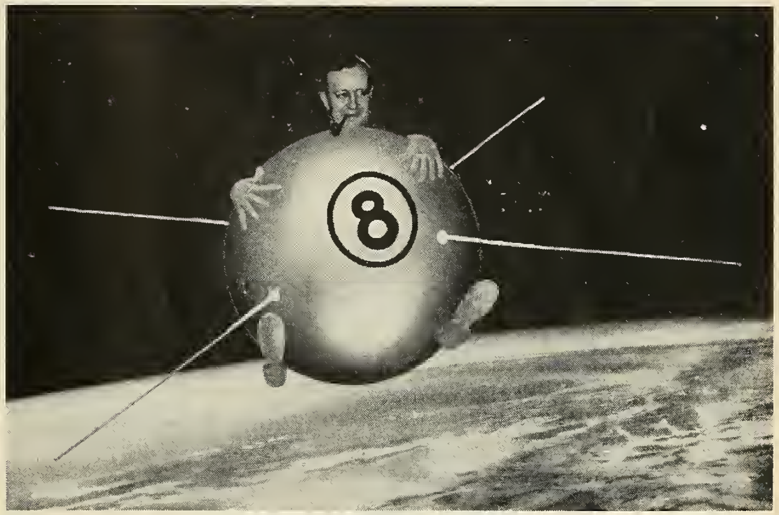
This series of events highlights the confusion surrounding Project *Vanguard*. Another contributing factor probably is the number of different agencies and groups having a hand in its direction. Also, as someone recently declared, "*Vanguard* is politically sensitive." This is particularly true where U.S. international prestige is concerned.

Other *Vanguard* developments include: completion of the purchase land for minitrack and visual tracking stations both here and abroad; beginning of construction and installation of gear at these locations; virtual completion in Washington, D.C., of the International Business Machines computer that will collect, colate and analyze reports from these and other stations.

A quick spot-check of the various major contractors in *Vanguard* propulsion indicates that the GE first stage is now all right; so, it is claimed, is Aerojet-General's second stage. Both of these are liquid rockets. Of the two third-stage competitors, Grand Central is reported to be completely out of any woods it might have been in—so confident in fact that some company officials have claimed that if the second stage liquid engine didn't pan out, they'd deliver a solid-propellant engine for that job in six months. Allegany Ballistics Laboratory, the other third-stage company, earlier was having trouble with burnouts in the engine's plastic casing, but it was confident of an early solution.

The Martin Co., *Vanguard* systems contractor, is now so confident of success of the project that it has recently hired a special man to handle all *Vanguard* publicity and enquiries. He is Dr. Donald Cox.

Meanwhile, with the last *Viking* having been fired, future launchings in the test series will probably be made exclusively with *Vanguard* components. Though all engines have been statistically tested many times, only one third stage has actually been launched. The tentative schedule now is to fire the GE first stage alone; GE first stage plus Aerojet second; then GE first, Aerojet second plus ABL third.



Aware of the telephoned, mailed and personal plaguing that Dr. John P. Hagen, Naval Research Laboratory Head of Project VANGUARD gets from quarrelsome cranks, well-meaning experts and the idly curious, an NRL photographer montaged Dr. Hagen behind the Vanguard eight-ball, a reasonable facsimile of which m/r reproduces here. Dr. Hagen's comment on seeing it was: "We can't have this kind of erroneous material leaking out of NRL. I have four feet—two of them for dragging when I'm asked to do something I don't want to do."

85TH CONGRESS
1ST SESSION

H. R. 2873

IN THE HOUSE OF REPRESENTATIVES

JANUARY 14, 1957

Mr. KARSTEN introduced the following bill; which was referred to the Committee on Foreign Affairs

A BILL

Officially designating the first earth satellite.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That Earth Satellite Number One be officially designated as the "Astranaut".

For the second straight year this bill, introduced by Rep. F. M. Karsten (D.-Mo.), is shelved in the House Foreign Affairs Committee. Karsten, wondering if the committee feels it doesn't have jurisdiction, has introduced a resolution to set up an Extraterrestrial Exploration Committee. Meanwhile, Astronant is no closer to being a name for VANGUARD'S pay load.

Underground Missile Plant to be Built Near Redstone

HUNTSVILLE, Ala.—The White House-State Department decision to supply the members of the North Atlantic Treaty Organization in Europe with missiles for mutual defense has resulted in an acceleration of activity at Redstone Arsenal, Army Ballistic Missile Agency and the Ordnance Guided Missile School. Employment at the three agencies has risen from 12,000 in December to 14,000 as of now.

And in the wake of the NATO decision several of the companies which have begun operations here in the past few years to work with the missile and rocket development teams at Redstone and ABMA, have been increasing their local personnel and planning for an expansion of activity that seems to be leading them more and more toward the manufacture of larger quantities of components and parts and even complete missiles. These include Chrysler, Thiokol, Aerojet-General and U.S. Industrial Chemicals division of National Distillers.

There has also been increased activity on the part of American Machine & Foundry which holds the rights to excavate nearby Green Mountain for what is commonly supposed to be the first U.S. underground factory for the manufacture of missiles and rockets, coupled with a sort of subterranean "junior Pentagon" where elaborate headquarters would be installed to direct the defense of the southern U.S. against enemy attack.

Several citizens of Huntsville have obtained permission from the State Docks Commission to purchase from the Tennessee Valley Authority some 200 acres of land on the Tennessee River for the purpose of building new docks that would serve the AMF underground factory. The money has been raised for the purchase and final consummation awaits only the completion of legal formalities.

Simultaneously, a new company, known as Chemstone would construct a limestone processing plant to crush the rock excavated from Green Mountain, converted into cement and other products and ship it out via the new docks. Involved in all this activity is a payroll of some 5,200 persons—or at least a 10% boost in the population of Huntsville, which has grown from 16,000 persons in 1950 to 52,000 today.

Another reassuring development has come in the refusal of the team led by Dr. Vernher von Braun to forsake their duties at Redstone and ABMA for many luring offers made by private industry located elsewhere. Despite all the hullabaloo since the Wilson decision of last November and the known presence here of "talent scouts" from a dozen or more large firms deeply interested in missiles and rockets, only one minor defection has occurred from the 125-member team, and this was a very subordinate man who had joined the team late, having come over from Germany only two years ago. So far, the original von Braun coterie of former German missile & rocket scientists remains intact, although von Braun himself and some of his associates have reportedly received upwards of 40 offers from as many outside firms.

Meantime, three well-known firms interested in missiles and rockets have inspected the 800,000 square feet of modern plant space available for purchase or lease following the demise of a cotton mill. All of these are firms which have been manufacturing parts, components and complete missiles.

The quantities of weapons that will be required by the 15 member nations of NATO will certainly give the Army new arguments for expanding its own development and research activitities and perhaps also to build up at last its own industrial complex for the production of missiles and rockets and to create the private industry team, the lack of which has provided critics of the Army with potent arguments.

German Rocket Society Learns by Doing

The Deutsche Arbeitsgemeinschaft für Raketentechnik (DAR) of Bremen, although only two years old, is attracting wide interest in their activities. Headed by an enthusiastic engineer, A. F. Staats, the Society is investigating a number of applications for rockets. In addition to the "oil-spray" rockets (m/r April '57, pg. 88) liquid propellant and hybrid motors are being designed, built and tested. Sounding rockets built so far have reached only modest heights but the fact that all components, including gyro stabilization and recovery gear, have been produced by an amateur group is remarkable. Three-staged sounding rockets are being built to be launched during the IGY. Students joining the DAR are intensively drilled in basic rocket technology and principles of astronautics. Practical experience is gained as helpers and workers in constructing and launching.

German "do-it-yourself" experiment.

Measuring Devices Readied for Satellites

Two new measuring devices are being readied for future use as part of the astrionics gear to be carried in satellites.

Varian Associates, m/r learned, has just received the go-ahead to build a light-weight version of its proton precession magnetometer for measuring values of magnetic field encountered by a satellite during its orbit.

The magnetometer operates using the principle of nuclear magnetic resonance simultaneously discovered by Dr. Felix Bloch at Stanford University and Dr. Edward M. Purcell at Harvard University in 1946.

The two scientists were jointly awarded the 1952 Nobel Prize in Physics for their work which was done independently using different methods.

Varian's estimate of the satellite magnetometer's weight is about 4-4½ pounds with an absolute minimum of 3½ pounds. However, in a report by Varian to the Naval Research Laboratory it was noted that the device would not be ideal.

An ideal device would be able to record, with extremely high signal-to-noise ratio, all values of magnetic field during one trip around the earth.

The information would be recorded and then "dumped" upon interrogation from the ground when the satellite was over a recording station.

However, storage is a big problem at this time, and according to the report, storage of full magnetic field strength may not be feasible in the first tests. Instead, spot checks may have to be made.

A new development in high-capacity light-weight recording devices holds out hope for inclusion of such a system among early experiments.

The State University of Iowa has built a tape recording system that weighs 6½ ounces and has a 48 channel capacity. Bandwidth of the system is 15 kilocycles. Power supply for the recorder will last four weeks.

Another recorder suitable for satellite use has also been built by the Signal Corps. One of the primary scientific tests in which the Signal Corps is interested is measurement of the earths' albedo or cloud coverage.

New Transistors Developed by GE

Development and production of three new high frequency transistors by the General Electric Co. is expected to extend the applications for these devices in equipment now limited to vacuum tubes.

The three new units are germanium tetrodes and one is designed for amplification at 120 megacycles, according to GE.

Characteristics of the new 3N29, 3N30, and 3N31 types call for a minimum gain of 10 db at 30, 120 and 15 megacycles respectively. Dissipation is 50 milliwatts at 25 degrees C.

For local oscillator use frequencies are: 3N29-50-60 mc, 3N30-200 mc, 3N31-30-40 mc.

New Publication On Electron Tubes

A new quarterly bulletin on electron tubes is being published to provide information to government agencies and contractors on research and development programs being sponsored by the military departments.

Known as *A.G.E.T. New Bulletin,* its publication began in January, 1957 to further objectives of the Advisory Group on Electron Tubes established by the Asst. Secretary of Defense (R&D) to achieve an integrated R&D program for electron tubes and semiconductor devices.

Information of a general nature which surveys state of development and new developments just started will be included in the *bulletin.*

Publication is by A.G.E.T. at 346 Broadway, New York 13, N.Y.

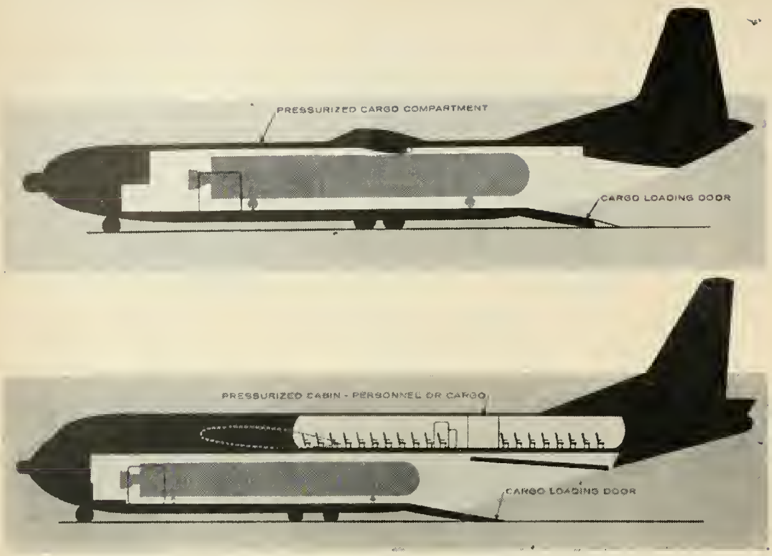
When the problem of sealing is a part of *design thinking* the whole design is bound to be better. This is especially true of *no-leakage* sealing. When your designs require sealing ... from −400° to +1000° ... why not call in one of our field men. One of the "O-seal" family*, may be the answer to save you time, money and effort.

FRANKLIN C. WOLFE CO.

A DIVISION OF PARKER APPLIANCE COMPANY

"sealing design specialist"

Culver City, California



Douglas Aircraft has made a proposal to the Air Force to build some new, giant-size transports capable of hauling an Atlas ICBM to any location in the world. Although WDD's General Ben Schriever is understood to be very much interested in the concept—appreciating the necessity for mobility in a future war—Air Force does not seem to have the funds for the king-size planes right now. No details on performance were given for the proposed aircraft, although some payload specifications have been discussed in the open. The larger version of the Douglas transports would be capable of hauling a complete Atlas and launching crew. Top picture shows C-133 now being built. C-132 is out for the time being. Both planes are turbo-prop powered.

GE Gets $83-Million *Atlas* ICBM Contract

General Electric Co. has announced receipt of a $83-million Air Force contract for "work in connection with guidance of the *Atlas* ICBM."

Role of GE's Heavy Military Electronic Equipment Department which will do the work was announced last year, but the size of the contract was not disclosed.

Also revealed was formation of a new Missile Guidance section of the HMEE department. R. L. Shetler will head the new section.

Shetler noted, "With this job behind us, there will remain no significant obstacles to the practical guidance and navigation of other space vehicles."

GE will divide the work between its Syracuse, N.Y. and Utica, N.Y. facilities. Additional space in Utica has been obtained, and 400 employees have been transferred there from the other Utica location.

Mich. U. to Hold Management Courses

University of Michigan will present a group of courses in management science and computer technology from August 19 to 30.

The short courses will feature a scientific approach to management decisions.

Attention will be focused on a comprehensive approach to planning, organization and control. These will include use of the digital computer, probability, statistical inference, methods of programming business operations and consideration of human capabilities and limitations.

Enrollment is limited to fifty students holding the equivalent of a four-year college course in business, engineering or science.

Transistor Output 59 Million by 1958

Latest forecast on the future transistor market has been released in a market survey made by the Stanford Research Institute for the Philco Corp.

The Stanford report included information supplied by 80 companies who cooperated in the survey.

Forecast was a production of 59 million germanium and silicon transistors in 1958, and 125 million units by 1959.

"PEDIGREE ... 2 TO 3"

Today, Narmco's structural adhesives, laminating materials, coatings, putties and resins have greater strength at higher temperatures . . . allow quicker cures with less preparation . . . are less expensive . . . more readily available . . . and have longer shelf life than ever before.

This has been no accident. It happened because a *key* ratio, possibly unique in the industry, was painstakingly created in the Costa Mesa, California, plants of Narmco Resins and Coatings Co.

The key ratio is 2 to 3!

This is what it means to you. In today's scramble for lighter, stronger, more heat resistant materials, organizations . . . to serve you best . . . must have a potent, steadily growing research capability. At Narmco two researchers . . . chemists, physicists, engineers . . . are employed for every three production workers!

To you who use Narmco products in the production of aircraft and missile parts and assemblies, this means steadily improving materials . . . of a quality you can depend upon . . . at lower cost . . . and delivered when needed to meet tight production schedules!

It also means new materials that *do jobs every day that metals alone can't do* . . . materials essential to the successful design and fabrication of tomorrow's aircraft and missiles!

NARMCO

PIONEERING THROUGH RESEARCH

Narmco technical field representatives throughout the United States and Canada can assist in solving your structural design problems quickly, efficiently and economically. For immediate assistance, write, wire or phone . . .

NARMCO RESINS & COATINGS CO., Dept. 17 600 Victoria Street, Costa Mesa, California

MIT Discloses Work on Inertial Guidance

After 18 years of security classified work in the development of gyroscopic instruments, the Instrumentation Laboratory of MIT opened the door and disclosed some details of their work. At a press conference recently, Dr. C. S. Draper, Director of the Laboratory and head of MIT's Department of Aero Engineering, lectured reporters on basic elements of inertial guidance and showed examples of their Hermetic Integrating Gyro (HIG).

The Model HIG-3 contains a gyro wheel which spins at about 12,000 rpm within a cylinder which floats in a heavy molasses-like fluid within another cylinder. Overall size resembles a tomato can. The floating gyro container pivots on sapphire bearings which are virtually frictionless. It is the concept of the "floated gyro" that is considered a major breakthrough in gyro technology. A miniaturized Model 10-I-G weighs about 3 oz. Power requirements are only 3/8 watt permitting transistorized circuits. It is understood that in May the USAF will make drawings of this circuit available to manufacturers.

Although the principles of inertial guidance are decades old it is only recently that application of new technology has resulted in measurements of much smaller angles and accelerations. This makes the modern stabilized gyro system an important navigating device for military aircraft and the heart of a long range ballistic missile. As Dr. Draper pointed out: "It is not the system but the state of the art which is news."

The Instrumentation Laboratory is under MIT's Division of Sponsored Research. The Staff currently employs more than 700 working in laboratories in Cambridge and at a Flight Facility at nearby Bedford, Mass.

50-Ton Machine Tool Guided by Tape

Details of the first production application of a punched-tape control system to a huge machine tool, using electronics to process blueprint information and turn out precision-built structural parts, have been revealed by the Martin Co. and Bendix Aviation Corp. The new system will be used in aircraft and missile manufacture at Martin's Baltimore division.

Built to Martin specifications by the Research Laboratories division of Bendix, the new system is a 50-ton, three-dimension (engineers call it three-axis) milling machine with associated electronic equipment that eliminates the need for hand-made patterns or master parts which themselves normally require several hundred man-hours to produce.

Dr. Albert C. Hall, general manager of the Bendix Research Laboratories division, explained that the tape-controlled process, technically known as "numerically controlled milling," was first used in mass production by Bendix to solve a bottleneck in the manufacture of a small, intricate cam that is one of the key parts of a jet engine fuel-metering system. In this instance, production of a "master cam" was a one-man job requiring from 5 to 10 weeks of highly skilled work. With the tape-control process, that operation can be completed in from two to four days.

New Electronics Firm is Organized

A new corporation, Era Engineering, Inc., has recently been formed by a group of scientists and engineers with aircraft and missiles industry experience. The company says its objective will be the development of new systems and devices in the fields of electronics, radiation and rocketry. Office facilities and laboratories have been located in Santa Monica, Calif.

The group, headed by Mr. David Shonerd, announces three new systems now available: (1) A simple system for measuring the distance between a missile and its target in a "near-miss" situation; the system will assess the effectiveness of missiles under experimental firing conditions and information will be available to firing crews immediately after impact, (2) a device for measuring the erosion of materials on missile surfaces under hypersonic environments; also available will be a complete system for measuring and recording the thickness of a skin material as a function of time, and (3) a radioactive recovery technique to mark and insure recovery of missiles and missile components after experimental flight.

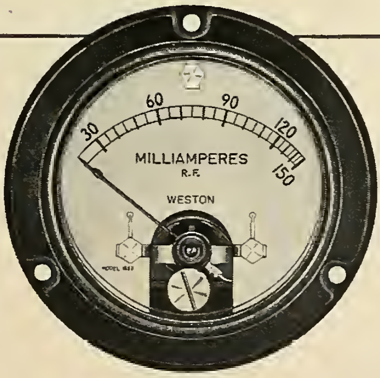
ARDC Sponsors "Smoke Puff"

Operation Smoke-Puff will begin in July this year at ARDC's Holloman Air Development Center. An extension of earlier tests, Smoke-Puff will constitute a detailed analysis of the effects of a man-made electron or ion cloud upon high-frequency radio signals.

time tested shock mount

The critical moving coil in Weston ruggedized instruments is insured against shock damage by these shock absorbing springs in back of each jewel bearing . . . another Weston ruggedized *first!*

The entire instrument movement is then cradled on a shock mount of specially formulated rubber . . . assuring continuous dependable operation in severest service.



A DAYSTROM UNIT

WESTON
Ruggedized
PANEL INSTRUMENTS

Equipment builders can't afford to compromise on instrumentation where service requirements call for instruments that will function dependably under severe impact, shock, moisture or temperature extremes. That's why *approved* Weston ruggedized instruments are so widely preferred. Their sound basic design . . . the *extra* values built-in . . . have proved their superiority under the most rigorous field conditions, providing unmatched performance that more than justifies their cost.

Expanded facilities now make Weston ruggedized instruments readily available for A-C or D-C needs in a variety of sizes and ranges. For the complete story, consult your local Weston representatives, or write . . . WESTON Electrical Instrument Corp., Newark 12, N. J.

Circle No. 12 on Subscriber Service Card.

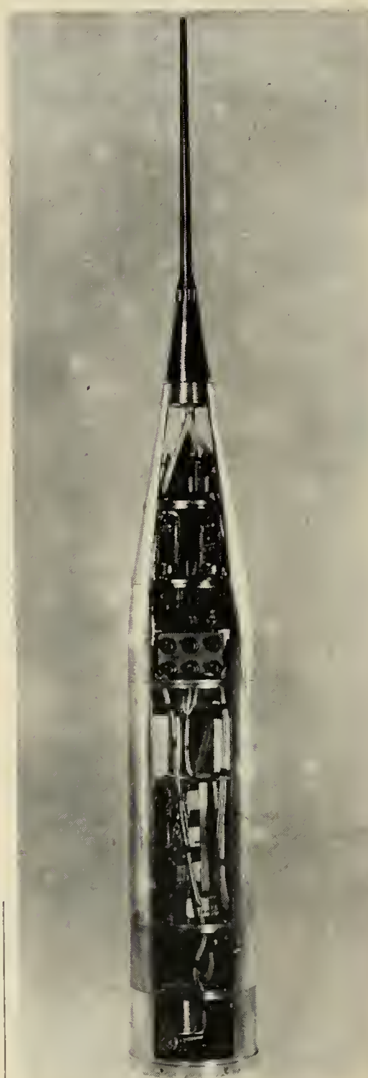
French *Monica* Rocket Performs Well at Low Cost

Designated the *Monica*, the French A.T.E.F.-14 series of three-stage sounding rockets have been undergoing development for more than two years. Utilizing a solid propellant, designated "plastolite," these rockets are notable for high performance, simplicity and low cost. Payloads of up to 33 lbs. have been carried to altitudes of over 300,000 ft.; 17 lbs. to nearly 500,000 ft. The cost per unit is 500,000 Francs (about $1,400). These facts indicate that French development of the art of low cost sounding rockets compares favorably with current U.S. work.

Four Models of *Monica* have been built to date. Characteristics and performance are detailed in the Table shown. In each of the first three models, two designs were tried, Type A in each case carrying double the payload of Type B. *Monicas* have a diameter of 6¼". Lengths vary from 10 ft. to nearly 18 ft.

Construction is relatively simple. The rocket body is of dural about ¼ in. thick. The rocket motor is of steel with a graphite nozzle. The individual stages are mounted in a slip-joint fashion.

The design thrust of the first stage is sufficient to take off from the launching ramp and achieve a velocity above Mach 1 in less than 5 seconds. Ignition of second and third stages is governed by time-delay relays designed to obtain maximum altitude. The rockets are shipped with propellant loaded. Ignitors and upper-stage firing relays are installed just prior to launch. Firing circuit runs on 12v. battery.



MONICA instrumentation.

Monica's normal payload consists of instrumentation such as accelerometer, aneroid capsule, pirani gauge, and/or cosmic ray measuring devices. Telemetering is accomplished on AM-FM bands of 4-6 channels. Other research programs contemplated or underway include experiments with animals (recovering by parachute), temperature probes and release of chemicals in the ionosphere to study the resultant reactions. Firings have also been made with "window" to study the nature of winds and tracers to measure trajectories accurately.

TABLE OF CHARACTERISTICS AND PERFORMANCE OF THE *MONICA* SERIES OF ROCKETS (A.T.E.F.-14)

	MONICA I		*MONICA II*		*MONICA III*		*MONICA IV*
	Type A	*Type B*	*Type A*	*Type B*	*Type A*	*Type B*	
Dimensions							
Length (in.)	11' 10"	9' 10"	12' 10"	10' 11"	17' 9"	15' 11"	16' 10"
Diameter (in.)	6¼"	6¼"	6¼"	6¼"	6¼"	6¼"	6¼"
Weights (lb.)							
Launch	154	136	172	156	276	260	271
Propellant ("plastolite")	62	62	74	74	137	137	136
Payload	33	15.4	33	16.7	33	17.6	33
Total Burning Time (sec.)	23	23	25	25	25	25	25
Acceleration, max. (g)	9.8	10.56	8.7	9.7	11	11.7	11.3
Performance							
Velocity, max. (ft./sec.)	2540	3240	3570	4550	4420	5290	4550
Altitude, max. (ft.)	120,000	173,500	220,500	339,000	347,000	475,000	307,800
Time of ascent (sec.)	93	112	129	158	158	184	152

ROCKET POWER PROGRESS REPORT

Taming Rocket Powerplants

by Walter O. Borcherdt

In charge of the Engineering Development Laboratory as well as the Valves and Controls Section at RMI, Mr. Borcherdt has over a decade of rocket experience. Before coming to RMI in 1951, he was senior project engineer on controls in the rocket department of Curtiss-Wright Corporation. Mr. Borcherdt received his degree in mechanical engineering from Stevens Institute of Technology in 1938.

Reliability of a rocket powerplant is the direct result of the simultaneously correct operation of all of its elements. Generally, this is assured by overcoming each element's own peculiar development problems. Among these elements is one type which has the interesting property of being composed of specific components, yet whose operational characteristics are significant only in the performance of the entire powerplant system. This element is the control system.

Present powerplant controls requirements are based on these straightforward, simple considerations:

1. **Prepare the powerplant for firing**
2. **Sequence and control the system to rated thrust**
3. **Vary thrust rapidly and safely as required**
4. **Shut down smoothly**

Step one may require the use of gas pressure regulators and relief valves to push the propellants safely from tankage to pumps. There must be switches and relays to indicate or control the valves which admit propellants to the gas generators and combustion chambers, and time delay cutouts to insure against unsafe accumulation of propellants.

In step two, ignition and combustion may be monitored to insure correct use of the high energy release rates. Turbines may be safely brought up to speed by throttling the propellants. Safety devices may be added to limit over-speed and avoid the danger of structural failure.

In step three, a controller (it may be hydraulic, electric, pneumatic, or a combination) is used to vary thrust. Here multiple loop servo systems are sometimes used to insure that thrust change rates, turbine speeds, vehicle acceleration or terminal velocity, and other parameters vary in a coordinated manner.

Finally, in multiple stage powerplants or piloted vehicles, the rocket engine must be shut down safely and the system automatically purged of propellant accumulations.

The successful implementation of these four steps involves the application of many devices of unique characteristics whose individual selection is intimately tied to the following question:

"What is the actual control system problem to be solved?"

Once this question is clearly and consistently defined, a tight performance envelope results. This makes the few possible solutions fairly obvious. The final stage is to apply the knowledge of a team of control specialists and proceed through the usual component development stages. At RMI, this team of specialists in controls engineering is made up of highly qualified mechanical, electrical and chemical engineers. These professional men have wide experience in the creation of control units and systems for rocket powerplants as well as other types of propulsion systems. However, there is a continuing need for qualified graduate engineers, able to participate in working closely with other groups of specialists, integrating the control system into the overall engine performance envelope.

The systems approach is of extreme importance to successful rocket powerplant control efforts. It is a standard approach of the RMI Controls Section. Sequence system design, switching circuit analysis, human engineering, feedback control methods, statistical procedures, information theory and latest research data on fluid flow control are among the techniques used. They are applied along with practical design concepts which result in the development of simple but effective controls systems.

If you desire one or more reprints of Mr. Borcherdt'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, New Jersey.

Power for Progress

4946

Russians Backtrack On *Mouse* Origin

The Russians seem to have been embarrassed by m/r's disclosure last November that a Soviet magazine was guilty of satellite design plagiarism. They appear to be making amends. m/r pointed out that a cross-sectional schematic satellite drawing attributed to engineer B. Lyapunov and artist N. Antonov was an exact copy of one of Dr. S. Fred Singer's early *Mouse* versions. Now engineer Lyapunov has written a new two-page article on foreign rocket and earth satellite developments for the Russian magazine *Znanie-sila* (Knowledge Is Power). In it, Lyapunov uses virtually the same artificial satellite drawing that bore his name in the previous story. But this time he gives Dr. Singer full credit for the design both in the picture cutlines and in the article's text.

AF to Track Drones With Decca System

According to a report from an industry source, the Air Force is planning use of a Decca Navigator system to keep track of its target drones.

The drones would be equipped with Decca equipment to receive signals similar to those used in Great Britain for air and sea navigation.

Drones which "go over the hill" would transmit Decca coordinate information to search crews through telemetering equipment onboard. Exact location of the drone could be quickly determined.

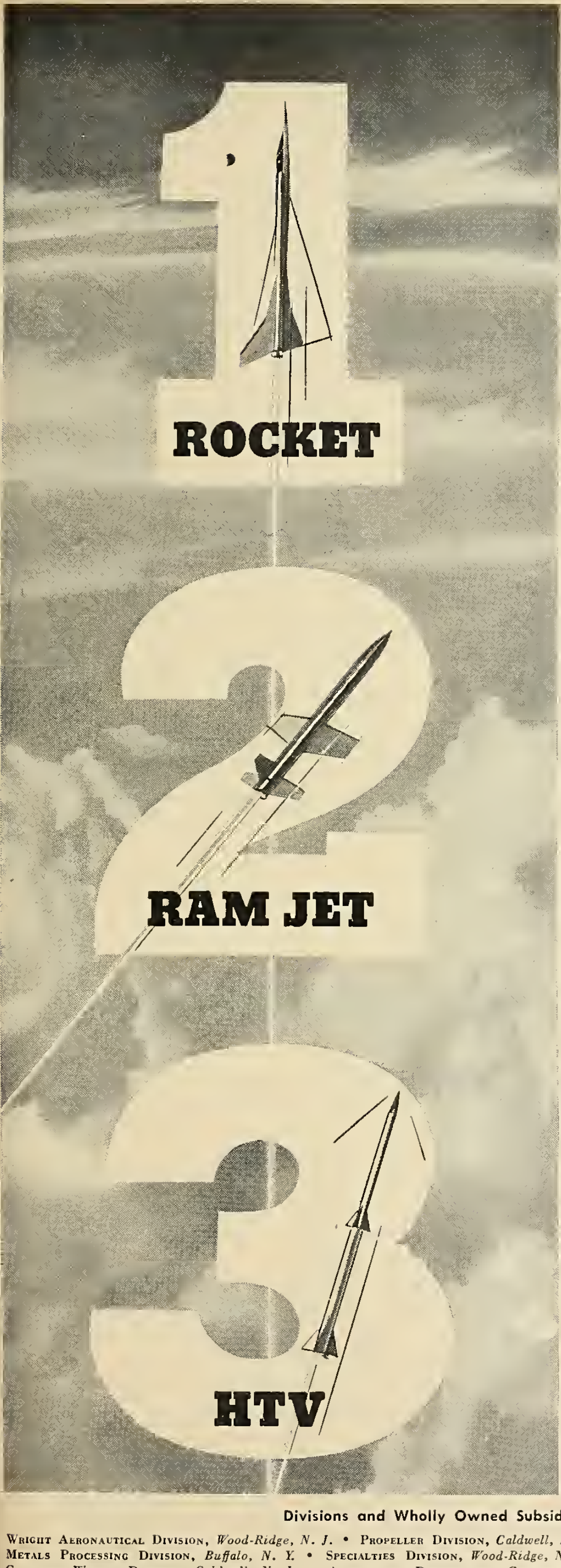
Equipment would be supplied by the Bendix Pacific Div., Bendix Aviation Corp. which supplies Decca Navigator Co., Ltd. equipment in the U.S.

IRE Convention To Meet in June

A National Convention will be sponsored by the IRE Professional Group on Military Electronics in Washington, D.C. on June 17-19, 1957.

Admiral W. E. Cleaves, Bendix Radio Division, Bendix Aviation Corp. will chair the convention which will theme "Missiles and Electronics."

Appointed to the executive committee as staff advisors for the convention are assistant secretaries of defense Frank Newbury and C. C. Furnas.



1
ROCKET
2
RAM JET
3
HTV

Missile Miscellany

This page is politically independent but skeptical . . . so it wonders:
——If it's to use up surplus funds that Post Office is investigating the possibilities of rocket mail service . . .
——If Defense Secretary Wilson, wandering about Patrick AFB and possibly holding his ears against Jupiter's roar, may have decided after all to learn something first-hand about missiles . . .
——How many realize how ineffectual true military security is; how effective Pentagon censorship has become; how it helps Uncle Joe's heirs and how it hurts Uncle Sam's . . .

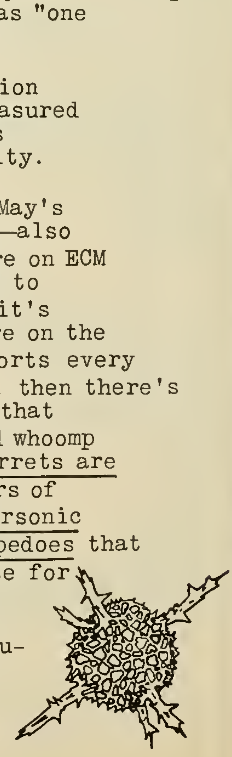
The other night at a philosophical function, an ICBM propulsion engineer asked this page: "The missile's here to stay, but is man?" . . . and from an atom editor emeritus, a quip about Pentagon Security Review: "A certain type of cat gravitates to the job.'' . . . and a simple explanation of things complex by Commerce Undersecretary Louis S. Rothschild before House Appropriations Subcommittee: "In other words, the whole purpose of SAGE is to bring aircraft together, so that they can hit one another with ballistic missiles of one kind or another"—at last a mission for Jupiter? That same evening a Relativity novitiate wondered if anyone had ever stepped back and looked at the velocity-dependent approach of mass to infinity as a drag effect in an as yet undetected medium.

To prove that truth is stranger: Once upon a time an AF general telephoned m/r to ask: "What are you, an Army house organ?" And it came to pass within a fortnight it was heard from out the jungles of commerce this charge by an Army-contracted advertising prospect: "You're just an Air Force house organ!" After this issue of m/r, what?

Missile has now been defined as an "airplane which saves manpower by eliminating the pilot but takes 372 men to launch . . ." And a classified missile as "one which only a news magazine may print a picture of . . ."

The limiting problem in inertial guidance accuracy are the integration circuits (giving a series result) needed to transform inertially measured acceleration into velocity and then distance. One answer that works eliminates one integration step by using thrust control to fix velocity.

About faces—this page just heard about SAC Chief General Curtis LeMay's when first he saw movie of Sidewinder disappearing up jet tailpipe—also after he was assured it too could be given nervous breakdown . . . more on ECM reveals it's essential sometimes to drop the "E" and in same business to make sure nobody pushes wrong button and sucks attacker into target it's planned to take the fingers out of pushbutton warfare . . . still more on the unessentiality of man, a computer now watches other computers; reports every so often with complete psychoanalysis of its charges' troubles . . . then there's the early Bomarc test when condensation gave full nose down reading (that wasn't) and "corrective" control caused it to do two inside loops and whoomp smack alongside blockhouse . . . B-52's sometimes troublesome gun turrets are to be replaced with missile batteries . . . and talk too this page hears of radar invisibility . . . still serious, talk in high quarters of supersonic underwater flight—over 2700 mph . . . work at Aerojet on rocket torpedoes that top 140 knots—which may be related to Minneapolis-Honeywell guidance for "long-range" torpedoes and GE sonar detection gear good well over 100 miles . . . an expert says we know less about the ocean than we do surface of the moon . . . GE missileman sees rocket on moon with instruments and transmitter (look ma, no men! again) inside 20 years—whatsa delay! . . . if plankton dreams of oceanographers come true, to right is hydroduct fuel of the future . . .



Rocket Trends

By Erik Bergaust

When we let our editors, correspondents and contributors loose on the subject of underwater warfare, submarine missiles and torpedoes, we learned one thing: the United States Navy is doing a tremendous job in this field—but industry is not at all aware of the fantastic possibilities that this field offers. True, many companies are working intensively on many sophisticated undersea warfare projects, but we found—nevertheless—that some of the most potential missile manufacturers did not even comprehend the concept of underwater missiles!

On the other side, we think it is appropriate to mention that many of the companies actively engaged in underwater missiles are so deeply involved in top secret work that the matter of covering their activities editorially was out of the question. But let us mention a few of them—without disclosing what they are doing—*Fairchild, General Electric, Convair Pomona, Raytheon, Coleman Enginering, Philco, General Mills, Minneapolis Honeywell, Brush Electronics, Clevite Research, Aerojet, Avco* and many others.

Yet, a good portion of what this country is doing in the field of underwater missile and submarine warfare is disclosed in the columns of this issue. As our publisher has pointed out in his editorial, this was made possible through the kind cooperation of Navy's Security Review Office. Perhaps we have only revealed a fraction of what's going on in this country—at any rate, let it be a warning to Russia's submarine commanders and their bosses in case they should be dreaming of a big surprise submerged mass attack on this country.

Our Navy is the number one marine defense force of the world. And in view of its meticulous efforts to advance itself in this field of silent, submerged warfare, and its awareness of the Red submarine threat, we can only invite industry to back our Navy in these efforts. It is crystal clear now that any Russian attack on this country will be a combination air-underwater assault. Her 500 to 600 submarines, eventually, would be used as missile launching platforms off our coasts. This is a rough threat—and a horrible thought—and we may not be prepared for this sort of thing. On the other hand, we have no reason to believe that Russia has perfected her entire submarine missile fleet and that she is ready for this kind of attack. And whenever she does get prepared we shall be equally capable to deter any such aggression.

The concept of undersea missiles is not new, but the application of such weapons is. Consequently, we have a long way to go. That's why industry must wake up right now and accept this important challenge. That's why inventors and designers must offer their ideas and suggestions now—so that our underwater early warning systems of the future and our anti-submarine weapons and missiles will be as supreme and deadly as our ballistic and anti-aircraft missiles.

We cannot tell now whether tomorrow's underwater super missiles will be propelled by solid rockets, electric motors, turbines, or what; we don't know whether they will be sonar-guided devices, or whether they will employ completely new guidance concepts. That's why there is room for a vast amount of research and development in this field, and that is why the goal of bringing about superior underwater missiles—whether they are designed to knock enemy planes out of the skies, or hit enemy subs or surface targets—should be pursued by every missile engineer.

This is the eighth issue of m/r. It is the second Navy issue. For good reasons. In fact, we now have published two Navy issues, two Air Force issues and one Army issue. Next? We have a vast field to cover. So we shall leave the services for a while and concentrate on the industry itself.

Washington Spotlight

By Henry T. Simmons

Flight test results for major new missiles are pouring into the Pentagon at a rapid clip as the tempo of firings picks up at Patrick AFB, Fla. The flood of data brings with it a new problem which may increasingly concern the military services and their civilian directors: how well does the tax-paying public and its press understand the basic philosophy of the missile flight test program? After hearing for many years the loud claims of the excellence of this or that service's weapons, it is not surprising if the public has become confused about the missile program, and even a little disgusted, as newspaper reports crop up headlining the explosion of a *Jupiter* or the failure of a *Thor*.

•

The purpose of a missile flight test program, in a nutshell, is to make the bird fail under informative conditions. Paradoxically, the missile which sticks to its flight plan is not providing information as valuable as the vehicle which blows up on its launching stand under circumstances which can be analyzed, duplicated and then obviated for all time. Keeping this in mind, it is easy to see that most of the recent firings at Patrick have been "successful" from a test standpoint, even though they would have been abject failures if they occurred on the battlefield.

•

The "big one" which Defense Secretary Charles Wilson saw fired at Patrick last month was the second flight test of the Army's *Jupiter* mid-range ballistic missile. The power lasted less than two minutes, with the bird apparently "failing" under circumstances similar to those in which its predecessor was lost earlier this year. One theory is that an eddy current formed by air blast at the skirt of the big missile drew rocket exhaust flame up around the base of the weapon and burned out some wiring.

•

A jittery range safety officer brought the second flight test of the Air Force's *Thor* mid-range ballistic missile to a sudden end in April. In a flight of about 40 seconds' duration, the big Douglas missile was sluggish in responding to its auto-pilot and appeared headed toward the mainland. Mindful of the time an Army *Redstone* fell on a nearby launching pad (thus becoming the world's first Inter-Pad Ballistic Missile), the safety officer detonated the *Thor* before it could do any damage.

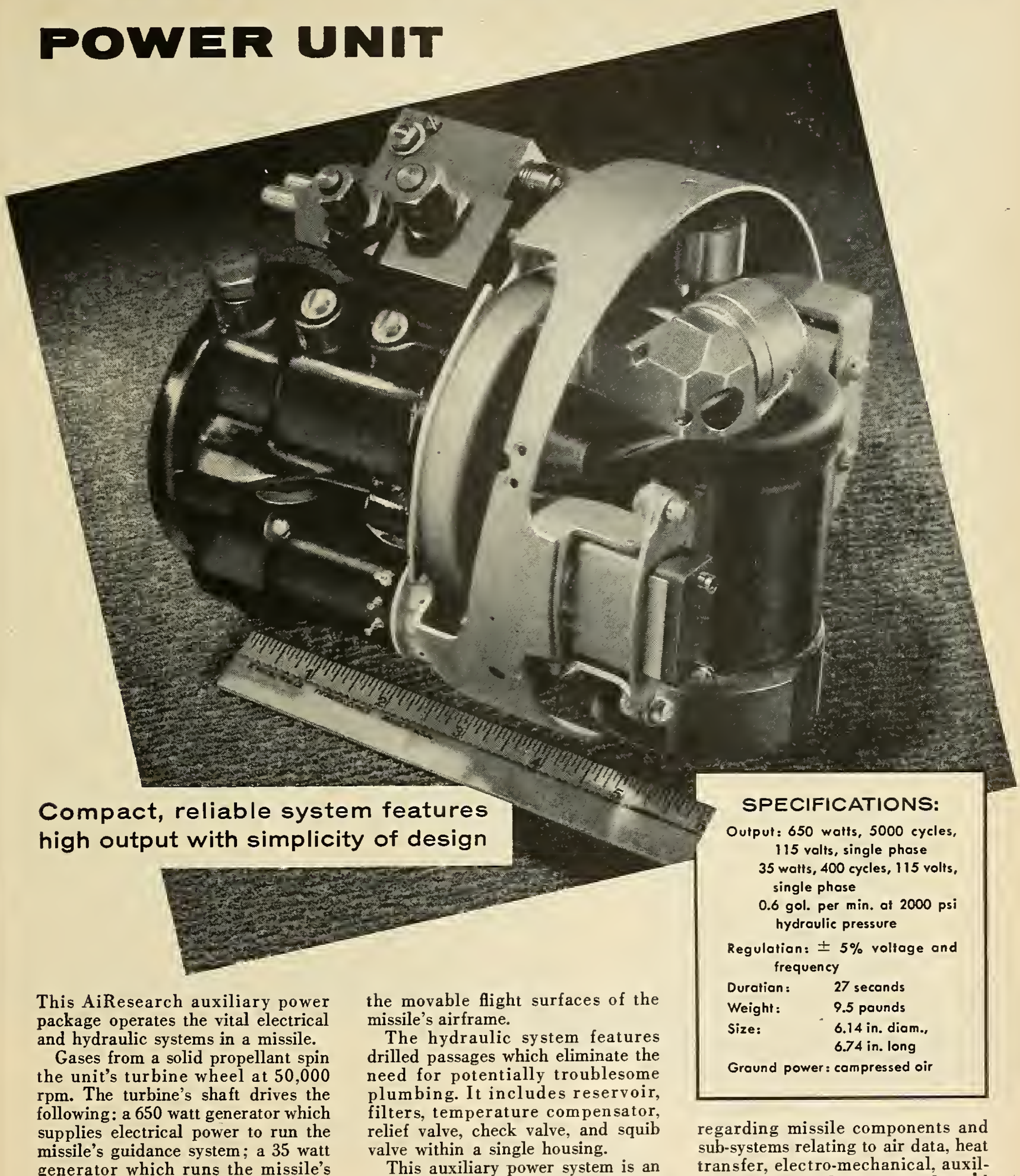
•

North American's rocket-ramjet *Navaho* intercontinental missile also got a second test flight about mid-March, it was learned. Despite grave and almost comical difficulties, it succeeded in demonstrating two major features of its operation—booster separation and ramjet ignition. The big bird accidentally carried part of its launching apparatus away during firing. Air blast finally tore loose the unwanted super-cargo, but this caused the booster to lose thrust. Nevertheless, the booster engine separated as programmed and there is evidence of ramjet ignition before the XSM-64 test vehicle plunged into the sea.

•

Look for the Air Force to seek Defense Department authorization for a prototype development program for the WS-110 manned bomber sometime next fall. This is the successor to the B-52 which Boeing and North American are presently working on. The airmen won't succeed without a battle, however. One Pentagon official says privately he will object to a WS-110 hardware program until an engine is clearly in sight which can use high-energy fuel. There's also the matter of money. Military spending during the current fiscal year is likely to hit $38 billion—$2 billion more than the Administration predicted in January—and the Pentagon will be inclined to go slow on ultra-expensive new projects.

AiResearch MISSILE AUXILIARY POWER UNIT



Compact, reliable system features high output with simplicity of design

SPECIFICATIONS:

Output: 650 watts, 5000 cycles, 115 volts, single phase
35 watts, 400 cycles, 115 volts, single phase
0.6 gal. per min. at 2000 psi hydraulic pressure

Regulation: ± 5% voltage and frequency

Duration:	27 seconds
Weight:	9.5 pounds
Size:	6.14 in. diam., 6.74 in. long

Ground power: compressed air

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.

The hydraulic system features drilled passages which eliminate the need for potentially troublesome plumbing. It includes reservoir, filters, temperature compensator, relief valve, check valve, and squib valve within a single housing.

This auxiliary power system is an example of AiResearch capability in the missile field. Inquiries are invited regarding missile components and sub-systems relating to air data, heat transfer, electro-mechanical, auxiliary power, valves, controls and instruments.

Outstanding opportunities for qualified engineers

THE GARRETT CORPORATION

AiResearch Manufacturing Divisions

Los Angeles 45, California . . . Phoenix, Arizona

Designers and manufacturers of aircraft and missile systems and components: REFRIGERATION SYSTEMS • PNEUMATIC VALVES AND CONTROLS • TEMPERATURE CONTROLS CABIN AIR COMPRESSORS • TURBINE MOTORS • GAS TURBINE ENGINES • CABIN PRESSURE CONTROLS • HEAT TRANSFER EQUIPMENT • ELECTRO-MECHANICAL EQUIPMENT • ELECTRONIC COMPUTERS AND CONTROLS

Circle No. 15 on Subscriber Service Card.

VOL. 2 NO. 5

MAY, 1957

missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS

m/r exclusive:

UNDERWATER MISSILES

A New Lethal Dimension in Unmanned Warfare

by Comdr. Charles W. Rush

AS A MEANS of delivering weapons against targets at sea or on land, the submarine possesses unique advantages over other weapon system. Cruising beneath the radar and visual detection stratum, somewhere in thousands of cubic miles of ocean volume, the submarine is not readily susceptible to being destroyed by surprise attack.

The advent of nuclear power has greatly enhanced the capabilities of the submarine. In addition to the almost unlimited submerged endurance and high speed which it contributes, nuclear propulsion makes the submarine a true all-weather ship. Not only can the nuclear-powered submarine ride out the worst storms in comfort and safety, it also can navigate under the Arctic icepack at any time of the year.

With the post-war change in the submarine forces' primary mission from destroying surface ships to sinking enemy U-boats, the requirement for a submarine-launched anti-sub weapon became paramount. Even the best anti-surface torpedo could not meet this new requirement—the problem had expanded into a new dimension.

Intensive research was applied to find a solution to the three-dimensional attack situation. The answer to this difficult problem was found in the conception of a homing torpedo that would guide itself to the noise emitted by a moving submarine. While this weapon unerringly seeks out a target sub, it is equipped with safety devices to protect the firing ship.

Another underwater-to-underwater weapon—one with a delayed action—is the submarine-laid mine. The submarine can first determine its exact navigational position, then lay these deadly "eggs" from its torpedo tubes in the location where they will do the most damage to enemy ships. Mobile mines have been developed which permit the submarine to remain outside an enemy harbor, while planting a minefield several miles distant.

After the war, the Navy recognized that the combination of the submarine and the guided missile would provide an effective system for deterrence of large scale aggression. In order to gain immediate experience with this system, the *Loon* missile, a modified German V-1, was fitted for shipboard.

Two submarines, *USS Carbonero* and *USS Cusk*, were equipped with launchers and radio command systems for guiding *Loon*. These early operations provided valuable experience, training, and testing for application to the higher-performance submarine missile systems which were to follow.

In 1947, the Navy initiated a program with the Chance Vought Aircraft Co. to develop a guided missile for launching from submarines. The result was the *Regulus*, a swept-wing, turbojet-powered, transonic missile capable of delivering an atomic warhead to a range of 500 miles. Two submarines, *USS Tunny* and *USS Barbero*, were converted to carry *Regulus* missiles.

In 1956, the Navy decided to complete the attack submarines *USS Grayback* and *USS Growler* as guided missile submarines. At the same time, construction was started on the first nuclear-powered guided missile submarine, *USS Halibut*. All of these submarines are designed to carry the *Regulus* missile.

Testing is now underway on *Regulus II*, a longer-range, supersonic replacement for the original *Regulus* missile. The configuration of all new air-breathing surface-to-surface missiles will be compatible with the new guided missile submarines, in order that the different missiles can be used interchangeably. This planning will expand the missile delivery capability of the new guided missile submarine. It will also extend the useful life of the submarine beyond the life of any one particular missile design.

(Ed. Note: To follow up the REGULUS II the Navy has the Triton development program, a Mach 4.0, 1500-mile range ramjet powered missile that will fit Regulus launching gear with only minor modifications.)

Spinning ball entering water at high speed leaves cavitation wake of water vapor similar to aerodynamic turbulent flow, exemplifying major underwater weapons system problem.

In addition to the air-breathing guided missiles, the Navy is working at high priority to develop a rocket-powered ballistic missile which can be launched from submarines. This is not an ultra-visionary weapon; its accomplishment is entirely within the current capacity of our missile technology.

One of the major areas requiring intensive development for successful utilization of long-range ballistic missiles is precise, all-weather navigation. Various new equipment being tested in the *USS Compass Island* promise to provide means of attaining the required accuracy, even under the darkest overcast conditions.

(Ed. Note: There are several approaches to precise underwater navigation. One might be the use of inertial systems similar to those now being developed for long range ballistic missiles. Another is the establishment of precisely located beacons on the ocean floor which could be "shot" the way aerial missiles now shoot the stars.)

Our subs are equipped with two types of sonar: active and passive. Active sonar is capable of determining both range and bearing of submerged targets, but it must send out detectable energy to do this. Passive sonar does not transmit energy to the water, but furnishes target bearing information.

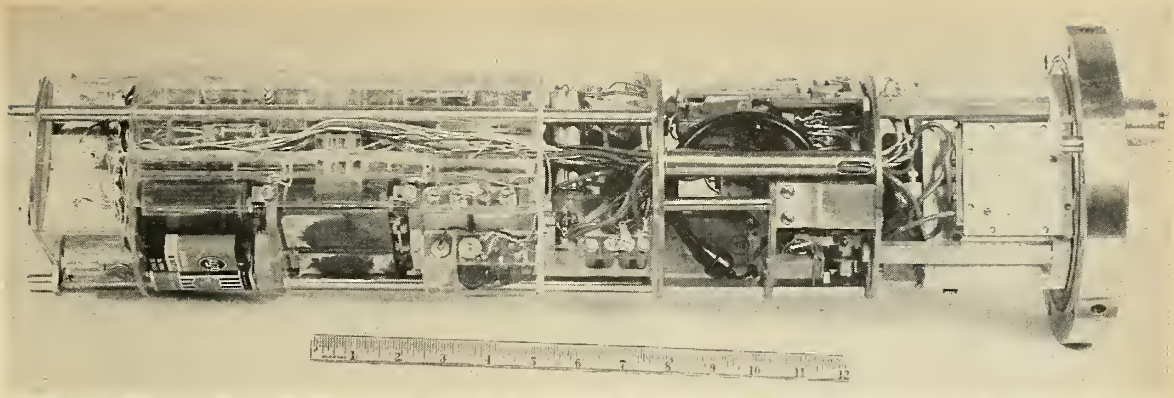
Against fast-moving targets, an automatic computer is needed for rapid analyzation of target and firing-submarine data. The trend in computer design is to equipment which resembles an electronic "brain." It must receive inputs from the sub's gyro-compass and underwater log, select data from the radar or sonar, perform complicated mathematical calculations in a fraction of a second, digest the data, predict the target's position on weapon arrival, and aim the weapon.

With the captain's permission, which he may give by throwing a switch, the computer can actually fire the weapon. Remarkably, computers have traditionally been one of the most reliable elements in our submarine weapon systems.

Future, foreseeable advances in submarine performance will place great demands on anti-submarine weapons. Submarines will run faster and deeper; weapons against them must follow. Our own submarines will be able to operate in the depths where enemy subs can be detected most readily; they must be equipped with weapons that have a high probability of sinking the high-performance submarine.

First, in order to minimize the time during which the target can evade and to reduce pursuit time after acquisition is made, advanced undersea weapons must be able to make high

A major hydrodynamic problem with torpedoes is that they may cavitate and



Showing that underwater instrumentation is not dissimilar to that required for airborne missiles, this assembly is used for studying the depths of the ocean. From left to right are: the battery and voltage regulator assembly; next, in order, comes the depth marker and pulse generator telemetering tube assembly and telemetering deck including servo-control tube for photomultiplier, pressure (depth) bourdon and linkage to microtorque potentiometer, function selector rotary stepping switch, ratchet relay, access plate to sealed photomultiplier and assembly aligning pin. A detailed study of the ocean's characteristics is vital to the successful development of modern underwater weapons systems.

speed. Secondly, as the maximum range of underwater detection equipment is increased, weapon range must be augmented to match. Enemy subs must be taken before they can strike.

At torpedo speeds greater than approximately 50 knots, the screw propeller's efficiency and ability to transmit power to the water decreases rapidly. This is caused by cavitation, which also causes radiated noise to increase substantially. To overcome these difficulties, very-high-speed torpedoes must be designed with optimum hydrodynamic form and jet propulsion.

Underwater jets may be of two general types: rockets and hydroducts, corresponding to rockets and air-breathing jets in the atmosphere. The disadvantages of rockets for underwater - to - underwater applications are that they must carry all of the mass required for propulsion and that their velocity and efficiency are limited by the resistance of the viscous medium. In order to gain high speed while retaining long range, underwater jet propulsion vehicles will probably utilize the hydroduct principle, which uses ambient water to increase the mass flow rate.

Even jet-propelled torpedoes have practical speed limits, which will be reached when their velocity causes the waterflow to break away from the torpedo shell. At this point, cavitation will take place on the torpedo body in the same way as on the propellers of slower torpedoes at lower velocity.

Cavitation caused by the torpedo body will present serious control problems; depth and steering rudders will be acting in an unstable flow pattern, caused by cavitation bubbles forming and collapsing. Alternate methods of control, such as jet vanes or controlled jet streams, will be necessary to direct the very-high-speed torpedo.

As the ranges of detection and location equipments are extended beyond their present capabilities, greater weapon velocities will be needed. Time of flight must be kept sufficiently short to insure getting the weapon within effective radius of the target.

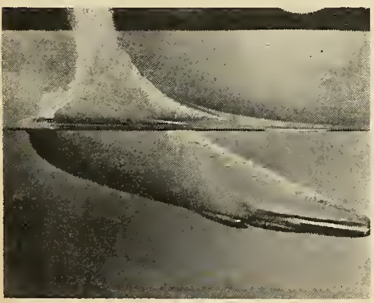
It may prove to be impracticable to design reliable underwater-to-underwater missiles with enough speed to reach extreme ranges in short enough time; thus, air-borne rockets may be the only feasible means of attaining the exceedingly high speed required.

(Ed. Note: This concept of the underwater-air-to-underwater missile is believed to be the subject of a development contract recently placed with Convair's Missile Division. Ideally, this missile would fit the torpedo tubes of current, conventional submarines and have a range of about 100 miles. This has been referred to as a Submarine Launched Inertial Missile—SLIM.)

Increased weapon range will give rise also to a requirement for new techniques to maintain terminal accuracy. One method of accomplishing this is to incorporate some type of remote guidance in the system.

It is feasible to adapt beam-rider guidance, similar to that used in anti-aircraft guided missiles, to underwater weapons. This will increase the probability of bringing the torpedo to within lethal range of the target at maximum range. Another possible means of increasing the kill probability at long range is to increase the lethal radius of the torpedo warhead. An atomic warhead could fulfill this requirement.

Recent technological advances—nuclear power, missile development, advanced hydrodynamics — have been advantageous to the submarine from the standpoint of both offensive and defensive power. A large expanse of rapid progress lies in the future.★



. . . due to uneven pressures to porpoise out of the water and off course.

Russia's Answer to Our SAC Bases

Development Of IRBM-launching Submarines Permits Soviet To Lag Behind In ICBM Work

by Anthony Vandyk

THE SOVIET NAVY's submarine fleet represents to Russia what the U.S. Air Force's Strategic Air Command represents to the U.S. SAC bases ring the Soviet Union. No major target in Russia is out of range of the USAF's B-52s.

For the Russians, however, no overseas bases are available. Even if the Red Air Force could obtain the use of bases in such countries where a strategic attack on the U.S. could be mounted, there is little indication that the bomber aircraft currently operated by the Russians would be suitable for use from such facilities. The Russians have not developed flight refueling anything like to the the extent that the USAF has pushed the technique. It is known that tests are being run for flight refueling the *Badger* (B-47 equivalent), but best intelligence information indicates that the big *Bison* (likened to the B-52) is not equipped for refueling in the air. The big 400,000 lb. turboprop *Baer* is likewise not equipped for flight refueling.

Without air bases and suitable flight refueling facilities for their modern bomber aircraft, the Russians would be in bad shape were it not for their submarine fleet. All evidence indicates that the Soviet submarines are in every way as efficient for Russia as SAC is for the U.S. The Russians have inherited all of Germany's know-how in the field of underwater warfare. The Red Navy took over most of what was left of Germany's World War II submarine fleet and certain construction facilities for underwater vessels.

In particular the Russians carried on development of the W-class long range submarine. The W-class submarine has a snorkel for submerged operation and combination diesel-electric powerplant and is a long-range ship.

The Russians also took over from the Germans underwater launching systems for guided missiles. There is evidence that much of the Red submarine fleet is fully equipped to launch IRBMs from underwater.

The Russian submarine fleet is currently in operational status. It does not remain in Soviet-dominated waters but sails to distant points in readiness for eventual operation.

Last month Senator Styles Bridges (R-N.H.) and m/r Managing Editor Erik Bergaust reported that a dozen submarines had been spotted off Cape Canaveral, Florida, where the U.S. are testing long-range missiles. "The story was not substantiated but we do know that the Russians spare no effort to

Two methods for launching underwater solid propellant rockets studied in this country are the tube-launching principle and vertical launching through the conning tower. Latter method might be employed for the Polaris. Both methods have been considered by the Russians.

learn what we are doing," Bridges stated then.

Other Russian submarines have been sighted near Japan, Newfoundland, and the Bahamas. The U.S. Navy does not comment on these reports but it is known that a large part of its current pre-occupation centers around the threat of the Red submarine fleet.

In the 12 years that the Russians have been working on the development of the German W-class submarine substantial progress has been made in several areas. Speed has been increased and range has been improved. But the most important development is the perfection of techniques for launching missiles from the submarines. It is estimated that every Russian submarine now under construction—production is at the rate of almost one a week—is equipped to launch an IRBM (FBM). The Russian submarine fleet in operation today includes between 400 and 800 vessels. Many of these are early models which are not equipped with missile launching facilities but probably at least a quarter of the fleet is comprised of modern types fully equipped for launching the IRBMs.

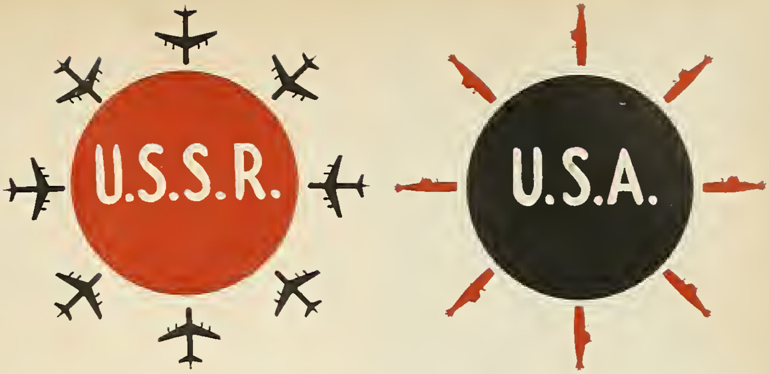
Though there's little reliable information as to the state of Russia's submarine missile art, they had a basis to start from 12 years ago—two methods for underwater launching worked out by the Germans but never put into actual operation. As reported previously in m/r, in one case small solid-propellant 21 cm *Borsig* rockets were mounted in external racks on the submarine's deck. These could be fired from under water by controls mounted within the submarine. This weapon system now is believed to have been developed to perfection by the Soviets. With this missile system the Red submarine fleet forms the greatest single threat to United States military security.

Even though U.S. anti-submarine warfare has reached a high state of effectiveness, it's still far from 100%. And with small-but-powerful nuclear warheads a reality, even 20% of Russia's submarine fleet launching even primitive missiles against our coastal cities could cause severe damage.

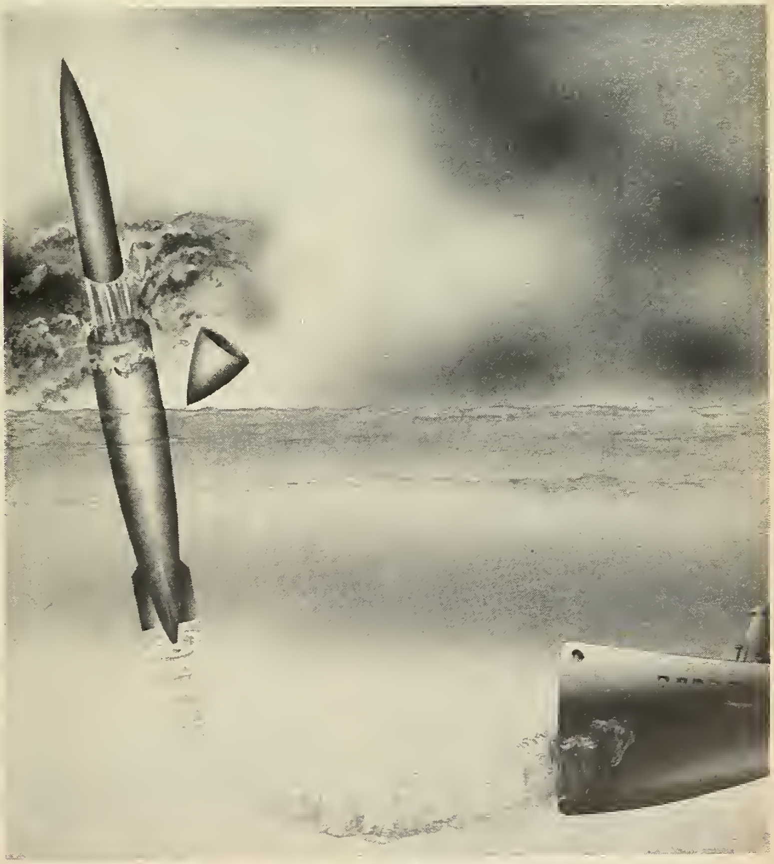
It is interesting to note that the Russians put great emphasis and faith in any weapon system developed by the Germans. In terms of missile systems, all major German concepts seem to have been adopted and accepted fully by the communists, such as the V-2, the *Reintochter*, the *Borsig* solid-propellant sub missiles, as well as the container-hauled V-2s.

While the Russians had great faith in the Germans and their missile technology and capability, and while several German scientists have enjoyed high privileges in the Soviet since the last World War, indications are the Russians are getting tired of playing with German post-war hardware. They have activated several all-Russian missile programs, and there is no reason to doubt that an all-out submarine-missile program is heading the list.

In addition to submarines, the Soviet Navy has a number of surface vessels equipped as missile ships, but these are of relatively minor importance since they can be easily detected. The submarine poses a very different problem, particularly when equipped with underwater missile launching facilities. It is a very difficult target to hit. Certainly the Soviet submarine threat to the U.S. is every bit as serious as anything that has faced the nation. ★



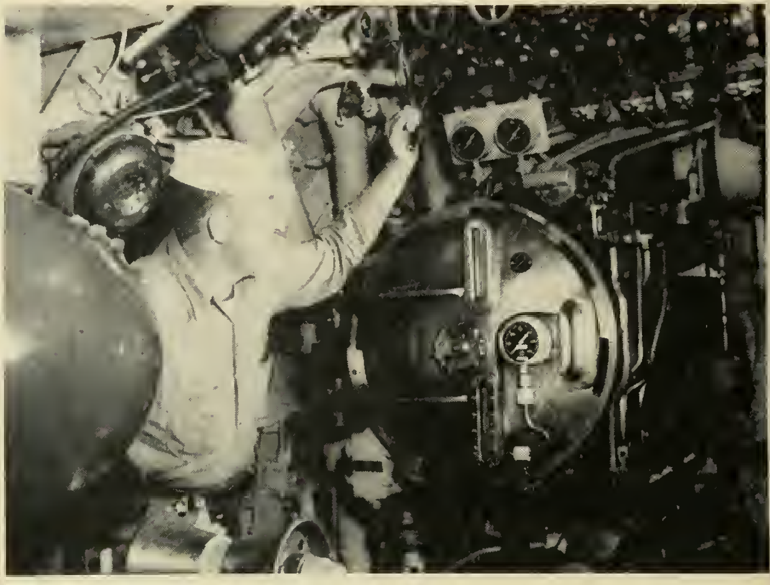
While the Soviet is completely surrounded by our SAC bases, we are faced with the problem of being surrounded by their missile-launching submarines. The latter, of course, are less vulnerable; furthermore, maintaining SAC bases involves close negotiations with our allies.



Liquid propellant submarine missile can be carried to the surface in torpedo-type container launched through large tubes in submarine's hull.

and Off She Goes . . .

Crew on board USS Archer Fish is taking on torpedo for practise exercises. 21-inch diameter electric torpedoes of this type are acoustic. Westinghouse Electric Corporation is now working on sophisticated Mark 37 high-speed, long-range torpedo and Clevite Research and Brush Electronics are pushing a Mark 43 torpedo through test and development. Although most modern torpedoes are acoustic, advanced versions may employ wire or other guidance.



Launching of torpedoes is still tricky business and requires precision and coordination on the part of the entire submarine crew. A miss can be dangerous . . .

. . . but a hit can be rewarding. Especially if the target is a huge tanker or an enemy anti-submarine vessel. This picture shows a successful result after several days of chase. Tomorrow's torpedoes will be too fast and too accurate for an enemy ship to do any evasive maneuvering.

Undersea Missiles at Westinghouse

By James M. Beggs and Thomas H. Campbell, Jr.

Westinghouse Ordnance Department

IN AN AGE when ICBM and IRBM are daily conversation pieces, the *torpedo* has been stripped of much of its glamour. Probably none of the early torpedo designers envisioned that the modern airborne family of missiles are but latter day stepchildren of the first true guided missile, the *torpedo.*

What of the future of the *torpedo as a missile* in the A and H bomb era? This question is easily answered by a spin of the globe and a comparison of water vs. land mass. The logistic mission of sea lanes remains and their ready access and control is as vital. Ship types, speed and propulsion may change but, in the final analysis, troops must occupy territory to control it. They, and air bases, must be supplied.

While our Navy experienced 60% duds in torpedo firing during the first year of the war, the Germans had a successful wakeless electric torpedo and the Japanese were operating an internal combustion torpedo of longer range and larger warhead than any in fleet use. The success of these weapons forced the Navy to look for advanced torpedo design on a "crash" basis and to seek greater production capacity than was available in Naval facilities.

In March 1942, a group of Westinghouse engineers with representatives of other major industrial concerns were invited to view the captured German electric torpedo and propose production bids. On the basis of the proposals submitted, Westinghouse was awarded a contract to develop the Mark 18 electric torpedo. Pressure of war operations and the extreme fleet need caused the Navy to place a time limit of 105 days for design and delivery of a prototype model.

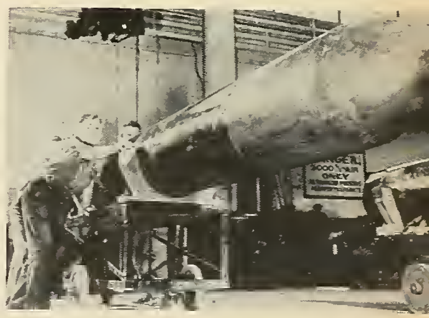
The captured German torpedo was turned over to Westinghouse with the intent that a "Chinese copy" be made for American use. This was impossible since parts could not be adopted to standard manufacturing procedure, some functions were not fully understood and the torpedo could not be adapted for launching in the tubes of American submarines.

The Chinese copy idea was set aside and a major design and development project undertaken using captured knowledge as a starting point. Warhead, exercise head, control mechanisms and torpedo gyro were added to the original development contract and still the tight time schedule was maintained.

Westinghouse delivered the first model 104 days after receipt of contract and four additional models within 15 days after delivery of the first test vehicle. In conjunction with the development of the torpedo, Westinghouse was ordered to design and develop tooling capable of reaching a maximum production level of 300 units per month, and awarded a production contract. Quantity delivery of the electric torpedos began before the end of 1942 and the Mark 18 weapon was introduced to the fleet in 1943.

When the electric Mark 18 arrived in the submarine force the reception was somewhat less than enthusiastic. Submariners exposed to one device after another which proved faulty, had learned to compensate for some of these faults and were not anxious to be stuck with another dud.

The Mark 18 had slower speed, 28 to 30 knots as compared to 45 knots of the higher powered steam torpedoes and was looked on with disfavor. The first electric torpedoes were taken on war patrol on a voluntary basis. The Mark 18 quickly established a reputation. Submariners became acquainted with the wakeless feature which prevented detection until a hit was secured, the dependable depth performance which allowed shallower depth settings permitting firing at targets previously



The country's largest manufacturer of torpedoes during the last war Westinghouse still maintains leading position in the field. Torpedo output today is classified, but the series of pictures to the right clearly indicate production is going strong. Navy spends approximately $50 million a year for conventional torpedoes.

Enemy shipping sunk by submarine forces during World War II totaled 1,314 ships, greater than the total of all other armed forces. Tomorrow's torpedoes and missiles will be designed to hit surface targets and aircraft as well . . .

neglected, and the simple but reliable contact exploder it carried. The demand for the Mark 18 increased from 30% of torpedoes fired in 1944 to 65% in the last six months of the war.

Parallel with this development, Westinghouse engineers in conjunction with the Navy Laboratories, undertook the design of torpedoes with acoustic as well as electro-dynamic controls. This extensive development program resulted in several different models and culminated with the production of a guided underwater missile, the world's first full-sized, all-electric, acoustically controlled torpedo, utilizing acoustic phenomena to seek out and follow its target until a hit is secured.

These target-seeking torpedoes were put in active use by the submarine force just prior to the close of the war. At that time the enemy's scope of operations was reduced and there was a shortage of good targets for our submarines. However, this self-directed undersea missile sank a total of five Japanese ships and holds the distinction of sinking the last enemy ship in World War II.

The enemy shipping sunk by submarine forces totaled 1,314 ships, greater than the total of all other armed forces. The Westinghouse electric torpedoes introduced at the mid-point when targets were becoming scarce accounted for over 400 ships.

During the interval between V-J Day and the Korean emergency, Westinghouse Ordnance halted production but continued in the field of underwater missile development and the field of sonar application, begun during World War II in cooperation with the U.S. Navy, Bureau of Ordnance. Much was accomplished in the field of miniaturization, control design, and underwater acoustic studies.

During the Korean conflict, Westinghouse Ordnance went into production of torpedoes for fleet use. During the two wars, a total of over 10,000 torpedoes were produced for the Navy.

At the end of the war in Europe, it was discovered that the German submarine force had a torpedo with a system for homing on the propeller noise of ships, giving chase and sinking them, a much more sophisticated system for guidance than that contained in their V-1 and V-2 rockets. It must be assumed that the Russians have access to this undersea missile and that they, as we, have the capability of using this "captured knowledge" to further the art of undersea missile warfare.

Since the self-contained undersea craft presents a grave threat as a launching platform for missiles and harassment to control of the sea lanes, weapons to combat this menace are extremely necessary in the NATO arsenal.

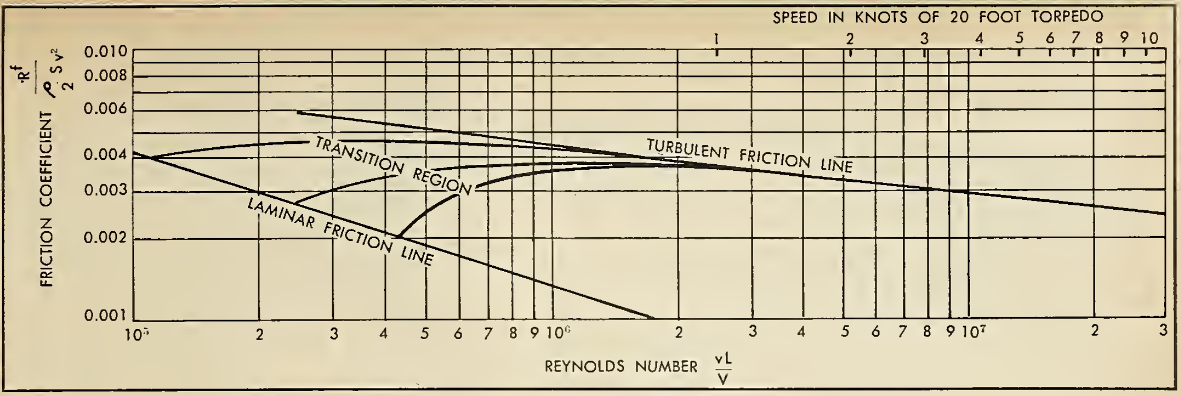
With this Russian capability, what are the problems facing our torpedo designers? The advent of the nuclear powered ships together with improved hull design, make possible higher and higher ship speeds, thus the torpedo of the future must have much higher speed to be effective.

Since the stowage capacity of submarines is limited, torpedoes of the future must be made more reliable and their kill capability must be increased. The history of modern weapons has been one of increasing complexity and the torpedo is no exception. With this complexity has come higher cost.

To justify this expense, our weapons must be increasingly effective and the torpedo of tomorrow must be able to detect, seek, catch and destroy with high probability of success any enemy target, surface or submerged, which ventures into open water.

Westinghouse Ordnance Department which was active in mine development and production during World War II as well as development and production of underwater missiles is continuing to maintain its leadership in the field of underwater ordnance. The company maintains as part of the Westinghouse Baltimore Defense Divisions, complete facilities for the development and manufacture of underwater missiles. This group of development engineers brings the skill and experience of acoustic, electrical, mechanical, electronic and hydrodynamic engineers to bear on the problems involved in developing for the Navy the newest type of underwater missile systems.

Since World War II through Navy-and-Westinghouse-sponsored research and development this group has developed and proven many of the latest concepts in the undersea missile field involving improved performance, speeds, accuracy and deadlines to keep our submarine force equipped to perform their mission in control of the sea lanes and carrying the combat action to the aggressor's waters.★



Beneath the Waves

By **Robert Taggart**
Reed Research, Inc.

WITH THE ADVENT of the true submersible—atomic submarines that can cruise at high underwater speeds for weeks on end—and with the growing practical knowledge of guided missiles of all types, the oceans assume a new strategic significance. This is why missile-makers now take another, different look at the fish and at birds like the diving petrel and loon.

The basic prototype for an underwater missile is the torpedo which has a long history dating back more than two centuries.

Perhaps the greatest technological change since World War II which affects torpedo design requirements is the complete revision in the concept of submarine warfare. The submarine was primarily a surface vessel which could submerge, when necessary, to stalk a target or to evade avenging anti-submarine vessels. Today, with the advent of nuclear power and other closed-cycle propulsion plants, the submarine is a true submersible.

This imposes a third dimension on torpedo design requirements. With the target free to evade vertically as well as horizontally, the missile must be able to follow these evolutions and strike home with deadly accuracy.

Thus it can be seen that the requirements for the underwater missile of today and of the future are altered drastically from those of the torpedo of World War II. It must attain high speed with a minimum of perhaps 60 knots. It must be silent both to avoid detection and to prevent acoustic interference with its guidance system. It must be capable of operation in three dimensions and of submerging to the maximum operating depths of submarines. The greater its range the more effective it will be.

First consider the speed requirement. Although the speeds of airborne and underwater missiles differ radically there are some similarities. In airborne missiles the sound barrier had to be overcome and now the thermal barrier presents a formidable problem. In underwater missiles similar barriers exist. The first is the turbulence barrier which has long been understood from the standpoint of practical underwater vehicle design.

The principal form of resistance to the motion of underwater bodies is frictional resistance. The amount of this resistance is a function of the surface area of the body and its speed. It is usual to plot this resistance-speed relationship on a non-dimensional basis with the resistance coefficient as the ordinate and Reynolds Number as the abscissa as shown in Figure 1. The resistance coefficient is a function of the frictional resistance, the density of the medium, the surface area, and the speed. The Reynolds Number is a function of the speed, the length of the body, and the kinematic viscosity of the medium.

The curve in the lower left of Figure 1 is the laminar line representing the resistance due to laminar flow over the body. As speeds are increased a transition takes place until a turbulent flow exists along the length of the body. As can be seen the resistance in turbulent flow greatly exceeds that in laminar flow and it can be noted that the transition from laminar to turbulent flow takes place at relatively low speeds. Assuming smooth underwater body 20 feet in length with a surface area of 100 square feet the typical frictional thrust versus speed curves are plotted in Figure 3. It is also obvious that if the body could remain in laminar flow throughout its speed range the


Shipjack, the first operational submarine using revolutionary Albacore hull.

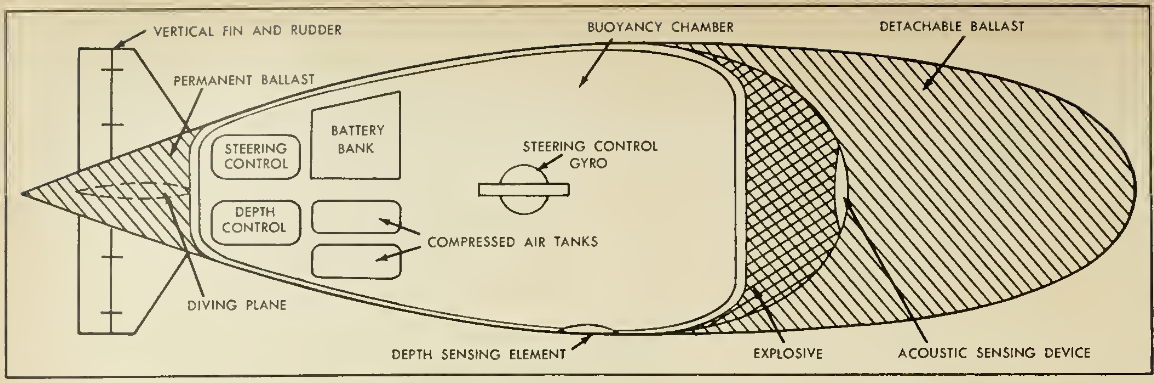


Figure 2. Drawing of possible propulsionless underwater Buoyant Ballistic Inertial Missile—BBIM.

thrust required for propulsion would be greatly lowered.

The cavitation phenomenon presents a more formidable barrier to high underwater missile speeds. As the velocity around a body or a propulsion system increases, the pressure drops. When this pressure becomes less than the vapor pressure of the water, air is pulled out of solution and bubbles are formed. These bubbles have many deleterious effects. They lower the density of the medium to such an extent that the propulsion device drastically loses efficiency thus limiting the top speed at which a missile can travel. The collapse of the bubbles as they enter higher pressure regions takes place with explosive force sufficient to erode away a propeller or control surface in a very short time. This bubble collapse is also a source of very high noise levels which render the missile easily detectable and interfere with its own acoustic guidance.

High underwater speed calls for a form design which varies somewhat from the conventional torpedo body. The total resistance of a submerged body consists of frictional resistance, roughness resistance, and form drag. The frictional resistance is a function of the wetted surface and the speed as shown in Figure 1. Roughness resistance is a function of the type of surface finish which is applied to the body. For a smooth, clean surface the roughness resistance is zero. For the average ship surface a constant addition of 0.0004 to the frictional resistance coefficient gives a resonably accurate estimate. For a well constructed and finished torpedo body an addition of 0.0002 is a fair average.

Form drag, for a well-designed underwater body, is a function of the wetted surface and the diameter-to-length ratio. As a general rule this resistance can be taken as one-half the product of the frictional resistance and the diameter-to-length ratio.

Because the wetted surface is such an important factor in high speed underwater form design it would appear desirable to contain the required volume within a form having a minimum wetted surface. The geometrical shape having the minimum wetted surface to volume ratio is a sphere. Yet if a sphere were used the separation of flow from the afterbody would be such as to make the form drag excessive.

For this reason it is necessary to use a more gradual curvature in the body profile but the symmetry around the axis is retained to form a body of revolution. The final form of a high speed underwater body usually has a blunt nose bordering on a hemisphere. The sections gradually increase in diameter to a point at about one-third the length from the nose and then taper gradually downward to a point, or small radius hemisphere, at the tail. Forms with diameter-to-length ratios on the order of 0.14 evidence the least total resistance for a body of practical dimensions.

There are methods by which the speed at which cavitation occurs can be increased. Since cavitation is a function of pressure, the deeper a missile operates, the less will be the possibility of its propeller cavitating. There are also some hydrodynamic tricks by which the pressure surrounding a propeller can be increased.

One of these tricks is to enforce a lower velocity upon the water as it passes through the propeller. Due to the theorem expressed by Bernoulli, as the velocity decreases, the pressure increases. This can be accomplished by the ducted propeller or pump jet.

Although this design serves to delay cavitation it also enforces an efficiency loss. The interior and exterior surfaces of the duct create an additional wetted surface which adds to the frictional resistance and to the pressure drag. Propulsive efficiency, which is in part a function of the diameter of the jet stream, is also reduced. The overall loss in propulsive efficiency due to these factors is often prohibitive. Various adaptations of this principle, such as the hydroturboprop and the hydroturbojet face the same limitations.

The next logical consideration might be rocket propulsion. Rocket systems have been outstandingly successful in airborne missiles, and hence they would appear to have possible application to the propulsion of underwater missiles. Liquid propellants can probably be ruled out because of the difficulties of handling fuel and oxygen aboard ship. Although storage and transfer systems for these lethal liquids have been worked out, they are extremely undesirable and would not be tolerated unless the justification for their use were overwhelming. Solid propellants do, however, present a distinct possibility for underwater use. In fact weapons already developed employ this means of propulsion in the water. Yet there are many shortcomings to underwater rocket propulsion which should not be overlooked.

Due to the reaction principle, rocket propulsion eliminates the cavitation problem insofar as propulsive efficiency of the missile is concerned. But due to the high velocity of the jet stream relative to the surrounding water, cavitation further aft in the stream is bound to occur which will be a source of excessive noise.

Rocket propulsion is also inefficient from both the propulsion and the resistance standpoint. The efficiency of a rocket propulsion system is a function of the relative velocity of the jet blast and the missile. Since the speed of the missile in water is low compared with its speed in air, the efficiency of the propulsion system is low. The propulsive efficiency is also a function of jet diameter but as the diameter of the afterbody of an underwater missile in-

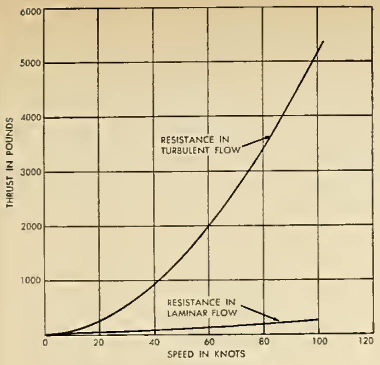


Figure. 3.

creases, so does its resistance.

Thus, although it appears that rocket propulsion with solid propellants may be a partial solution to the underwater missile problem, a number of difficulties remain to be overcome.

Smaller fish such as the swordfish are said to attain speeds in excess of thirty miles an hour. All slender game fish such as the marlin, wahoo, and dolphin are credited with high speed. The 1946-1947 British Scientific Expedition to the Antarctic Whaling Ground made what are considered to be reliable measurements on the speed of whales. Even a lumbering 120 ton, 90 foot monster can attain a speed of 20 knots for a short burst of about 20 minutes duration, and can maintain a speed of 14.5 knots for two hours or longer.

The great maneuverability of the fish appears to lie in his ability to contort his body at will in a manner best adapted to the desired maneuver. This ability is accentuated by the fact that his propulsion and maneuvering mechanisms are integrally related and his full thrust can be directed along the line of the maneuver to be effected. His maneuverability seems also to depend upon size, the whale being probably the least maneuverable of all fish. Yet even the whale can dive and turn with an ease yet unattained by manmade under-water craft.

In studying the propulsion of fish it appears that phenomenal results are achieved in translating muscular energy into propulsive force. One plausible explanation of this phenomenon is that fish actually operate in laminar flow in spite of operation at Reynolds Numbers at which turbulent flow would be expected. Studies on coatings and pliable materials are now being made in an attempt to duplicate this characteristic which has so great a potential value if it can be realized.

The propulsive machinery of fish, being primarily muscle, is silent. His propulsion device, the undulation of body and tail, also appears to be surprisingly noiseless. Studies conducted by the Woods Hole Oceanographic Institute have shown that high speed starts and stops and sharp maneuvering of porpoises produce no apparent cavitation. Indications are that large fish can move at top speed without producing any detectable cavitation or turbulence noises.

Another possible solution to the propulsion problems of high speed underwater missiles is the elimination of propulsion systems entirely. Two forces are available to an underwater missile which may be used to move it through the water—gravity and buoyancy.

One concept of a missile employing these forces is shown in Figure 5. A heavy, detachable ballast weight forms the nose cone. When this cone is in place the missile is excessively heavy in the water. Upon release from a surface ship, aircraft, or submarine, it would drop straight for the bottom reaching a terminal velocity which would be determined by its waterborne weight and its resistance. Control of the diving planes could convert this vertical motion into a glide path at an angle of perhaps as little as 30 degrees with the horizontal. At the greatest depth available the nose cone could be released at which point the missile would become buoyant. It would then rise reaching a terminal velocity determined by the buoyancy and the resistance of the new and smaller form. Again diving planes could be controlled to force the missile into a glide path leading it away from the launching vessel and toward the target.

A gyroscope is provided for directional control and a pressure sensing diaphragm is included to determine the release point of the weighted nose cone. In the nose of the buoyant body an acoustic sensing device is shown which could be used to control steering and diving planes to direct the missile to the target.

The potential of such a missile can best be shown by estimating the performance of a hypothetical design. Using the general configuration of the missile shown in Figure 5 with a length of 18 feet and a diameter of 4 feet, the displacement would be on the order of 9000 pounds. If the nose ballast were a solid steel casting its weight would be about 15,000 pounds. Assuming the weight of the structure and warhead to be 2000 pounds the excess weight would be 8000 pounds. In the dropping phase this missile would reach a terminal velocity on the order of 70 knots in a vertical direction. At a 30 degree glide angle this speed would drop to about 30 knots.

After release of the nose ballast the reserve buoyancy would be about 7000 pounds. During the rising phase of its trajectory the missile would achieve a terminal velocity of about 25 knots on a 30 degree glide angle increasing to 60 knots on a direct vertical rise. A typical trajectory is shown in Figure 4.

This type of missile would be relatively quiet and would be inexpensive. Cavitation would not be a problem. It would be limited in range and in maneuvering flexibility. Its greatest value would be realized in water of great depth which is the controlling factor on range.

Missiles with undulating bodies and underwater ballistic missiles offer interesting possibilities and some food for thought. They are probably not a complete solution for the ultimate in underwater missiles. In fact their deficiencies in this respect have been pointed out. It is quite possible, however, that the fundamental principles upon which they are based may serve in combination with other propulsion schemes to finally evolve a missile which satisfies all requirements. ★

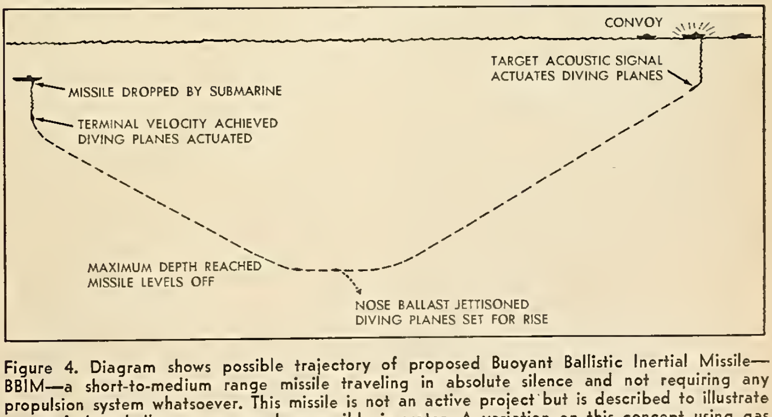


Figure 4. Diagram shows possible trajectory of proposed Buoyant Ballistic Inertial Missile—BBIM—a short-to-medium range missile traveling in absolute silence and not requiring any propulsion system whatsoever. This missile is not an active project but is described to illustrate some of the wholly new approaches possible in water. A variation on this concept using gas cylinders and buoyancy tanks might conceivably be used to transport an IRBM missile across the ocean for launching at the land mass of Europe. By alternately flooding and blasting out tanks it would travel sine wave course—up and down limited only by gas cylinder capacity.

TOMORROW'S TORPEDO

Future underwater torpedo development faces a long hassle with one of the most stubborn elements scientists could encounter—seawater.

This stubbornness is especially evident in guidance and propulsion.

Traditionally the torpedo is preguided. Before launching, its course has been established internally through gyroscopic stabilization and guidance mechanisms programmed for a given pattern.

But in this age of high speed and high maneuverability, the torpedo must now cope with rapidly changing conditions after it is fired.

This means the torpedo must carry its own capability.

Three possible means of detection are: acoustic, radio frequency and infra-red techniques.

Transmissibility of infra-red in seawater is practically nil. At this time there appears little chance for successful use of this part of the spectrum for torpedo guidance.

Underwater radio-ranging offers little hope for underwater detection at any of the frequencies that might be practical for torpedo use.

A good example is the very low frequency communication system used by the Navy for keeping in touch with its submarines around the world (even those that are submerged), which transmits on about 10,000-15,000 cycles. Its antennas cover an area measured in miles, and power output is in megawatts.

The acoustic method of detection seems to have won out for currently operational torpedos. A Westinghouse torpedo on display recently had a rubber diaphragm in its nose.

It is believed an acoustical system is carried by this new torpedo for detection of its target. Whether the device uses sound generated by the target or reflections of sound generated by the torpedo and reflected off the target is not known.

The World War II technique, turning off all noise generating equipment in order to escape detection, would do no good against a torpedo with noise generating equipment.

The need of torpedoes as three-dimensional weapons complicates acoustical sensing problems. Advent of the atomic submarine, and the concept of submarine-launched intermediate range ballistic missiles, means torpedoes must find and destroy the launching submarines.

For this reason depth must be added to operational capabilities.

This restricts the various detection methods to be considered.

Even now, with acoustical guidance, sea water does not present a medium of uniform transmissibility to sound.

Temperature changes rapidly from point to point, and so does the pressure. To these variations can be added other spurious signals reflected from objects other than the target, such as the ocean bottom or schools of fish.

One of the most urgent needs for future torpedoes is the ability to predict future position target.

This need is similar to problems encountered in firing non-detection types of rocket weapons against other aircraft. The speed of both the launching vehicle and the target vehicle must be known and the information used to calculate a collision course.

Submerged speed of the new atomic submarines has not been disclosed. However, they are believed to be of such a high velocity that new types of torpedo detection and prediction equipment must be developed to cope with the problem.

The first electrically driven torpedoes were used by the Germans during World War II. They had the prime advantage of leaving less of a tell-tale wake than bubble-producing steam motors.

Present day torpedoes are electrically powered by motors little larger than ordinary five horsepower motors. However, they deliver "many, many times five horsepower."

As the torpedoes are planned for use at lower and lower depths, the pressure problem mounts. Hull strength becomes a paramount concern of any new torpedo design.

From purely a propulsion point of view significant successes have been achieved in research and development work with more sophisticated types of propulsion. In many cases these parallel those used for airborne and space-bound missiles—ramjets and pure rockets. Speeds triple those of World War II torpedoes have been achieved in special full-scale test tanks.

The main draw-back has been and remains that these missiles are extremely noisy. Also, unlike the electric torpedo, many leave an all-too-obvious bubble wake. This gives the target two methods of detecting the attack missile—visual and acoustic.

In addition, there is still no known hydroform that can travel at 100-knot speeds without cavitating. This phenomenon is a major source of noise in itself. However, work now underway to develop methods for providing boundary layer control for subsurface vehicles, if successful, will revolutionize the basic concepts of undersea warfare.

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 either heavier-than-water solids or 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 10 to several hundred miles. Its warhead will be either nuclear or with conventional explosives.

Another factor in torpedo design is the need for operation more than once. A torpedo is fired only once "in anger" but might be fired a number of times for tests.

A one-shot electric motor might be designed for a very high efficiency if it were to be used just once. But the motors used in torpedos must be capable of both repeated use and high efficiency.

Thus far most torpedo research and development has been done by government laboratories. The product of this work was then handed to industry for integration in a weapon.

With the increased need for torpedoes for use against missile-launching-submarines and perhaps an anti-torpedo torpedo, the systems engineering approach becomes more necessary, as it has in atmospheric and space missile designs.

At least one company plans development of torpedoes on a systems engineering basis.

UNDERWATER PROPULSION
Engineering Horsepower to Velvet Hooves

IN WORLD WAR II, the submarine revealed its full potential for destruction, and among the steps taken to cope with the menace to our shipping was the application of the then newly developed techniques of sonar to electronically control the steering of a small electrically-propelled torpedo. This passive-acoustic homing torpedo was perhaps the first "guided missile" in the sense that we know it today.

But spectacular advances in underseas warfare capability have occurred with the advent of nuclear-propelled submarines, and the simple battery-propelled torpedo of the immediate post-war years is useless against such submarines, both from the speed and deep-diving standpoints. Modern weapons are needed for the anti-submarine defense of future years. Although some refinements are possible in both batteries and electric motors, it is obvious, from the energy requirements involved, that some kind of thermal propulsion will be needed in torpedoes capable of attacking, say, a submarine like the Nautilus.

The problems of thermally propelled, high-speed, deep-diving anti-submarine missiles are yet to be solved completely. The powerplant developments have much in common with airborne guided missile technology, but are distinctly different because of the fact that the torpedo is "flying" in a surrounding of water rather than air or space. Some of the special problems of anti-submarine torpedo power-plants are structural integrity, acoustic silence, the effects of deep operation on powerplant performance, and the utilization of "exotic" fuels.

For this comprehensive roundup on progress in modern underwater missile propulsion systems, m/r is indebted to the U.S. Navy Bureau of Ordnance which performed in accordance with the highest traditions of the Naval service. This article is a combination of two received—one by Jack W. Hoyt, Naval Ordnance Test Station, Pasadena; and one by G. G. Gould, J. F. Brady, S. Wolf and R. M. Dunlap, Naval Underwater Ordnance Station, Newport, R. I.

In general, all torpedo propulsion systems consist of an energy source, a feed system, a device for converting the stored energy into torque and a device for converting torque into thrust. For extremely high speed vehicles, the conversion of stored energy into thrust may be accomplished directly in a reaction chamber-nozzle assembly.

In 1903, the first turbine-driven torpedo was produced by the Bliss-Leavitt Company from 1905 through World War II, all U.S. thermal powered torpedoes have used turbines as prime movers.

Electric torpedoes started with the Foster torpedo in 1872. This torpedo, as well as the more successful Sims-Edison in 1877, was controlled and powered from a shore station by means of a trailing wire. For want of a satisfactory battery, development of electric torpedoes was abandoned in this country. The Germans however, placed them in service in both World Wars.

The characteristics of torpedo energy sources are the same as those for guided missiles with one major exception. For reasons of stealth, the torpedo should have no wake. Its exhaust, if any, should have a predominance of condensable and soluble products.

For certain applications the range and speed requirements of the torpedo are such that a relatively low energy storage capacity is required, which favors battery-motor propulsion. These also have the advantages of no wake and performance independent of depth.

The World War II electric torpedo used a conventional lead-acid battery. Now, Silver cell batteries (Zn-alkali-Ag2O2) 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.

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

New Bedford shoemaker Wm. Cunningham's rocket powered torpedo was way ahead of its time when, in 1894, he touched it off in the road before his house. The only casualty was a fire in the local butcher's icebox. Unfortunately, it never found its way into the Navy's Arsenal.

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 the 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.

Monopropellants, although attractive from a simplicity point of view, are relatively low in performance and, in general, have a high percentage of non-soluble gases in their exhaust.

For torpedo application, solid propellant systems are attractive because of their simple mechanical construction, minimum number of parts, simplified handling and lack of feed system requirements. As a result of the system simplicity, its reliability should be high. The disadvantages of solid propellants as torpedo energy sources are the large quantity of non-solubles in their exhaust (wake) and their inflexibility in packaging to obtain a desired gas generation rate.

As undersea warfare is largely a matter of listening, it is paramount that a weapon be quiet.

Another requirement for the torpedo propulsion plant is small size and weight, particularly for the aircraft launched torpedoes. Overall weapon system weights are often lower than 400 lbs.

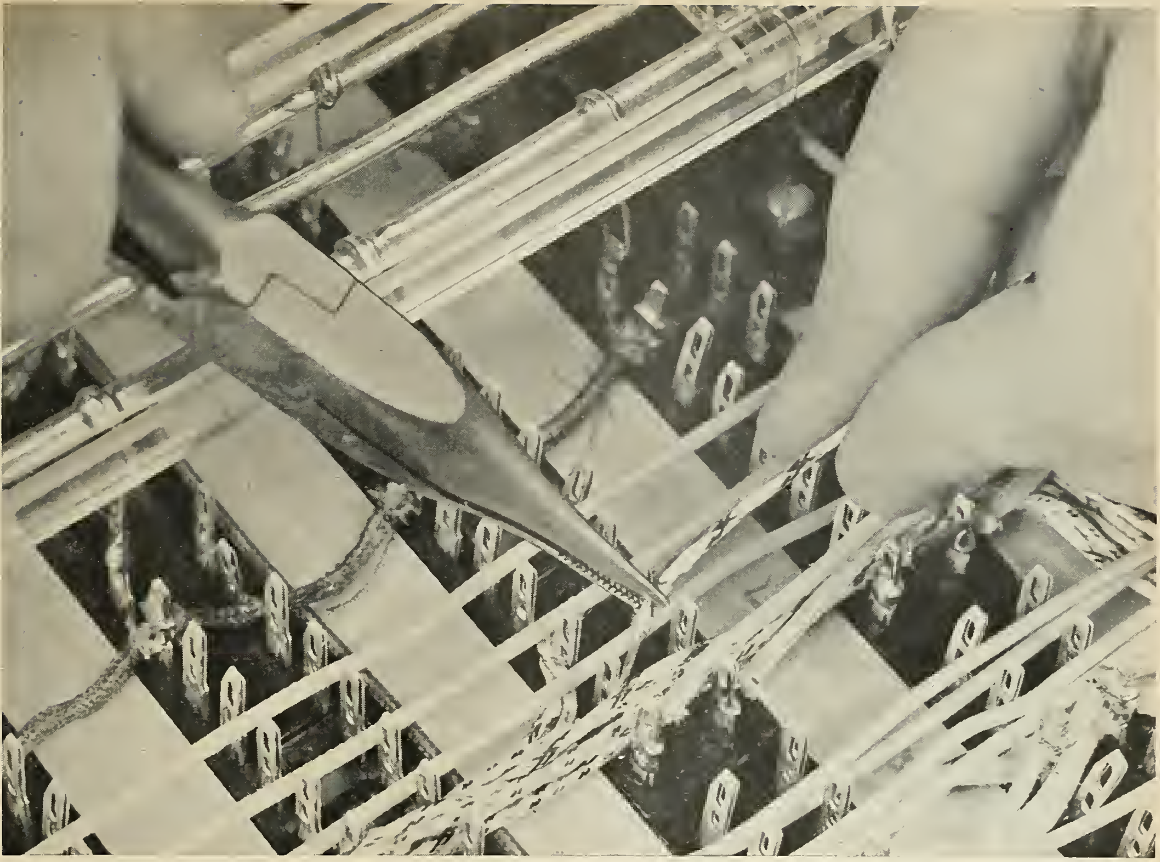
It is the deep-diving requirement that makes the ASW torpedo powerplant problem really unusual.

The high back pressure encountered at deep submergence strongly influences the choice of thermal powerplant employed in the missile—should it be a reciprocating engine, or should a turbine drive be used? Actually there appears to be, as in aircraft propulsion, definite regimes in which one or the other method has a weight-volume advantage.

Generally speaking, American practice indicates that in the lower power levels, say under 100 or so horsepower, the engine drive is a more economical thermal system, but above this level, turbine drives are better. Torpedo reciprocating engines operate on essentially a "steam-engine" cycle, which is less affected by back pressure than the simple turbine cycle; this advantage is outweighed by greater powerplant bulk as the power level increases. Torpedo turbines are usually of the partial-admission axial-flow type; the high back pressure penalizes the small power level turbine due to high windage losses. As the power level is increased, this penalty diminishes.

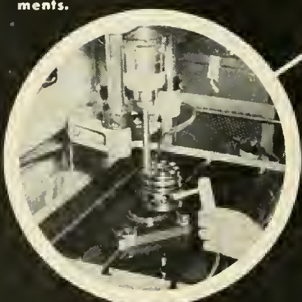
Partial admission means that gases are admitted to only a portion of the periphery of the turbine—while the remaining blading churns relatively stagnant gas. As the back pressure on the

Striking demonstration of the similarity between aerodynamics and hydrodynamics, this model of a Chance Vought F4U was put in water tunnel to study turbulence in high subsonic range.



RESEARCH
Continuing research to discover suitable designs, fluids and materials to anticipate future High Temperature requirements.

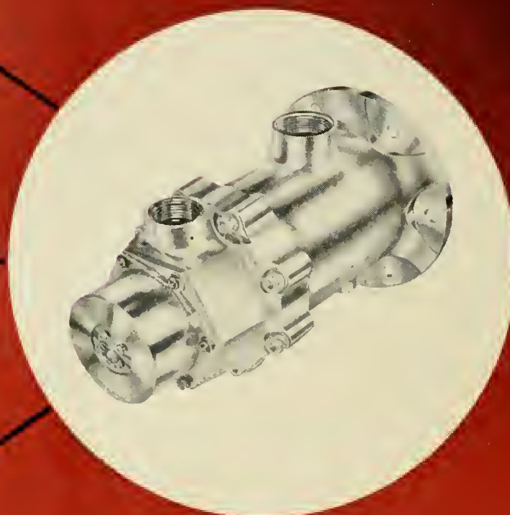
DEVELOPMENT
Laboratory and Test Equipment to pre-prove performance under known or anticipated environments.



PRODUCTION
The most modern manufacturing facilities plus craftsmanship to build "Precision on a Production basis."

400°F

... for 150 Hours continuous duty



STRATOPOWER®

..... HYDRAULIC PUMPS

Specified for Elevated Temperatures—

400° F and higher is a reality with advanced STRATOPOWER Aircraft Equipment. Research, design and manufacturing skill applied by STRATOPOWER to years of hydraulic experience combine to produce high temperature equipment that meets your thermal requirements of tomorrow, today. STRATOPOWER development personnel, working on the most advanced high temperature problems, have produced outstanding results. STRATOPOWER Pumps, incorporating these high temperature developments, are available in prototype quantities.

WATERTOWN DIVISION
THE NEW YORK AIR BRAKE COMPANY
STARBUCK AVENUE • WATERTOWN • N. Y.

Circle No. 17 on Subscriber Service Card.

turbine is increased to, say, the 500 ft. submergence level, the power absorbed in this churning (the so-called "windage loss") becomes appreciable.

The high windage losses of axial-flow torpedo turbines has led to the consideration of tangential-flow machines of the type manufactured by the Terry Steam Turbine Co. These turbines appear to have a windage loss similar to a smooth disk, and although their aerodynamic performance is perhaps less than that achieved by axial-flow units, their shaft output is relatively constant over a considerable range of depths.

Because of their simplicity, reliability, wakelessness, and insensitiveness to depth, electric propulsion systems have always been attractive. Unfortunately, the power-to-weight ratio of such systems has always been low. Design effort, therefore, has been expanded to development of high power-low weight electric motors. An obvious method for improving the power to-weight ratio is to increase motor speed. This necessitates either high speed propellers or a gear reduction.

Unfortunately, experience has shown that either alternative results in higher radiated noise. Counter-rotating electric motors serve to increase power-to-weight ratio without requiring gear reducers. Considerable improvement, noisewise, is obtained thus.

Except for electric drives, the turbine has been the traditional power plant for U.S. torpedoes. Overall prime mover efficiencies of the pure impulse turbine (including gear train losses) of approximately 48% are being obtained, compared with the turbines of jet aircraft and of stationary power plants which obtain 85-92% efficiency. A perhaps more important criterion is the working fluid through-put required per unit of power. Representative values for various types of turbine systems are as follows:

Steam power plant .	7.46 lbs/HP hr
Aircraft turbo prop engines	15.4 lbs/HP hr
Torpedo turbine ...	12.0 lbs/HP hr

Considering the torpedo turbine's compactness, it compares quite favorably.

In brief, the trend in torpedo turbine design is toward higher rotative speeds, more arc of admission, higher inlet temperatures, and improved gas passage design to reduce shock wave problems. Consideration is also being given to multi-stage units to more efficiently handle the high pressure ratios.

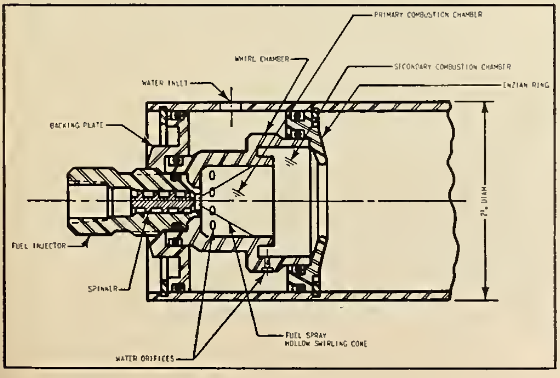
Recent advances in metallurgy, however, allow us to increase speeds to more favorable values. For example, at 1200°F Inconel "X" has a working strength of 74,000 p.s.i. compared to 11,000 p.s.i. for 8630 steel. Thus, at 1200°F Inconel "X" wheels may be run at speeds 2.5 times as fast as wheels made from 8630 steel.

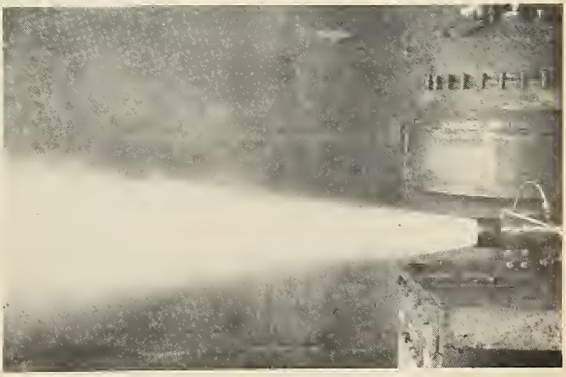
Arc of Admission: To date, torpedo turbines have utilized less than 25 per cent of the available arc of admission. If the entire arc were used, four-to-five times more power would be obtained than is required. To utilize the full arc of admission, without producing tremendous quantities of power, requires reduction in the size of the machine. To maintain a good ratio of wheel to jet speed, the rpm of the machine must be increased. Advances in bearing design now permit running at speeds above 50,000 rpm whereas a few years ago 10,000 rpm was considered high.

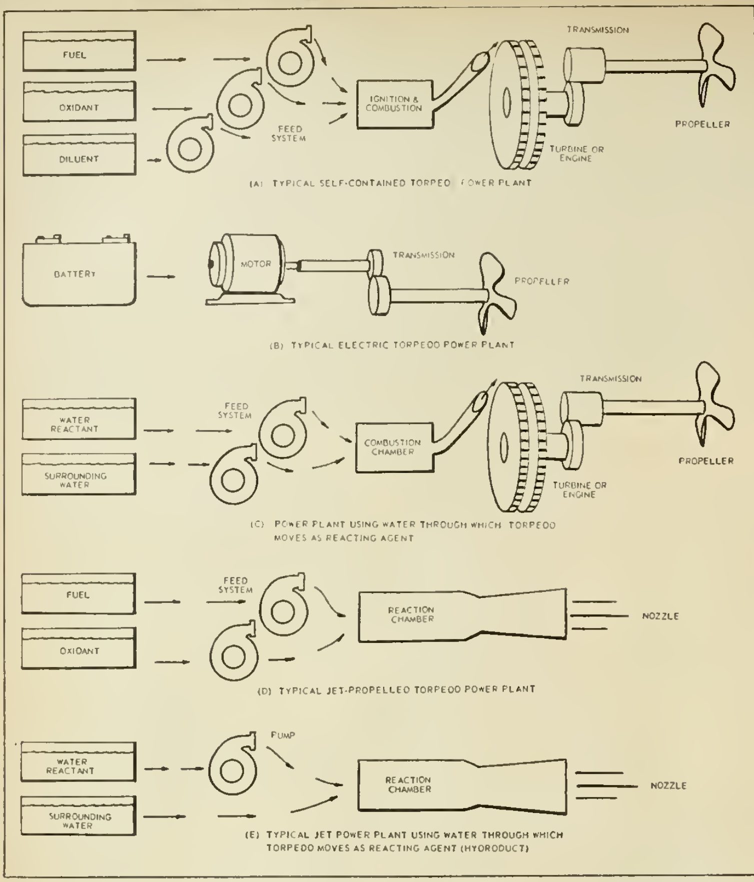
Because of their high efficiency in the lower power output range, their ability to operate without a diluent, and their lack of windage problems, reciprocating engines are competitive with turbines for certain applications.

Early torpedo reciprocating en-

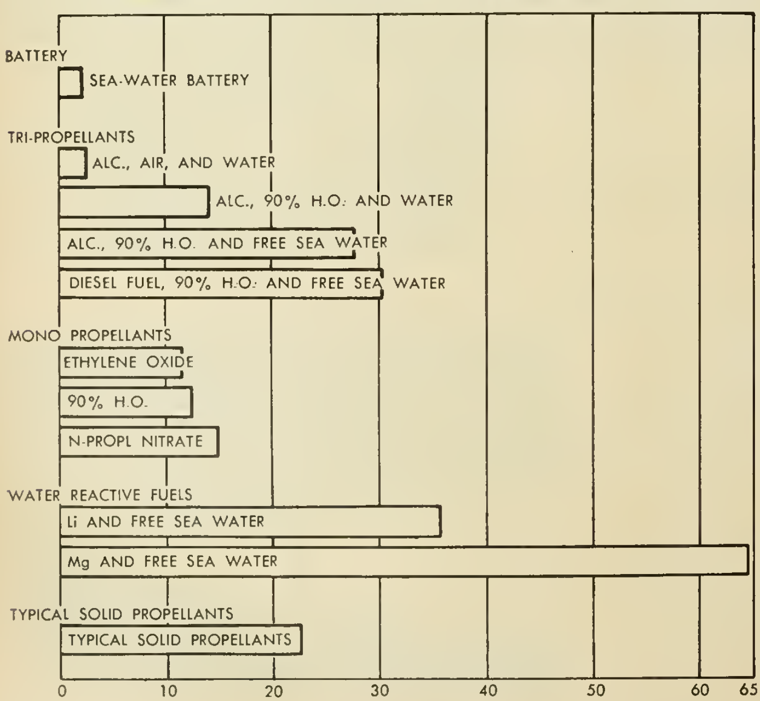
Combustor for torpedo turbine drive resembles rocket motor. To the left is a schematic drawing and to the right the combustor is shown on a static test stand, looking much like a rocket.







Above are the basic layouts of five possible torpedo propulsion systems reading down in the order of their sophistication. Below, their theoretical comparative performances are charted.



gines were similar in most respects to conventional steam engines, running first on compressed air and later with hot gases burned in an external combustion chamber. Air was first used as the oxidant, and more recently, hydrogen peroxide. One version of the engine uses peroxide decomposition products as the oxidant while other experimental engines utilize direct injection of liquid peroxide into the cylinders.

Most torpedo reciprocating engines operate on a two-stroke, modified Brayton cycle. A four-stroke cycle torpedo engine was developed by the Germans during World War II, but not placed into service.

Numerous mechanical engine designs have been made. Three and four cylinder radial, four and eight cylinder "V," horizontal opposed piston, and various barrel-type configurations have been tried.

The major problems still to be solved include valving, cooling, and reliability. Reciprocating engine design still remains more of an art than a science. The solution to most problems must be obtained by "cut and dry" methods as opposed to the refined theoretical work that may be accomplished on other types of prime movers.

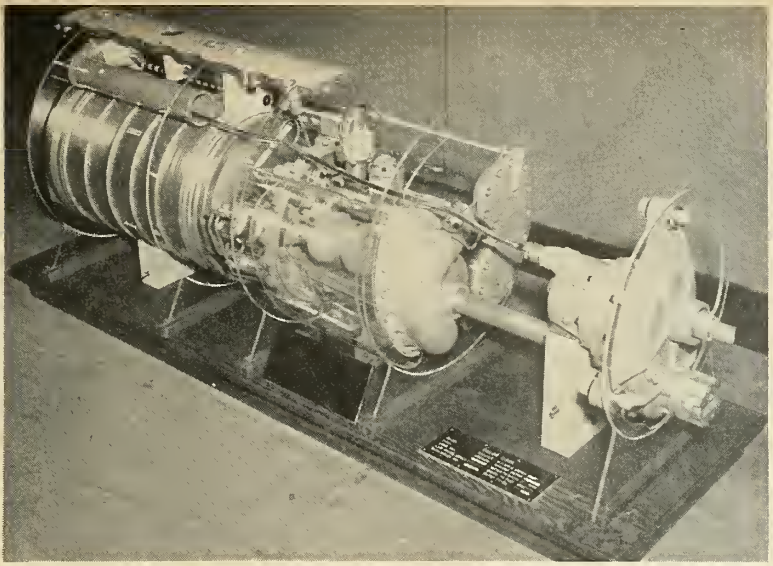
Devices analogous to the aeropulse, the turbojet, and the ramjet are practicable for underwater propulsion. These devices are the hydropulse, the hydroturbojet, and the hydroduct respectively. Use of underwater rockets, although technically feasible, is impractical except for extremely short ranges because of the unfavorable ratio of torpedo-to-jet speed.

Although all the above jet devices are promising for torpedo propulsion, their use will depend upon the requirements of the future.

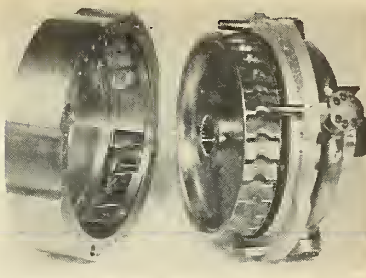
The power plants described above require extensive testing to ensure that they function reliably under all conditions of operation.

Many of the questions concerning the components respond to conventional test techniques. Some do not. Take for example, simulation of the operation of a gas turbine and combustion system driving a torpedo in 1000 feet of sea water, corresponding to a back pressure of 444 p.s.i. with combustion chamber pressures of perhaps 1800 p.s.i. Containing and controlling these pressures, absorbing the power and extracting the performance data becomes a formidable problem. So does measurement of differential pressures across flow control orifices.

Noise output of torpedoes is measured while the torpedo is running, both captive and free. At the Underwater Ordnance Station in Newport, R. I. is



A modern torpedo reciprocating engine including fuel tank, oxidizer tank, accessories, controls.



Tangential-flow turbine is only slightly affected by windage losses at high back pressures. This is type of turbine used with combustor.

what is believed to be the world's largest tank for the measurement of the underwater sound output of a captive torpedo running under full power.

At the Aerojet-General Corp. in California is another unique facility. Here a tank of water in the shape of a ring is equipped with a rotating arm which can carry a full size torpedo at speeds double those of most torpedoes. In this tank the thrusts of novel propulsion systems, employing high velocity jets, can be measured. When the engineer reports that the torpedo is still putting power into the rotating boom at over one hundred knots, history is being made. This tank is equipped with special wave dampeners to effectively still the water for the torpedo as it hurtles through the ring channel time after time.

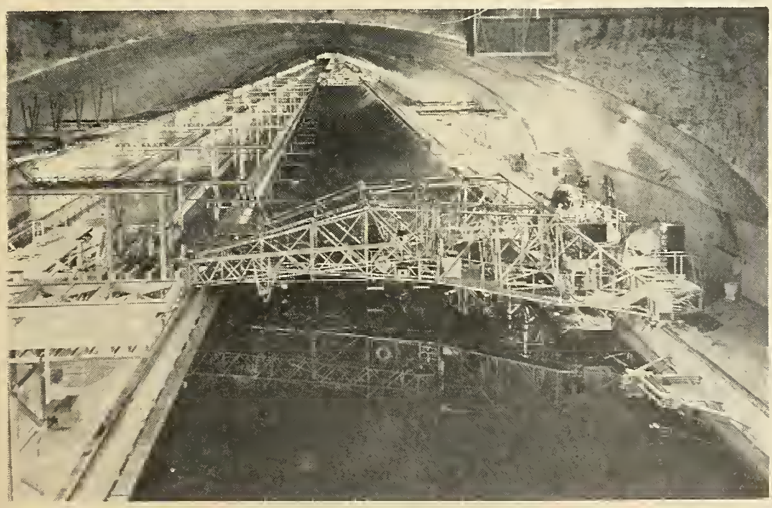
To measure speeds and accelerations of free running torpedoes, the Navy has installed in the bottom of Narragansett Bay, R. I., a grid of hydrophones connected by over one hundred miles of underwater cables. These hydrophones, listening to noise made by the running torpedo, feed banks of recorders and computers to provide reliable witness to the performance of the tin fish as it speeds up the range.

The underwater range can plot, second by second, the position of the torpedo to within a few feet during its run. Sound measurements, well into the ultrasonic range, are recorded to be compared with those made in the anechoic tank.

Practical limits are imposed in the design of torpedoes by other considerations than the power plant alone. For example, a running range of 50 miles, with the necessary fuel to go that far, although technically feasible, is operationally unsound. But even assuming a 100 mph torpedo, the time of flight to the target would permit a half hour of evasion on the part of the target ship. Even at shorter ranges, while a 50 mile-per-hour torpedo takes two minutes to go 3000 yards, a 15 knot target can travel 880 yards.

Thus the need points to shorter flight times. This can be achieved in many ways. One obvious means is by increasing the speed, although this has certain limitations. A most significant problem is the horsepower required since this goes up as the cube of the speed. Ultimately, the torpedo could be designed to operate in two mediums —be fired from underwater, emerge and fly most of the way through the air and then return to the water for its final phase of attack.

With atomic submarines a reality, future targets will be capable of much higher sustained speeds. The torpedo of tomorrow is aimed toward defeating the high performance submarine of the future. ★



World's longest indoor towing basin for testing underwater missiles and ships' hulls, Navy's David Taylor Model Basin has an uninterrupted run of over 3,000 feet and towing speeds up to 60 knots (69.1 mph). So close is test control, two car rails are adjusted to earth's curvature.

High performance (work output per unit weight and unit volume of reactants).

Minimum insoluble products of combustion to cut wake.

Low freezing point, for a wide range of operating conditions.

Low vapor pressure, to simplify storage, transport, pumping.

Low toxicity, for ease and safety in handling.

Ready availability and ease of preparation.

Non-corrosive materials and products of combustion.

Shock insensitive under external shock, high temperatures.

Simple and positive ignition with short ignition delay time.

Primary requirements to be considered in the selection of propellants for modern torpedoes.

Underwater Missile Auxiliary Power Units

By William L. Burriss
and Matthew J. Pastell
AiResearch Manufacturing Company

Woosh! Out of the deep blue sea . . . Amazing German submarine rocket experiment was in the mill at end of World War II, but German admiralty refused to develop the system since it was conceived and demonstrated by the Army...

THE GUIDANCE and control of missiles can only be effected through the use of internal power, usually electrical and hydraulic. In most instances this power is not available from the main propulsion engine. It is necessary, therefore, that an auxiliary or secondary power source be provided within the missile.

The use of static power supplies, batteries and precharged hydraulic-pneumatic accumulators has been effective in early operational missiles because such power packages are particularly advantageous for small loads of short duration. However, similar components for increased loads and longer duty cycles of missiles in development and still "on the board," in general, would be excessively large and heavy. Under these conditions, the utilization of "dynamic" energy sources, i.e., a propellant gas-operated prime mover driving a hydraulic pump and electric generator, could effect large savings in space and weight.

Considerable experience has been gained by the missile industry in the use of propellant gas turbines for auxiliary power. Although analysis indicates other prime movers such as displacement type machines to be feasible (perhaps even advantageous), there is little experience in their application.

The most common requirement for an auxiliary power unit (APU) is to provide a-c electrical power. When direct current is required, in almost every case rectification of high frequency a-c power will show a considerable advantage over the use of d-c generators.

The total power level does little to affect the complexity of the unit, but the quality and variations in electrical output are primary considerations in establishing the complexity and reliability of the complete system. Close frequency control over a considerable load range requires a complex speed control system, and close voltage control requires the addition of voltage regulators.

At present, frequency control can be maintained within ± 3 per cent over a 0 to 100 per cent load range, ± 2 per cent over 75 to 100 per cent load range, ± 2 per cent over 50 per cent to 100 per cent load range, and ± 1 per cent at constant load with a fairly simple and reliable speed control. With a more complex system, frequency regulation to within ± 0.20 per cent can be maintained over any desired load range.

Over small electrical load ranges, permanent magnet alternators offer advantages in simplicity and light weight and have sufficient inherent voltage regulation for many applications. Since the output voltage of the conventional permanent magnet machine is not controlled, it will vary in direct proportion to the alternator speed; therefore, the over-all variation in output voltage is the sum of the frequency variation plus the alternator voltage "droop" over the desired load range.

In addition, these are sensitive to power factor so that variation in power factor also increases the over-all voltage range. When the electrical load variation exceeds 70 to 100 per cent, additional alternator mass is required to provide sufficient inherent regulation for proper over-all voltage control (± 5 per cent) or else some type of regulator must be employed.

References:

(a) NACA TN 1807—*Effects of Partial Admission on Performance of a Gas Turbine.*

(b) Stodola, A., Steam and Gas Turbines, Vol. I, McGraw-Hill Book Co., Inc., 1927, pp. 194-202, (Reprinted, Peter Smith, New York, 1945).

(c) Vincent, E. T., *The Theory and Design of Gas Turbines and Jet Engines,* McGraw-Hill Book Co., Inc., 1950. pp. 415-422.

Present trends in missile accessory power units indicate that voltage regulation is generally more critical than frequency regulation and that when electrohydraulic output is required, very large changes in load can be expected. These trends favor the use of alternators with a controllable electromagnetic field which can be adjusted automatically to eliminate the effect of frequency on output voltage and compensate for the normal voltage "droop" when changes in electrical load occur.

A flux-switch alternator with a combination permanent magnet and electromagnetic excitation with the latter supplied by load-current sensing transformers provides good voltage regulation.

Duty cycle and alternator frequency are primary considerations in sizing an alternator for power supply use. High frequency (800 to 10,000 cps) allows high rotational speed with attendant reductions in size and weight. The duty cycle will determine the thermal capacity required of the alternator to avoid overheating, and as a consequence, the weight of materials in the alternator.

External cooling with fuel or by other means can either considerably increase the operating duty cycle or generally reduce the alternator weight for a given duty cycle. An example of how high frequency and short duty cycle (uncooled) can reduce alternator size is a 3-kw, 4800-cps, 48,000-rpm alternator weighing 3 pounds.

On units requiring hydraulic power, the hydraulic system demand is usually such as to require steady-state power at a low level and transient power at a considerably higher level. In selecting the hydraulic components which will best meet the requirements, various hydraulic pump and accumulator combinations must be reviewed to see which combination results in minimum system volume and weight.

The first step in the review is to translate the hydraulic requirements to total volume of hydraulic fluid required as a function of flight time. By comparing the requirements with various hydraulic pump capacities, it is possible to determine the accumulator volume required for any given pump capacity.

The accumulator volume is then plotted as a function of pump capacity. Since the pump capacity determines, to a large extent. the power level of the system, it is also possible to establish propellant volume as a function of pump capacity. By combining accumulator, reservoir, propellant and pump volumes, it is possible to prepare an optimization curve of total hydraulic system volume as a function of pump capacity.

Using this optimization curve and considering secondary effects such as pump heat rejection, control system complexity, and packaging restrictions, a pump-accumulator combination is selected to provide the smallest practicable hydraulic system.

Speed control can in general be achieved by two methods: (1) by the application of external parasitic loads; and (2) by controlling the flow of the turbine working fluid, either as raw fuel or as hot exhaust gases.

Each of the general methods can be applied in either of two ways:

1. Discontinuous—When speed control is being maintained in this fashion, the parasitic load is applied or the working fluid shut off only when the upper speed limit is approached. When the unit has decelerated to the lower permissible speed, the load is removed or flow of the working fluid is initiated. The step-load change characteristic of this method has sometimes led to its being called a "bang-bang" control scheme. Present ethylene oxide auxiliary power units provide speed regulation to about ±2.5 per cent using a "bang-bang" fuel flow control, and solid propellant units have been built to about ±1 per cent.

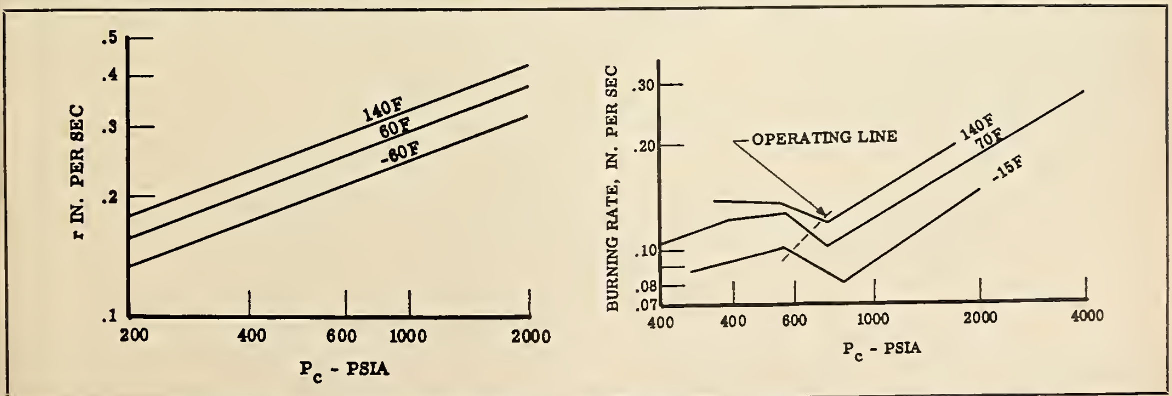
2. Proportional—When speed is controlled in this way, the parasitic load is applied in proportion to speed or the working fluid flow is varied in inverse proportion to speed. Using proportional fuel flow regulation and sophisticated electronic controls, steady-state accuracy to ±0.2 per cent can be attained.

The applicability of a control scheme is dependent upon the type of load changes imposed upon the over-all power unit. Step-load changes, like those encountered when a hydraulic power unit incorporates a hydraulic pump unloading valve, makes close-speed control more difficult and usually requires increasing the complexity of the system.

The ideal isentropic power derived from any turbine can be expressed as $HP_i = W \Delta H$

Where HP_i = ideal power input
W = weight flow of working fluid through the turbine
ΔH = enthalpy drop per pound of working fluid

Of course, the ideal power is not realized as the result of leakage losses, aerodynamic nozzle and blocking losses, and shaft losses. The shaft losses for a full-admission turbine include bearing losses and disk friction and windage losses. The disc windage losses as shown by References (a) and (b) may be expressed by the following approximate relationship:



Mesa type discontinuity exhibited by doublebase propellants tends to minimize dependence of burning rate on pressure.

$$HP_{df} = K_1 pD^2V^3$$

where HPdf = disc friction power loss
K_1 = proportionality constant determined by turbine rotor design and clearances
p = fluid mass density
D = rotor diameter
V = rotor peripheral velocity

Since the propellant gas turbines designed for missile auxiliary power unit applications are characterized by relatively low power output (1 to 70 shp), they are usually partial admission machines. Of the major losses that occur, the leakage losses are approximately proportional to the degree of admission, while the windage losses are relatively independent of the degree of admission. For this reason, in order to evaluate turbine performance in an application wherein significant windage losses are expected (as result from the exhaust back pressure in an underwater missile), it is appropriate to define the turbine over-all efficiency as follows:

$$\eta_o = \eta_{ad} \frac{HP_s}{HP_s + HP_{df}}$$

where η_o = over-all turbine efficiency
η_{ad} = turbine adiabatic efficiency
HP_s = shaft power output
HP_{df} = disc friction power loss

Further, it can be seen that the turbine adiabatic efficiency can be expressed as a function of the turbine velocity ratio, U/C (ratio of the effective rotor tip speed to the spouting velocity), shown by Reference (c) to be as follows:

$$\eta_{ad} = K_2 \frac{U}{C} (\text{Cos} \propto - U/C)$$

where K_2 = constant of proportionality determined by turbine design
U = effective rotor tip speed
C = spouting velocity of the working fluid
$\propto$ = absolute gas inlet (to turbine) angle

It can be seen, therefore, that the over-all turbine efficiency may be expressed

$$\eta_o = K_2 \frac{U}{2C} (\text{Cos} \propto - U/C) \frac{HP_s}{HP_s + K_1PD^2U^3}$$

This indicates that, while the adiabatic efficiency increases linearly with the turbine tip speed, the windage losses increase as the cube. It further indicates that some sacrifice in the adiabatic efficiency is necessary for optimum over-all performance. For example, a 4.0-inch diameter turbine rotor rotating at 50,000 rpm will have disc friction losses of approximately 1 horsepower at sea level (14.7 psia turbine discharge pressure).

In an underwater missile application at 1000 feet depth with a turbine exhaust pressure of approximately 500 psia, the disc friction losses for the same turbine would be about 30 horsepower.

When compared to the APU output of a nominal 10 hp this leads to an over-all efficiency of one-fourth the adiabatic efficiency. It is clear then that reasonable efficiencies will be difficult to achieve on small output units with a conventional turbine.

Use of a drag turbine or a displacement type machine is indicated for low output (under 50 hp) applications. A drag turbine offers an advantage in such applications since reasonable efficiencies are obtained at very low velocity ratios. This permits use of low shaft and tip speeds where disc friction losses will be low and also offers the possibility of providing direct drive of a generator and hydraulic pump without the conventional gearbox. Analysis also indicates that relatively high efficiencies, in the range of twenty-five to forty per cent, can be obtained from displacement machines operated off propellant gases. However, the displacement machines will find restricted applications until more experience is gained in their use.

The turbine working fluid of an auxiliary power unit is usually the hot decomposition or combustion products of a propellant. Some very small, short duration power units have used high-pressure stored gas, but because of the very low energy content of cold as compared to hot gas, it is seldom employed and is not discussed here.

Solid Propellant and Liquid Monopropellant

The solid propellants offer two great advantages, simplicity and compactness. However, because of the relatively high burning rates of existing solid propellants, and the fact that the entire fuel tank must be stressed for high temperature—high-pressure operation, their use has been limited to units of relatively short duration. Also, once combustion of a solid propellant is initiated, it cannot be readily controlled by external means, so it cannot be started, completely stopped, and restarted as is required by some irregular duty cycles. Solid propellants are essentially constant energy devices which cannot be metered for operation at part load.

The liquid monopropellants allow considerable flexibility in packaging since the required fuel volume conceivably can be contained in a tank of practically any shape. They also have the advantage of being able to be started and stopped as required by controlling fuel flow to the gas generator. The primary disadvantages of the liquid monopropellant system are its relatively high dead weight (for short duration units) and its complexity.

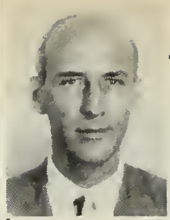
The effects on selection of a propellant for an underwater missile application are threefold: (1) the generator pressures are much higher, (2) hygroscopic propellants are undesirable, and (3) the ambient temperatures are less severe.

Higher pressures require heavier gas generators to maintain safe stress levels. While liquid monopropellant performance is relatively unaffected, the solid propellants are greatly affected. Both composite and double-base solid propellants increase burning rates as the generator pressure increases.

This phenomenon necessitates the use of longer grains than would be required in an air missile for the same duty cycle. Of course, the "mesa" type discontinuity exhibited by double-base propellants tends to minimize this dependence of burning rate on pressure as indicated by Figures 1 and 2.

The hygroscopic properties of certain propellants would be disadvantageous in underwater missile use. The effects are more severe with solid propellants than with liquid monopropellants. Absorption of water by a solid propellant results in erratic ignition and combustion, and ash in the propellant gases.

The effect of ambient temperature, as with hygroscopicity, is more severe on solid propellants than on the monopropellants. Except for such items as the boiling point and the freezing point, liquid monopropellant performance is relatively unaffected. Of course, additional energy is required to initiate decomposition, but the energy difference is not too significant.



Propulsion Notes

By Alfred J. Zaehringer

Big push is now for expansion in LOX generating and transportation equipment to power our new line of ballistic missiles (all using LOX). Office of Defense Mobilization and the Business & Defense Services Administration now offer fast tax write-offs if producers can turn out LOX and nitrogen of at least 99.5% purity. Other conditions: LOX-nitrogen production ratio must be 4—1 and delivery to military customers must be assured. Latest new LOX plant will be a $9 million unit at Acton, Mass. for Air Reduction. Overall, the firm is expanding oxygen facilities by at least $20 million. Linde is to expand its oxygen facility at Ashtabula, Ohio by $12 million with similar boosts at East Chicago and Kittaning, Pa.

Improvement of the standard dewar flask—used for storing LOX and other liquefied gases—has been reported at Bureau of Standards, Cryogenic Engineering Laboratory, at Boulder, Colo. Evacuated powders such as diatomaceous earth, perlite, and silica aerogel have been used.

First tank-car shipments of Westvaco Dimazine were recently made by Food Machinery from its S. Charleston, W. Va. plant. The fuel, dimethylhydrazine, now goes into the *Nike* and other new missiles.

Improved physicals in hypergolic white fuming nitric acid systems is claimed in a new patent granted the California Research Corp. The firm found that addition of 4% sodium nitrite to a 96% WFNA-4% water solution lowered the freezing point to —97°F. In addition, a similar mixture could be stored at 122°F for 48 hours without gas evolution. It is claimed that the mixture does not greatly increase the ignition delay in most hypergolic systems.

Relation of chemical structure and "hypergolicity" of amine fuels has been suggested by RMI. For best hypergolic operation, the rules are: have one C-H bond at the alpha-C in an aliphatic primary amine; use a methyl group in place of a secondary H atom; don't use a methyl group for a secondary H further away from the N than the alpha-C; use amine, hydroxyl, or phenyl groups on the beta-C; alkyl in primary saturated aliphatic amine should be myl; in secondaries it is outyl; in tertiaries it is propyl. With the same number of carbons, tertiary amines are best, next come secondary and are followed by the primaries.

New partnership on the horizon: Gulf Oil Co. and Mine Safety Appliances Co. (a subsidiary of Callery Chemical) will cooperate on joint efforts in the field of high energy fuels and boron chemistry.

Standard Oil Co. (Ind.) has a new hypergolic fuel for use with nitric acid. The liquid is made by pyrolysis of hydrocarbons from butane, butylene, ethane, gas oils, naphtha, propane, and propylene. For hypergolic operation, the acid content has to be at least 95%.

In experiments with a hydrogen-fluorine torch, Temple University researchers have hit a maximum flame temperature of about 4300 K. Composition was 54% hydrogen and 46% fluorine.

French experimenters are using a turbo-reactor to study the combustion of hydrocarbons with an eye to understanding the combustion of kerosene. Work sponsored by the Ministry of Air under Rappeneau and Roy is turning up laminar and turbulent flame speeds, flame temperatures, and vaporization data. Another work by the same agency has concluded that in the combustion of substituted pyridines, this compound has a high anti-detonating power which is probably a result of its strong anti-peroxide formation reactions.

New stabilizer for nitrocellulose propellants has been disclosed by Hercules Powder. Some 0.2—2% of the substituted diphenylamines, urea, or dicyandiamide and 0.02—1% of citric, phosphoric, or stearic acid is blended with a nitrated cellulose to form a product of 13.1—13.2% nitrogen.

New Design Trends for

Harvey Aluminum Extrusions

To any experienced engineer or designer, aluminum extrusions are a common commodity. You don't have to tell him that extrusions offer such advantages as ease of fabrication, design flexibility, etc. He knows that. What he wants to know now are the newest advances made possible by the extrusion process.

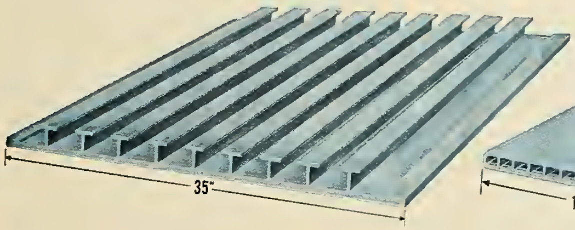
Potential for new configurations and applications

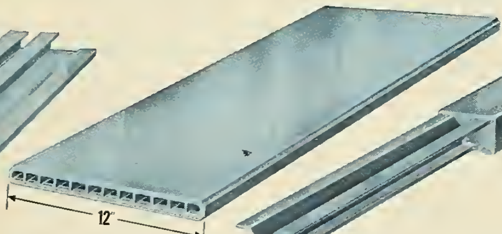
Typical new applications for Harvey Aluminum Extrusions are illustrated below. The design possibilities for aluminum extrusions are now practically limitless. Large heavy press sections; unusually complex shapes; wide, integrally stiffened skin panels; solid, hollow, and stepped extrusions; and extra long thin sections can be obtained from Harvey in all aluminum alloys. Heat-treated shapes can be produced in lengths up to 80 feet, weighing as much as 2,500 pounds. The maximum circumscribing circle diameter practical is 25½ inches. For functional, structural, or decorative applications demanding custom design plus light weight, corrosion resistance, high strength, and a naturally attractive finish, Harvey Aluminum Extrusions are first choice. And remember, Harvey is traditional for high quality and service.

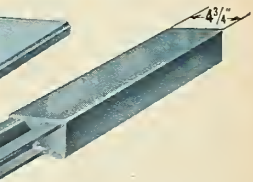
Harvey Aluminum leads in extrusions

Harvey's completely integrated facilities include a large complement of extrusion presses ranging in size from 1400 tons to 12,000 tons, stretch-straighteners up to 3,000,000 pounds capacity for lengths up to 105 feet, and the newest supporting and finishing equipment.

If you have a problem with extrusions, thoroughly qualified Harvey specialists are always ready to help you improve your product. Write to Harvey Aluminum Sales, Inc., Torrance, California, or contact the nearest sales office listed under "Aluminum" in your classified telephone directory.







INTEGRALLY STIFFENED SKIN PANEL is produced in extra wide widths on heavy presses. Combination of skin and stiffeners in large panels minimizes machining, simplifies assembly, improves performance of aircraft, missiles, and military vehicles.

DECK COOLING PANEL for aircraft carrier is extruded on heavy presses. Light-weight, water-tight aluminum panels circulate water to offset intense heat generated against deck in jet aircraft operations.

STEPPED EXTRUSION for aircraft structural member eliminates machining and reduces assembly time. Aluminum part is lighter and stronger than outmoded built-up section formerly used.

Making the most of aluminum . . . for everyone

HARVEY Aluminum

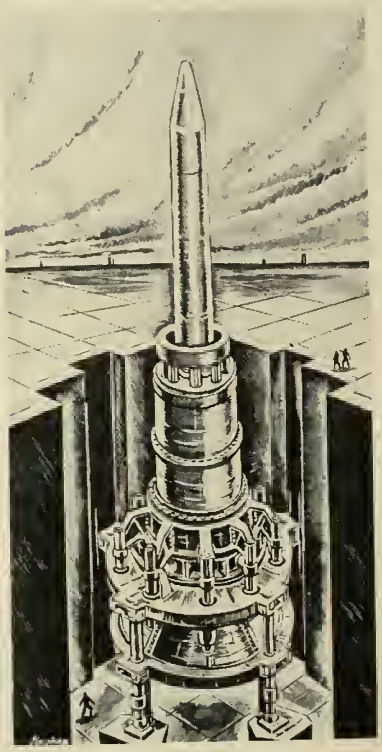
HARVEY ALUMINUM SALES INC., TORRANCE, CALIFORNIA

Harvey is a leading independent producer of quality aluminum products in all alloys and sizes: Rod and bar, pipe, tube, hollow sections, press forgings, forging stock, impact extrusions, structurals, special shapes, extrusions, screw machine products and other aluminum products. Harvey is also producing similar items in titanium and steel.

engineering briefs

Loewy Contract For *Polaris*

The Loewy-Hydropress Division of the Baldwin-Lima-Hamilton Corp., New York City, has been awarded a contract by the Navy for design and construction of a full-scale ship-motion simulator for testing the Fleet Ballistic



POLARIS ship motion simulator.

Missile, *Polaris*. The device will be installed at Patrick Air Force Base in Florida.

Ship motions will be reproduced from magnetic tape recordings taken at sea. The unit will be capable of conducting actual test firings.

Magnesium Extruder For Missile Output

The Dow Chemical Co. announces completion of a 13,200-ton extrusion press, the largest in the world for extruding magnesium, the second largest for non-ferrous metals. It is expected to be especially useful in the production of round hollow tubing for missile bodies. It is able to produce integrally stiffened sections from nine to 20 inches wide; I beams from 11 to 28


Reaching for a Star...
Photon powered interplanetary craft
Speed: 186,000 Miles Per Second
Travel Time to Nearest Star: 3.6 years
Man's most elaborate thoughts on interplanetary travel now involve a photon powered craft whose speed would be that of light, 186,000 miles per second. This would make travel time to the nearest star, Alpha Centauri, about three and one half years.
When a light propelled craft comes into being, we believe that Western Gear will be actively and intimately involved, just as it is today, participating in major projects, designing and building automatic or semi-automatic aircraft gear drives, control systems and rotary electrical equipment.
While our eyes are on the future progress of aviation, our engineering and manufacturing talents are occupied today in solving the myriad control problems of the industry. For thorough reliability and the RIGHT design, why not call a Western Gear Application Engineer now? Write, wire or telephone Western Gear Corporation, General Offices, P. O. Box 182, Lynwood, Calif.
"The difference is reliability" • Since 1888
WESTERN GEAR Corporation
ENGINEERS AND MANUFACTURERS
WG
5754
PLANTS AT LYNWOOD, PASADENA, BELMONT, SAN FRANCISCO (CALIF.), SEATTLE AND HOUSTON... REPRESENTATIVES IN PRINCIPAL CITIES

inches high; round tubing from a 10-inch to 24-inch outside diameter. It boasts a 3000-ton piercer for optimum simplicity in producing hollow extrusions.

Diversey Builds New Missile Plant

Diversey Engineering Co. president J. H. Kauffmann has announced construction of a new $250,000, 31,000 square feet plant at Franklin Park, Ill. Planned especially for missile work, it will have the most modern contour milling equipment, largest Monarch Air Gage tracer lathes and will be equipped to work on titanium, inconel, A-286, Haynes stellite and zirconium.

Colloidal Graphite Used In Satellite Construction

Colloidal graphite suspensions, supplied by the Acheson Colloids Co., Port Huron, Mich., are used as a lubricant and parting agent during the deep-drawing and spinning of the satellite's magnesium sphere. After the naptha carrier has evaporated and left a tough thin graphite film on the magnesium, the sheet is preheated to 600-650°F. The prelubricated hot sheet is then deep-drawn into a hemispheric shape by a 750-ton hydraulic press.

Brooks Perkins, Inc., manufacturer of the spheres, says "ten to fifteen or more" are to be built for testing and actual firing.

Cambridge Reveals New LOX Facility

Cambridge Corp., Lowell, Mass., has revealed details of its new liquid oxygen loop project R-1, the first commercially available facility of its kind in the U.S. The liquid oxygen cold flow test facility is available to private industry for testing performance and reliability of rocket and missile equipment in the cryogenic field.

Army Engineers' A-Plant Is Air Transportable

Last month the public was given its first look at the Army's prototype package power reactor, designed to be air transportable to advanced bases, such as, for example, missile launching bases. Designed by the Atomic Energy Commission and built by Alco Products Inc., Schenectady, N. Y., the first APPR (Army Package Power Reactor) will be used primarily for test and development. Its rated output is 1855 kilowatts.

Submariner "Swede" Momsen

On undersea warfare, 60-knot submarines, high-speed underwater guided missiles and hydrodynamic boundry layer control

Naval Academy graduate Vice Admiral Charles B. Momsen, USN (Ret.), is Mr. Submarine. Developer of the famous Momsen escape lung, he has pioneered undersea warfare since just after World War I. Now retired, he is anything but inactive but, as a fast traveling consultant to industry, leads the nation's thinking on the eve of the submarine's greatest era of development—peaceful and military.

Q. *Admiral Momsen, will you tell us how the strategic role of the submarine compares past, present, and future?*

A. In referring to the past, I'll take World War II. Then the submarine was handicapped. It was slow and was restricted in its ability to stay submerged. It was referred to as a weapon of opportunity because it had to be pretty much in the path of the target it was seeking to attack.

Q. *What were the underwater speeds?*

A. In the beginning of World War II, the maximum submerged speed was nine knots, and if the submarine ran at nine knots it would only run for about one hour before it ran its batteries down. Its top surface speed was 18 knots. German submarines started out with about the same speed characteristics, but they improved their underwater propulsion system by using thin plate batteries with greater capacity. Toward the end of the war they had one submarine which we believed could make 26 knots.

Q. *Was that with the hydrogen peroxide motor?*

A. Yes. That was the Walther cycle, and hydrogen peroxide with diesel engines. That submarine didn't actually get into the war but it was the forerunner for some work that we've done. They built one working prototype. It was undergoing tests when the War ended.

Q. *Wouldn't the Russians know that design?*

A. Oh, yes.

Q. *The Russian submarines are supposed to be based on the German Type XXI long range design, aren't they?*

A. Yes.

Q. *What can you say about the type XXI's range?*

A. Well, when we refer to long range submarines we refer to those capable of operating 5,000 miles away from the bases. A great many of the Russian submarines listed now as you know are quite old, but on the other hand they are building new ones and unfortunately we don't know too much about their characteristics.

Well, we're still talking about the strategic role of the submarine which at present is undergoing an evolution. We're getting now to higher speeds and greater submerged endurance, but no one has a complete fleet of that type of submarine as yet. We can't say that the present is changed much from World War II, but the future holds a great deal of change. I think the future submarine will have mechanical endurance that's practically unlimited. It will have speed capabilities as high as 60 knots underwater. You can never make it on the surface. A submarine inherently will be able to make more speed submerged than on the surface. The reason for that is that a submarine completely submerged and two or three diameters below the surface is freed of wave making losses.

Q. *Can you speculate on future under-sea warfare?*

A. Yes. With the high speeds which will be available to submarines, they will pass from the category of the weapon of opportunity to a weapon which creates its own opportunity, and of course the strategic role will be very much improved because they can get to more places on more assignments and possess a much greater technical capability when they get there. An animal confined to the surface of the water is limited in its tactics to two dimensions of travel. The birds and fish who operate in three dimensions have an inherent tactical advantage. Therefore, I believe that when the submarine is fully developed, or as

Future submarines . . . will do 60 knots.

In three dimensions . . . an advantage.

Fish have nerve ends in their skin.

fully developed as the aircraft, surface ships will not be able to protect themselves. It follows that in the not too distant future control of the sea may well be by submarines and aircraft. I feel that this is coming.

I think you will remember that toward the end of World War II, the Germans had prepared a V-2 or V-3, I think perhaps a V-3 missile, in a container which was to be towed behind the submarine to our coast off New York City.

It all points to the fact that the submarine had that capability. At the present time, as you see, we're bringing our submarines up to the surface and launching from the deck, but I feel that eventually we'll be able to launch missiles through tubes and they will be either torpedoes which operate entirely in the water, or will come to the surface and become airborne for various purposes, intercepting surface ships or aircraft through the use of radar.

Q. *Will 60 knots for the submarine be faster than, say World War II torpedoes?*

A. Much faster. The fastest torpedoes that we knew of were around 45 knots, but that was fast enough for the target which they were seeking in World War II. I believe that no matter how high the submarine speed will get we'll always be able to make a torpedo go faster, simply because the torpedo doesn't have personnel in it.

Q. *What was the outside range of the torpedo that we used during World War II?*

A. Approximately 10,000 yards.

Q. *Does this apply to the straight run torpedo or sonar guided for both?*

A. That was a straight run and fairly slow speed, about 30 knots. Our torpedoes had two speeds, high speed for short range and low speed for longer range.

Q. *Am I correct in assuming that the reason for emphasizing the quietness in torpedo propulsion is that you don't jam your own homing devices that way?*

A. For a homing weapon there is always a battle between the self noise and the noise of the target, and the weapon has to be quieter than the target by quite a margin because it's listening to a target at some distance away. But, submarines versus submarines is much like Indian warfare. One has the advantage of not being committed to move. He can lay quietly in one place. The other one has an objective to go through, and to accomplish this he must move. This makes a certain amount of noise.

Q. *Sonar has been the primary basis for torpedo guidance. Are there any other methods that might be used?*

A. Well, in general electro-magnetic waves do not penetrate the sea and therefore, one way or another we have to rely on sound for the exchange of intelligence whether it's a torpedo or a communications system.

Q. *Isn't there a sound refraction problem in the ocean that can get quite severe?*

A. It is a very difficult problem. What actually refracts sound is the change in density. The speed of sound is a function of the density, and the greater the density the higher the speed of sound.

Q. *What effect does this have on homing torpedoes?*

A. An acoustic torpedo is always aiming at the noise source. It may be a long way around but eventually it arrives at its target.

Q. *We understand that the fish are not concerned with such things as cavitation, that flight, often at high speeds, is remarkably silent. Do you feel that performance of man-made water vehicles might be improved through careful study and emulation of fish design?*

A. I would think so. We have no known hydrophone that can record the noise of a fish traveling through the water.

Some fish hit speeds of around 50 knots, and they're highly maneuverable. The porpoise is fairly fast; the barracuda is very fast. But I don't think we really know how fast they can go because very fast fish rarely have the urge to go at their top speed.

Q. *They never cavitate?*

A. Never, unless they are very close to the surface. Cavitation is a function of pressure, and if they get very close to the surface, well, then they get less water pressure around them and are apt to cavitate. But I have seen barracuda come right up to the window of a diving bell at very high speeds, stop suddenly with not the slightest sign of cavitation, no noise and look at you for a few seconds and then like a flash he's gone again and still no sign of cavitation. I've done some work with the Coleman Engineering Co., in Los Angeles on the matter of hull cavitation and the reduction in drag. Dr. Max Kramer, a German scientist working with them, has been studying this subject for quite a while, and we believe that he has solved the riddle as to what causes cavitation and how to prevent it and promises a very substantial reduction in drag.

That work is a private venture and is not being supported by any of the military. Very often we get very fine things from private projects.

Q. *Can you say anything concerning when the prototype with a 60 knot sub might be launched?*

A. I haven't the slightest idea. I notice that about two weeks ago in the *New York Times* there was a very small article that said the British were developing a very high-speed submarine. It's feasible, it's coming. There's no question about it's coming. The question is whether the effort will be put into it.

Q. *Effort means dollars?*

A. Well, that's right, hard rocks. Dollars, and there

If flow is laminar . . . noise is reduced.

Torpedoes . . . will become airborne.

The sea is still a place to hide.

are some technical developments, too, that we think are feasible. There aren't any problems that can't be solved.

Q. *Does anyone know why fish don't cavitate?*

A. Well, cavitation is caused by unequal pressures along the side of the surface, as it moves through the water.

Q. *Is cavitation equivalent to going from laminar to turbulent flow in the boundary layer?*

A. Exactly the point. The difference between turbulence and laminar flow is the unequal pressures along the surfaces. It's my feeling that the fish has nerve ends in its skin and that unequal pressures are uncomfortable. Through muscular effort he makes minor changes in his shape and keeps the pressures equal and therefore, the flow laminar. And if the flow is always kept laminar you will not have turbulence, and your water noise will be reduced.

Q. *Might you not then, where you tend to cavitate, blow in or suck off water to maintain laminar flow?*

A. That's right. It's the same approach, but in aircraft turbulence results in increased temperatures plus increased drag whereas in the submarine, it's increased drag and increased noise. And, if submarine turbulence can be controlled through the control of the boundary layer it will be applicable to propellers as well.

Q. *Do you personally feel it would be practical to develop a medium range ballistic missile capable of fitting and being fired from the torpedo tubes of submarines now in service?*

A. Not necessarily from current torpedo tubes. We have been locked to a 21-inch tube for many years. The Japanese increased theirs to 24 inches. There's no reason why we shouldn't use 24 inches or even 48 if we had a purpose for it.

Q. *Just to get complex for a moment, do you see any future need for a transitional missile that starts out traveling underwater; then rises to the surface and becomes ballistic; then reenters the water to act like a torpedo again?*

A. That sort of thing might be needed for a restricted submarine, but not the submarine of the future.

Q. *Well, suppose we had an underwater distant early warning system—a network of sonar buoys spotted around our coasts. We wouldn't need as many anti-sub submarines on patrol. A submarine off New York equipped with such a missile could attack an enemy submarine off Cape Cod.*

A. Then it wouldn't have to travel underwater first, except to float to a safe vertical firing position. Only two stages would be required. That is something that is under consideration. There's no need for three stages. I'd like to suggest also that such a sonar buoy network would be readily subject to destruction by the enemy.

Q. *Would this be true of passive devices?*

A. In the defense against future submarines, if they're going to be as quiet as I think they will, there will have to be more than just passive sonar. An active system could be traced by its own signals.

Q. *What was the range of passive sonar in 1945?*

A. By World War II the Germans could hear a large surface ship perhaps 75 or 80 miles away. They could hear convoys with ease at 30 or 40 miles.

Q. *Can we assume this has been improved?*

A. Yes. We can hear depth charges, for instance, tremendous distances, several hundred miles.

Q. *Can you get direction and estimate range?*

A. You can get a pretty good direction fix but no range. Underwater sound is a very interesting subject because we have in the past been thinking only in terms of the spectrum of sound that the human ear can hear. We haven't investigated the very low frequencies or the high frequencies beyond the oral range. There is a principle that we'll have to keep in mind that the higher the frequency, the greater the attenuation of the sound in water. In other words, very high frequency can be heard at only very limited ranges, where very low frequencies travel perhaps thousands of miles. That is the nature of sound in water.

Q. *What are the limitations of underwater warfare?*

A. Well, there are three areas of limitation. One is communication; the second is navigation; and the third is human endurance. Now we've talked quite a lot about underwater communications and so far as we know at the present time sound is the only means of communicating completely underwater. Low frequency radio penetrates the water a little bit, a matter of a few feet. From a navigation standpoint, I think a great deal can be done. Nowhere in the ocean is land more than five miles away vertically. We can put navigational fixes on the bottom just the same as we do navigational beacons for aircraft on land. From the standpoint of human endurance, that is a problem everywhere and in every endeavor of life we have to provide fresh water and air to breathe.

However, if we look again at nature we find fish are able to get oxygen which is in solution in the sea water and have their CO_2 carried off in the sea. This is the same process of the human lungs, except that we expose air to a membrane. Now in the ocean there's much less oxygen in a cubic foot of sea water than there is in a cubic foot of air. Therefore, great quantities must flow over the membrane. If we can ever become as smart as nature why we'll have all three problems solved. It's quite interesting that fish maneuver so well together. You see a school of fish make a radical change of course simultaneously without collision. Fish will spawn in a river and go to sea and disappear hundreds of miles away, maybe thousands, and yet the following year they come back to that same river.

Q. *I would like to ask you whether you think the submarine is the best weapon against another submarine?*

A. I believe that it is. I have been advocating that for some time. I believe that the submarine has inherent advantages over another submarine that nothing else has. Some people in the Navy now say that we shouldn't have submarines that are specifically designed for anti-submarine roles, that all submarines should have those roles. I have never believed in that because I think that if you have a very important mission for any ship or plane, that it ought to be built for that mission.

Q. *What do you see as the peaceful future of underwater development?*

A. That is another area in which I am doing work now, and it's quite interesting. The U.S. Rubber Co. is working on underwater fuel and cargo transport by means of rubber barges. We can make these rubber containers of considerable size. They can be towed by a submarine and I believe that it will be financially or economically feasible to transport fuel, grain and other bulk cargo, cargoes that can withstand the sea pressure. You've got two advantages there. One, less drag under water than on the surface. Two, the bulk of your investment, the tow boat, doesn't have to sit in port for three weeks while they load and unload it. Also, it is free from wave motion and wind and storms. For the return trip this container can be rolled up and carried on the deck of the ship and you don't have to tow an empty ship in ballast on the return trip. You don't need a long tow line because you don't have the motion of the sea to work against and because of the nature of the material, rubber being flexible, you can violate all the laws on length-to-beam ratios that are required on ships. You could make one of these containers 20 ft. in diameter and a mile long if you want to.

Q. *Of course, for military purposes again it would be invaluable.*

A. Yes, safety concealment from attack. The sea is still a place to hide. ★

Rocket Propellants for Underwater Missiles

By Alfred J. Zaehringer

THE ROCKET POWERPLANT now allows the underwater missile spectrum to be expanded to include other subs, ships attempting evasive action, anti-sub patrols, and even distant land targets.

The advent of rocket and nuclear power has given the submarine a new lease on life. Atomic power gives the sub an almost unlimited striking range while rocket power can replace the conventional torpedo or deck gun. The main purpose of the modern sub will thus be to carry out atomic strikes on distant land targets—while remaining conveniently submerged.

Environment (Care)

To the landlubber rocket engineer, two environmental conditions are encountered—pressure and temperature.

The underwater pressure is a product of depth and density. With seawater (density about 64 pounds per cubic foot) about 33 feet of depth raises the pressure one atmosphere. Thus, at a depth of 60 feet, the pressure is about 60 psia.

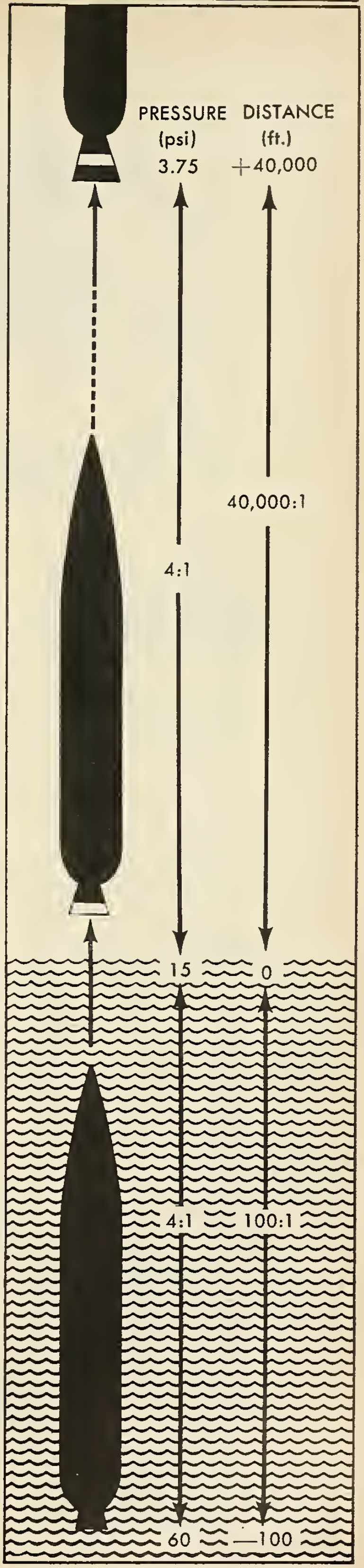
For optimum expansion the nozzle should expand the combustion gases to ambient pressure. Thus, as the missile rises vertically, the pressure decreases, and the nozzle has to get bigger. Therefore, some optimum expansion point has to be selected.

It is perhaps fortunate that a vertically ascending missile will be under greater than atmospheric pressure for only a short time. However, the difference in thrust (and overall pressure system) must be taken in account.

It is interesting to note that at a depth of only a few feet, water pressure can be helpful, in effect increasing the nozzle length without adding missile weight; this effect, useful in rocket torpedo work, acts to increase the thrust coefficient. Since subs can operate at 200-300 feet, operating normal liquid rocket engines poses some problems:

How do you operate at a chamber pressure of 300 psia when the outside pressure is greater (pressure at 300 feet is about 320 psia)? What is the optimum expansion ratio for rapidly changing pressure? What about variable combustion pressure? Not only are propulsion problems difficult but structures must be beefed up to take the higher external pressures.

How far down would you want to fire an IRBM? For a missile nearly 100 feet long, the depth would have to be 100 feet so that the missile is still submerged. It appears the depth would be 200-300 feet for maximum hiding.



Pressure difference (4:1) to depth of 100 feet is about same as from sea level to 40,000 feet. This calls for increasing nozzle exit area for optimum expansion.

Table 1
PROPULSION SYSTEM PARAMETERS

Type	System	Performance	Hazard	Cost	Storage
Liquid	LOX-Fuel	H	V-L	Low	NP; OB
	Acid-Fuel	H	V-L	Medium	EX; OB; IB
	Peroxide-Fuel	H	L	Medium	EX; OB; IB
	Peroxide-Cat	M	L	Medium	EX; OB; IB
	Ethylene Oxide	M	L	Medium	?
	Alkyl Nitrate	M	L	Medium	?
Solid	Composites	H	Low	Low—Medium—High	EX
	Double-Base	H	Medium	High	TS

H: over 200 lb sec/lb
M: below 200 lb sec/lb
NP: not practical in missile
V: Vapor
L: Leakage
EX: Extended periods
TS: Temperature sensitive
OB: Outboard
IB: Inboard

Possibly one item of consolation —sea temperature could be quite useful. For one thing, the surface temperatures have a narrower fluctuation than on land. The upper limit is 80-85°F in the tropics and seawater freezes at 28-29°F. Thus, the temperature range is only 50-55°F. Within a given season, the variation is less than 10°F and about 1°F between day and night.

As you go down, the temperature the world over tends to become lower and constant—the average is about 34°F. Thus, we have a gigantic constant temperature bath and an exposed underwater missile will not operate under such wide temperature extremes as experienced by land or air missiles (viz., —80° to 180°F). It is conceivable that if needed heat could be fed to the missile to maintain higher operating temperatures.

In a vertically ascending missile, the effects of waves would have to be considered. When breaking the surface, the missile would not yet be moving fast and would be vulnerable to waves and then the winds.

Since timing might be critical against a land (or air) target, a calm sea can't always be counted upon. A breaking wave on a solid object, for example, can generate pressures of 2,000-14,000 pounds per square foot over a time span of 0.05-0.005 sec.

The variation of wave height with wind speed will certainly be instrumental in determining when to fire—particularly a large ballistic missile.

Other factors, too, are important. For long-range missiles designed to operate entirely underwater (such as anti-ship or sub), guidance and control systems will have to take care of varying currents or shifts in currents. Action of seawater on structures, especially where missiles are immersed for prolonged periods, is also important.

Not only is it a matter of preventing corrosion and barnacle growth but you also have to worry about keeping out water. This is quite different from land or air missiles.

Propulsion (Feeding)

The selection of a propulsion system for an underwater rocket is governed by such factors as performance, storage, hazard, etc. Such parameters are presented in Table 1. Of the liquid propellants, LOX systems are not attractive for ready-to-go storage in missiles for extended periods of time.

However, all liquids offer one large headache for naval service: leakage. In addition, a very high degree of reliability is required and, at the present time, this reliability could best be offered by solid systems. Solids can now give ready-to-go systems which can be stored for over a year with zero maintenance.

Maintenance, however, may not be a strong objection if the sub's prime mission is to launch an IRBM. Of all the liquid systems, the nitric acid propellants can come close to meeting all requirements.

Because of relative insensitivity to low temperature operation, and ability to operate at high pressures (1000-2000 psi), the composite solids would be ideal for underwater use. Other advantages are: grain designs can allow for a programmed thrust (and pressure).

In addition, there are the mesa composites where burning rate is independent of pressure in the 1000-2000 psi range. This is advantageous since the effects of back pressure can be absorbed and the grain geometry can allow for the best mass flow (including a variable mass flow) during a rapidly decreasing sea pressure.

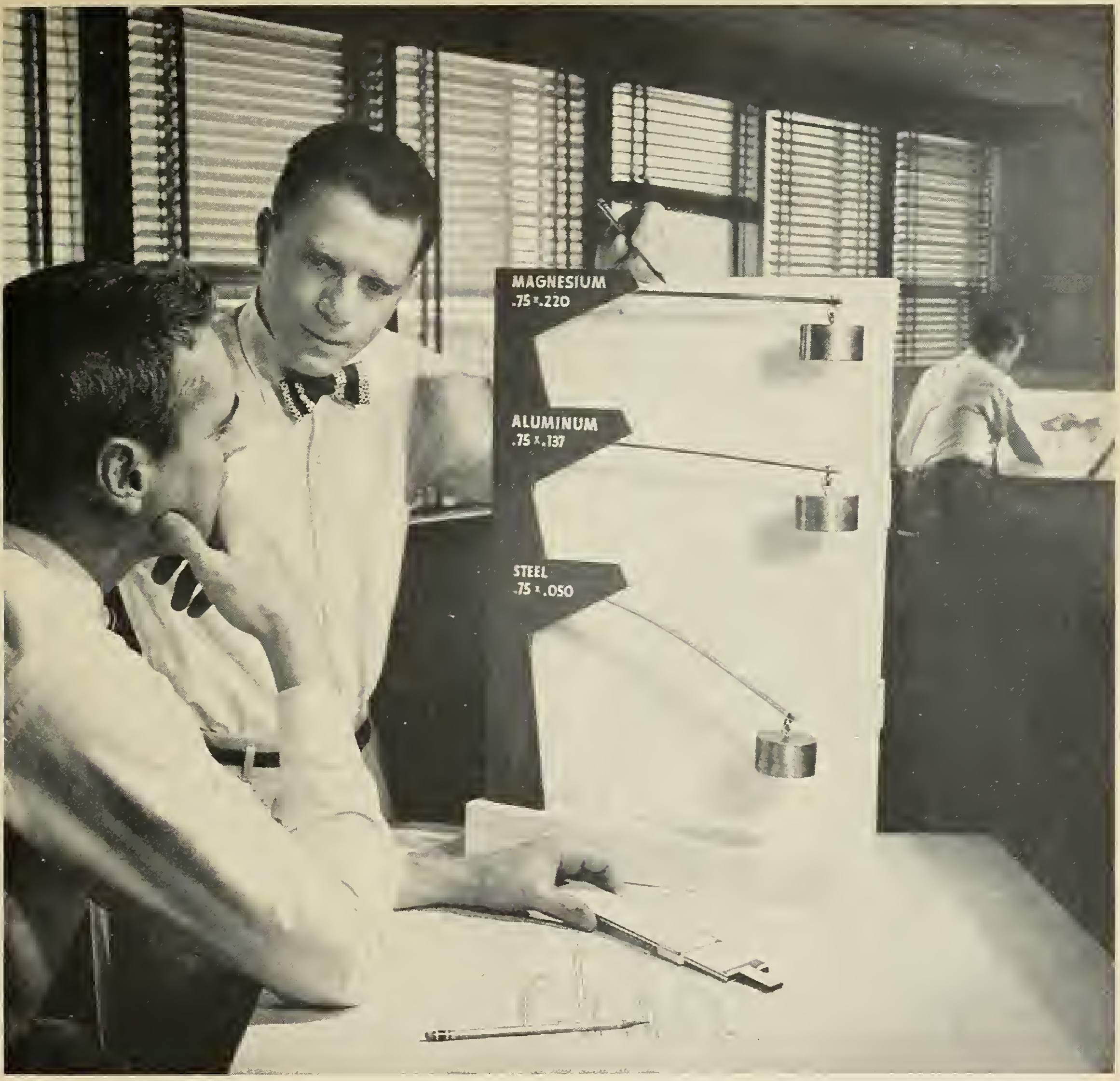
Internal storage systems could be used for smaller missiles (rocket torpedo or flak) of both the liquid and solid variety. Deck pods could be used for large missiles where the sub's crew could be used for servicing the missile.

Towed pods would be attractive for very large systems or for the high hazard liquids. Another advantage of a towed pod is that it could be jettisoned on completion of the mission or could be dumped if necessary to save a sub.

It is thus seen that missiles will breathe new life into the submarine. The impact on naval strategic and tactical warfare will be as great as nuclear power. With such subs, the age of the present highly vulnerable aircraft carrier is rapidly coming to an end. The salient features of the missile-sub weapons system are: unlimited range and striking power, relative independence of a vulnerable base, and the very great element of surprise.

Since 1955 the Russians have been completely independent of German brain power, although most of the current missiles reflect the German thinking that conceived them in their early stages of development. There is some evidence that the Russians are still using Peenemünde missile base in East Germany for underwater missile research projects.

All evidence indicates that Russia is now on its own in the missile field and is doing well. Missile enthusiasm abounds among the entire Russian executive class. The apparent attitude of Russia's leaders is to have large quantities of undersea missiles available as quickly as possible. As is the case with most Soviet weapons, the emphasis is on simplicity and reliability.★



Rigidity! At equal weight, magnesium is 18 times stiffer than steel

Magnesium's unique combination of strength and light weight gives it some outstanding abilities as a structural metal. Take rigidity, for example. A magnesium bar has 22% the stiffness of a steel bar of the same dimensions.

But stiffness increases as the cube of section thickness. So, if thickness of the magnesium is increased to twice that of the steel, the magnesium bar will be over 70% more rigid—yet weigh only half as much. And if thickness is further increased until the bars are of equal weight, the magnesium bar will be 1878%—or over 18 times—more rigid!

Similarly, a magnesium bar of equal rigidity to an aluminum bar will weigh only 75% as much as the aluminum bar. At equal weight, the magnesium bar will be over twice as stiff.

From these facts it's easy to see that magnesium can do a structural job equal to or better than steel and aluminum—and with appreciable savings in weight—whenever it's practical to increase section thickness. For more information contact the nearest Dow sales office or write to us. THE DOW CHEMICAL COMPANY, Midland, Michigan, Magnesium Department, MA 1402R.

YOU CAN DEPEND ON DOW

Aerophysics

By Seabrook Hull

Being within a lifetime of extensive space travel, as we are now, certain basic concepts deserve more thoughtful consideration. Not the least of these are some of the fundamental hypotheses of relativity, at which point this column ventures into a phase of astrophysics.

An interesting and disturbing element of Einsteinian thinking is the "apparent fact" that the speed of light is constant to any observer, regardless of the relative motions of different observers observing the same light source. This, of course, is an awkward assumption. Yet wherever capable of being tested and checked, either astronomically or within the confines of some of man's more exotic research equipment, relativistic mathematics is meticulously born out.

If light velocity is constant for any observer, and we measure astronomical distances in terms of light-hours and light-years, then these distances (absolute spacial displacement) must vary for different observers. This concept does not appear to be at variance with relativity. Physical time also is dependent upon the relative motion of observer and observed. And, distance appears to be a function of velocity and time in any coordinate system.

Thus man, in his proximate ventures into outer-space, would seem to be limited in velocity only in terms of earth-bound observation. Relative to the coordinate system of the space vehicle itself, the velocity of light will remain constant, notwithstanding the velocity of that vehicle. This is one of the disturbing but essential assumptions of the General Theory of Relativity. Thus, the velocity of a free vehicle in space seems to be theoretically without limit. Again, relative to an observer on earth, this vehicle's observed velocity would be limited to a fraction of the earth-measured velocity of light.

However, in terms of the "absolute" coordinate system of the space-traveling vehicle itself, there would be no such restriction . . . for the only relativistic limitation on the vehicle's velocity is that it cannot exceed that of observed light. Yet this is constant for any observer, and regardless of the relative motion of that observer, the velocity of light is the same—186,000 miles-per-second. Thus a vehicle covering light-year distances (as observed on earth) in hours would still be traveling at less than the speed of light (as measured by the vehicle).

Pursuing this line of reasoning a few steps further becomes very disconcerting. For example, distance must thus be a function (or friction) of the observer and inconstant by any comparison: Spacial displacement becomes a chance (or optional) variant.

These lines of reasoning, dwelling on so-called Eigen conditions, may well be open to considerable argument, but this column hopes they serve at least to emphasize the real, practical need for: (a) Relating basic thinking theory to upcoming operational problems and (b) reexamining and justifying Relativity in terms of the many more recent (and startling) subnuclear observations. It would also seem to necessitate a new and more careful look at the concept of "free space" itself—the raising of the possibility anew that there is in fact a universal medium (once called the ether), a current source of confusion which, once comprehended, would become absolvent of some of the more fundamental anomalies. In any case, it should be obvious that Einstein's was an approach, not an end to understanding, that already more *thinking* is needed.

O.K. Mr. Satin?

Astrionics

By Henry P. Steier

When will the first *Vanguard*-with-satellite be fired? Seems like a good clue to the answer could be the status of the camera tracking station installations. Latest report from IGY scientists is that cameras will be installed at the rate of one per month starting this summer.

Since a dozen camera stations are planned, it looks as if the schedule for first attempt to place a satellite will be around July 1958. IGY starts July 1957 and runs to December 1958.

Big unknown about the earth and its continents is the distance between various points on earth's surface. Some guesses are that we are miles off in distance information between continental European and North American points.

Any planning for ICBM use would need most accurate distance information possible. Planned IGY camera tracking should add whole new orders of distance information accuracy to our fund of information. Data from cameras is expected to bring accuracy to within a few feet. Such information will be an important factor in data fed to big computers for calculating ICBM trajectories.

•

Recently a physicist came up with another idea on distance measurements. He said atomic powered submarines might be used to measure point-to-point distances between coastal areas. He suggested that the constant speed capability of these subs while submerged would make them useful for deriving distance from point-to-point times obtained.

First need for accurate distance information will probably be during ICBM test flights off the coast of Florida. These will be in the same general direction as the satellite launching. Recently reported was a plan to set up Air Force electronic missile tracking gear on the island of St. Helena off the African coast. Distance to that point, for example, would be most useful in evaluating ICBM tests.

•

Phase angle tracking systems similar to the Minitrack stations to be used for tracking the satellites' positions is "old hat" to the Cubic Corp. Similar systems built by Cubic have been in use at Patrick AFB for some time. Called DME-COTAR, phase angle measurements are used in this system for determining test missile trajectories, distance and position data. Operating at between 200—450 megacycles, tracking accuracy is said to be much better than with radar. Accuracies of two feet in distance at 200 miles and 0.03 mils in direction are claimed. Cubic expected it would get the Minitrack contract for the satellite program but lost out when the Navy developed its own system.

•

In the midst of speculation about whether the press will be permitted to view the first *Vanguard* launching is hope for on the spot viewing by the general public if the military will permit it. Rumor is that International Business Machines Corp. is negotiating to sponsor a big TV broadcast of the event.

•

Note to lady rocketeers: A Latin American gentleman has a suggestion on how to shorten the time to moon travel. Dr. John P. Hagen, Project *Vanguard* Director was asked at a recent press conference, "When will the first moon trip be made?" The inquiry came from Maximilian Garavito, Editor and Publisher, "Revista Aerea Latinamerico." Hagen said he preferred to answer in terms of money and engineering needed rather than time. Senor Garavito then said he saw no reason why, since Columbus discovered America using money from jewels pawned by Queen Isabella, the women of America could not give their "jewels and stocks" for the first moon ship.

From instant SCOPE diagnosis

And the most thorough METER analysis...

To Power control and test equipment: Electric, Electronic and Hydraulic

Sun OFFERS COMPLETE ENGINEERING, DESIGN AND CONSTRUCTION FACILITIES OF THE HIGHEST STANDARD OF RELIABILITY

SUN Equipment is known for its Reliability. Whether it be a simple d'Arson galvanometer meter, an oscilloscope specially circuited for specific instantaneous readings, or a large and complex hydraulic power supply and remote control testing unit for missiles or rockets—the reliability of SUN Equipment can be depended on with the utmost of assurance.

SUN Equipment has proved itself reliable for 30 years in industries whose requirements are as exacting as those of the aeronautical and astronautical fields.

Whether your problems and needs are concerned with:

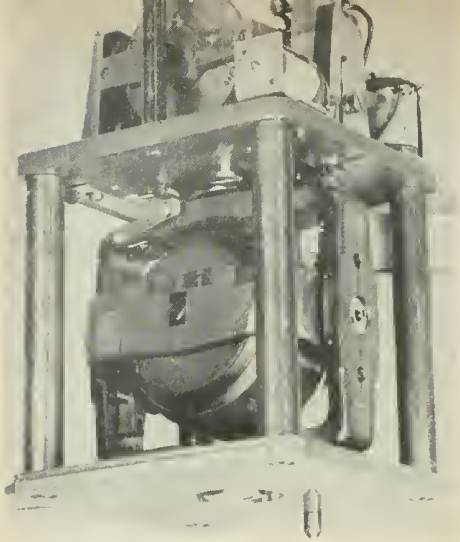
- Ground support test equipment for missile systems.
- Quality control test equipment for missile component functions.
- Firing stand test equipment or
- In-factory functional test equipment,

our engineering and manufacturing facilities are available to you. And we are sure you will find them the finest extant in our fields. We welcome your inquiry.

SUN ELECTRIC CORPORATION

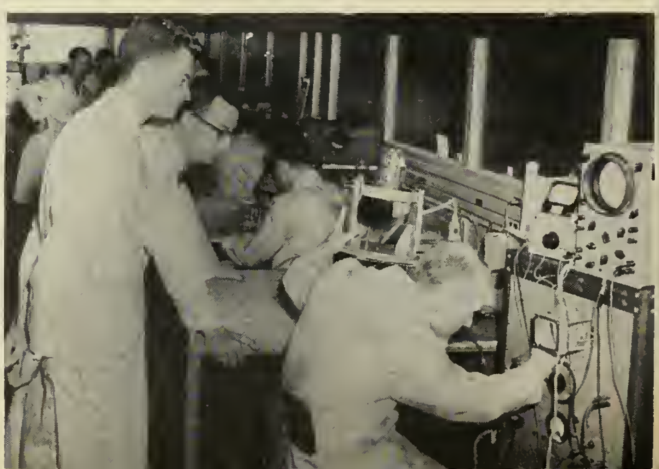
6323 N. AVONDALE · CHICAGO 31, ILLINOIS

6701 S. SEPULVEDA BLVD. · LOS ANGELES 45, CALIFORNIA

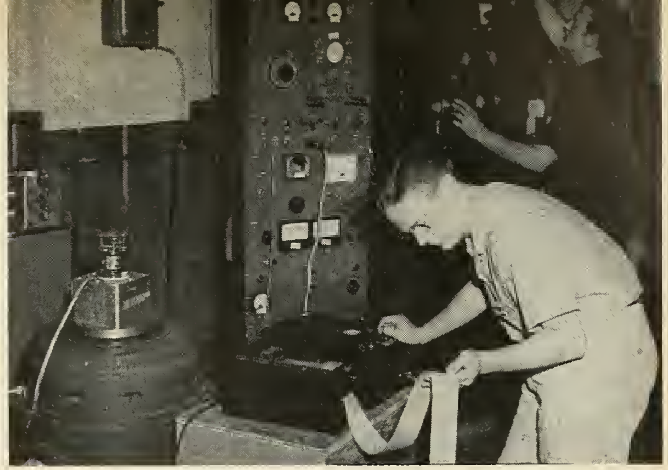


Birth of a Torpedo Gyro System

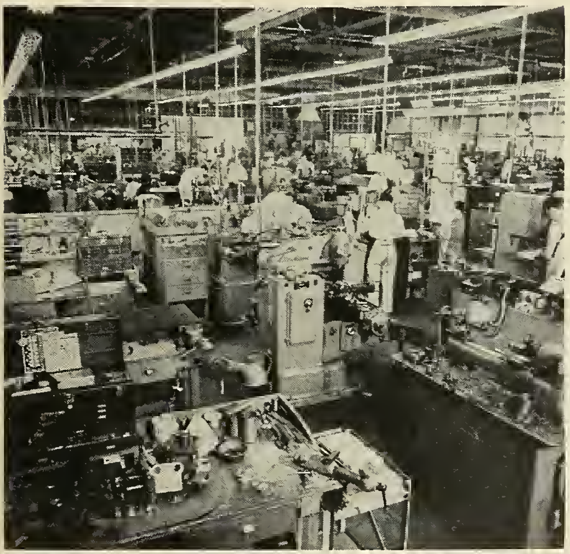
The torpedo gyro essentially serves a course control function and provides a safety measure against anti-circling to return. On the drawing table at Whittaker Gyro an experimental model is designed. From these specifications the prototype department builds component parts and tests them. When all components seem acceptable, a complete instrument is assembled and subjected to a thorough checkout. The new torpedo gyro now goes to the drafting table. The designers convert computations into a working design from which a prototype model will be built.



Following assembly the gyro is then sent to the test department. Specialized test equipment is needed to meet requirements and quality control measures. These include full function and environmental testing. Here, a test engineer subjects the course control gyro to high frequency vibration and acceleration tests.



To supplement the standard parts which are ordered from outside sources, the machine shop, shown here; turns out the precision components which are peculiar to this type of torpedo gyro.



The course control torpedo gyro is assembled in rigidly controlled atmosphere where temperature and humidity are constantly regulated. Any one entering the room must put on a nylon smock.

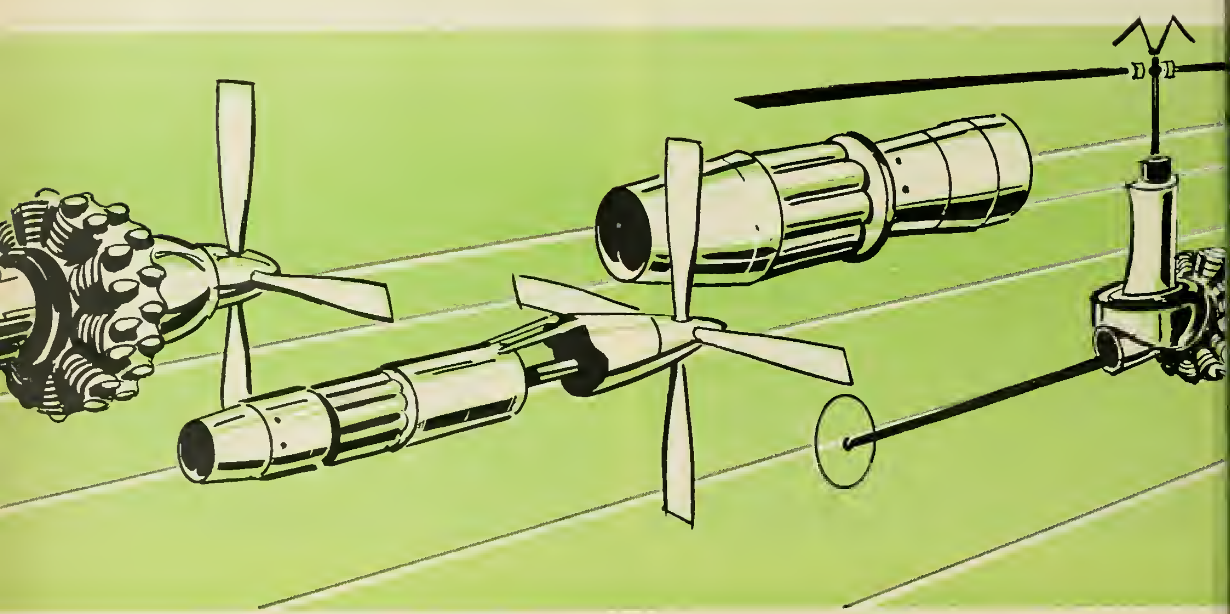
The gyro is packed and inspected, boxed and re-inspected before it goes into delivery channels. The magnitude of importance which this gyro will play in the guidance system of the modern day torpedo will justify the intricate preparation and care which follows each of these instruments to its destination.

SMALL JET ENGINES...
CHAMPION WEIGHT LIFTERS

An entirely new family of aircraft will evolve from a new family of small lightweight jet engines now under development at the Fairchild Engine Division. These new powerplants will feature incredibly high thrusts and great lifting power...yet will be so light they can easily be carried by two men.

Highly compact, with low frontal areas, the small jet engines will deliver thrust/weight ratios starting at 8 to 1 with a long range potential of more than 10 to 1. They will be used in the high performance, lightweight trainers, interceptors, target drones, pilotless aircraft including missiles and intermediate class passenger and cargo jets of the nineteen sixties. They will also be used to power fighters and utility cargo craft, executive aircraft . . . and will make jet Short Take Off and Landing (STOL) and Vertical Take Off and Landing (VTOL) aircraft practical.

The small jet engine may be used singly, in pairs and in clusters. It provides multi-engine reliability in aircraft of a size now wholly dependent on a single engine. The small jet engine will produce greater versatility and utility in airplanes of tomorrow.



COMPARISON OF LIFTING CAPACITY OF POWER SYSTEMS

How the new family of Fairchild Small Jet Engines compare with other mechanical lifting systems.

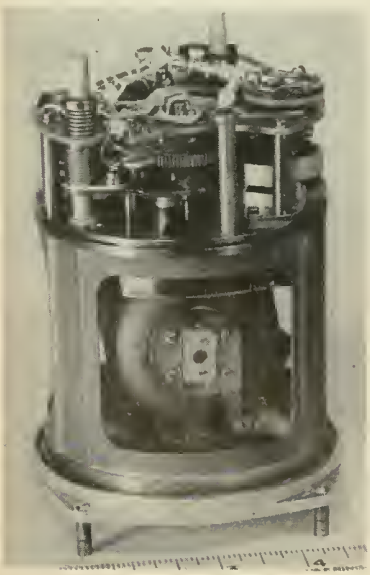
GYROS . . .
To Prevent Torpedo Vertigo

By Donald J. Rammage
Whittaker-Gyro

ONE OF THE MOST important advances in our country's weapon arsenal has been the development of the sonic homing torpedo. Although, the gyroscopic principle was involved in earlier torpedo experiments, it became increasingly important in sonic homing torpedo development where its role in the guidance system effected great changes.

Before the advent of the sonic homing torpedo which had its beginnings in World War I, the gyroscope was used to keep the torpedo on a straight course to the target. But it was costly to produce.

In spite of all efforts to increase the accuracy of the gyroscope and consequently the torpedo itself, the percentage of target hits was low. This was not due entirely to unreliability. The vessel under attack might spot the torpedo and take evasive action or it might be steering a zig zag course and change course after the torpedo had been fired. This demonstrated the need for a device to automatically cause the torpedo to home on the target.



Modern gyro for the sonic-homing torpedo. Small yet extremely reliable, Model 501705 is light and low in cost.

With the development of such a device, the gyroscope's role in the torpedo was immediately changed. It was no longer necessary to build extreme accuracy into the course control gyroscope. Most inaccuracies could now be overcome and corrected by the electronic sonic homing device.

While this would appear to give the gyroscope a back seat in torpedo guidance, it was found that it was still required. It was necessary to have a stable directional reference that would work in conjunction with the sonic homing device.

Before World War II the design, development and production of standard torpedoes was done largely by the Navy in its Ordnance plants. The all important directional gyro was also manufactured in the Ordnance plants. At the beginning of World War II, these plants were under terrific pressure to produce torpedoes in quantity under trying conditions.

Such programs were of high priority and there appeared little, if any, incentive for the development of the sonic homing torpedo. Up to this time, almost sole concern had been for torpedo accuracy as aimed and launched from a surface vessel or submarine. Our staggering losses during the war pointed up the need for a torpedo which could seek out submarines.

The experts at this point reached the conclusion that the homing torpedo had a multi-delivery capability—the same type torpedo could be launched from a ship, aircraft, blimp or a submerged submarine, seek out and kill with equal results.

It was decided early in the development that an electric drive would be required as well as non-cavitating propellers so that no tell-tale trail of bubbles would reveal position. To obtain counter propellant rotation (to keep the torpedo on a straight course) it was necessary that one set be driven with the shaft of the starter motor and the other set with the frame. This necessitated mounting the drive motor (automobile starter) with a set of bearings on the housing and bringing power to it through slip rugs. The need for electric power to drive the torpedo and operate its electronic equipment dictated the gyro's operation from an electric power source. Previously the gyros had to be air driven as this was the only power available in the torpedo.

At the stage of the hot-water-tank-and-breadboard-equipment no depth control mechanism was available although the feasibility of the sonic homing torpedo had been established. The development of this one remaining piece of equipment stood in the way of the entire program. Depth controllers were used on the standard torpedo but they were allowed high priority.

At this point fate intervened. One of the principal design engineers had undertaken some do-it-yourself hot water heating system repairs in his home. He was directly concerned with the controlled-submersion problem and this caused him to consider the principles of the pressure regulating mechanism. Here he found the device that was needed: essentially bellows and two electric mercury switches. He dismantled it from the heating system and a quick test in the following days proved its capability for the job.

While the development of the sonic homing torpedo proceeded, John James came to the Underwater Sound Laboratory at San Diego to assist in the development of a decoy-type torpedo. This device was to be launched from a ship being attacked by sonic homing torpedoes and by virtue of the quantity launched, undertake to decoy the sonic torpedo away from the ship.

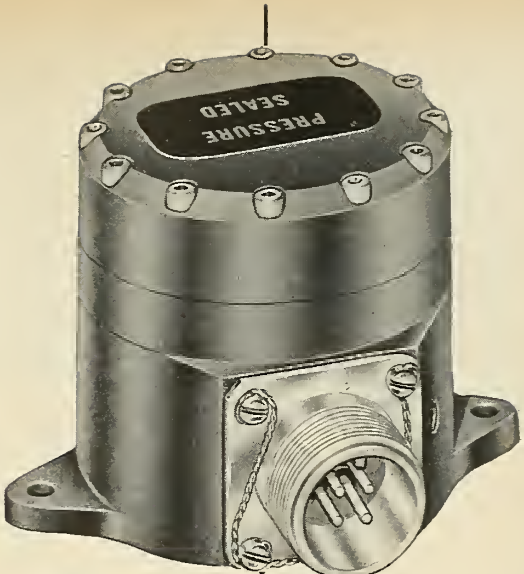
During the latter part of World War II, several other firms were working on development and improvement of the sonic homing torpedo. Among these were the Bell Telephone Laboratories with Western Electric Company as the production group.

Each group was working on a different torpedo for particular tac-

LINEAR ACCELEROMETERS

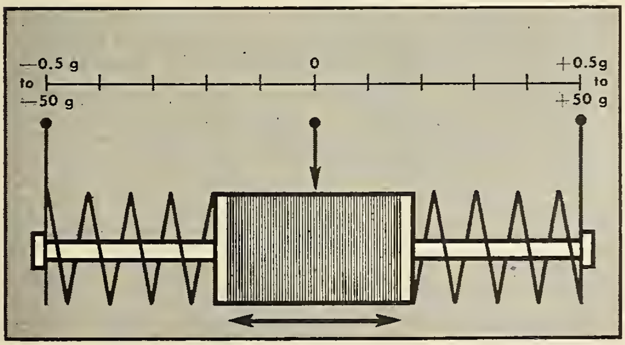
for Aircraft and Missiles

ZERO CROSS-COUPLING
NON-PENDULOUS TYPE



Shown Actual Size

Honeywell Linear Accelerometers sense positive or negative accelerations or both in either the vertical or horizontal plane. Designed for use in aircraft and missiles, they are available in a variation of ranges from ± 0.5 g to more than ± 50 g's depending upon requirements. These units consist of a centrally located mass restrained by coil springs and supported on a linear-type ball-bearing. Any movement of the mass on either side of the null displacement position is measured by a potentiometer pick-off, providing a high level output signal. Viscous damping is incorporated for improved dynamic response. Zero cross-coupling is inherent with this true linear non-pendulous design. (Cross-coupling is defined as a change in output signal caused by an acceleration applied from any direction in a plane normal to the sensing axis) Excitation may be as high as 100 volts (A-C or D-C) depending on the potentiometer resistance. *Write for Bulletin LA* . . . Minneapolis-Honeywell, Boston Division, Dept. 45, 1400 Soldiers Field Road, Boston 35, Mass.

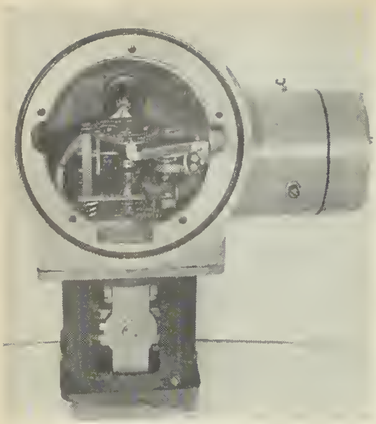


- LINEAR RESPONSE
- D-C OUTPUT SIGNAL
- VISCOUS DAMPING
- HERMETICALLY SEALED
- EXTREMELY RUGGED
- WEIGHT: APPROXIMATELY 0.9 POUNDS
- ENVIRONMENT: MEETS MIL-E-5272A

MINNEAPOLIS
Honeywell

BOSTON DIVISION

Write for Bulletin LA



Mark 27 torpedo gyro. Accurate, predetermined course can be established by presetting the course-sensing element.

tical missions but all were using the sonic homing principle.

Whittaker Gyro with its work in the direct-current-powered gyro field was able to use basically similar gyro wheel and gimbal configurations and supply different sensing elements, caging mechanisms, case configurations.

The gyroscopes for the Mine Mark 30, the Mark 27 and the Mark 32 torpedoes contained gyroscopic elements modified from the roll control free and rate gyro and Air Force Type B-10 used in the *Azon* and *Razon* radio-controlled air-to-ground bombs.

The first sonic homing torpedos operated so that they homed on the noise generated by a ship's propellers and were primarily designed for use by submarines against surface ships.

The gyroscope for the Mark 27 was designed so that it could be given an initially determined course by presetting the sensing element before launching. The gyroscope was therefore designed so that the gyro's course-sensing element could be remotely set by means of a selsyn system operated from the fire control center.

The complete gyroscope package was mounted to the internal surface of the hull. By removal of a plate in the hull the gyro could be caged and an initial course set by hand into the gyro sensing element.

Once this was done the torpedo would then proceed along this predetermined course for a certain distance where the gyroscope would be electrically disconnected from the system and the sonic homing device would take over. It would become the controlling element for course control to the target or surface vessels.

At this point, it became apparent that the sonic homing torpedo required sound on which to home. It was obvious that the defense against such a weapon would be to stop the ship and shut down all power, cutting off all noise.

Another approach was to have the torpedo send out a sound wave and pick up the sound reflection from an object in the water. Thus a sound from the target would not be required. This approach was used in the Mark 32 which was produced by Philco.

This type of torpedo has a wider variety of applications than the basic sonic homing torpedo. It can be launched from ships, airplanes, surface vessels, blimps and helicopters. It does not need to be initially aimed. Once in the water it can look for a target.

For one such torpedo model a rate gyro was used for the course control. The rate of turning for the torpedo either to port or starboard had to be established. To accomplish this Whittaker designed a rate gyro with a sensing element consisting of switch contacts which would establish a turning rate.

The rate gyro portion of this instrument was given a new frame and sensing elements. With this type of gyro control, a search program can be established and the torpedo can continuously circle or proceed in any desired direction by means of a series of turns, first to port and then to starboard.

Another type of gyro, used to establish a search program, is a free gyro whose course-sensing device can be rotated by an electric motor which can be programmed. The programming can then cause the torpedo to circle in the direction desired or to proceed on a straight course until the torpedo hears the target. The sonic homing device overrides the gyro and directs the torpedo to the target. This gyro is used in the Mark 43 torpedo.

After World War II most development work on weapons was slowed down, the Korean War spirited production of the sonic homing torpedo. Whittaker Gyro found itself in the position of being unable to supply all the demands for gyroscopic instruments.

It was necessary as a compromise to furnish major gyro components to the government and prime contractors. They in turn completed the gyroscopes for use in the sonic torpedos.

In the years between World War II and the Korean conflict, major developments had been made in the manufacture of gyroscopic instruments and as soon as it was possible, Whittaker Gyro undertook the development of a gyroscope especially designed for use in sonic homing torpedos. Up to this time the gyros this company turned out for the various torpedo programs had been modified types originally developed 10 years earlier.

It was thought by many of the torpedo manufacturers that because of the decreased accuracy requirements of the gyro for sonic homing torpedoes they could be made at extremely low costs. However, this was not the case.

It was found that many of the torpedoes were used in applications where the torpedo and gyroscope were subjected to high shocks, high sustained accelerations, high vibration, wide trying tension temperature variations and other extreme environmental conditions. Further, small size and light weight were more in demand.

The design of the gyroscope for the modern sonic homing torpedo must take into consideration many factors in addition to basic sensing accuracy. These include the tactical mission of the torpedo, the environment conditions to which the gyro will be subjected both during its final mission and en route to its final mission. It must have exceptional reliability and lastly be of small size, light weight and low cost.

To design a gyro, taking these factors into consideration and weighing each one in relation to cost, has required extensive research including the evaluation of many design approaches and countless tests.

The culmination of the research and development has resulted in the production of the Whittaker Model No. 501705 gyro. This instrument incorporates many innovations such as monel gimbals which derive their strength from the use of spherical and cylindrical shapes. This has allowed the use of thin sections which reduce the weight of the components to little more than if made from aluminum.

The use of monel has eliminated the need for corrosion protection on the major parts. The use of monel has also eliminated one of the major problems created by wide changes in operating temperatures.

The coefficient of expansion of motor shafts, gimbals, and frames are now made of materials which essentially have the same coefficient of expansion thus maintaining dimensional tolerances between major components. This prevents creation of damaging forces on the bearings or the creation of too great clearance between parts which could cause unbalance. Major components have been designed for fabrication by punch press and screw machining.★

Cavitation—an equivalent of aerodynamic turbulent flow—troubles both ends of a torpedo. Fig. 1 shows propeller turbulence; Fig. 2, cavitation at the nose cone.

HYDRODYNAMICS
The Art of Silence

by Prof. George F. Wislicenus
State University of Pennsylvania

THE TORPEDO is a submerged body kept suspended in its medium primarily by its buoyancy, and is therefore hydrodynamically a first cousin to the rigid air ship or "dirigible" rather than to airplanes.

Considering the well advertised advances in the torpedo's most important target, the submarine, it can be taken for granted that demands for increased speeds will be ever-present. Considering that the density of water is about 900 times that of air at moderate altitudes, this isn't going to be easy.

From the point of view of drag the classical torpedo speed of 45 knots may be regarded as equivalent to airplane speeds in the neighborhood of 950 knots.

Since the velocity of sound in water is of the order of 4000 feet per sec. It is immediately evident that the "Mach numbers" of the bodies travelling at foreseeable speeds under water are very low compared with all airplane speeds now in use.

There exists however, in hydrodynamics a phenomenon quite analogous to the compressibility or Mach-number effects in gases which becomes effective, and is indeed of decisive importance, within the speed ranges of torpedoes as well as submarines.

The hydrodynamic phenomenon that plays the same speed-limiting role in connection with liquids as "Mach-number effects" in the field of gas dynamics, is known as cavitation. Cavitation is defined as the local vaporization of a liquid in motion, caused by local pressure reductions resulting from the dynamic actions of the liquid.

These local cavitation voids have a detrimental effect on the overall efficiency of the device. Cavitation also causes mechanical damage, but most importantly, it is noisy. The very onset or "inception" of cavitation, barely visible to the eye under favorable test conditions, has been found to be acoustically as harmful as more extensive cavitation. This interferes with sonar-directed torpedoes.

The parts of torpedoes most susceptible to cavitation are the propeller blades since, by virtue of their helical (screw-like) motion, these blades cut through the water at a higher speed than the torpedo itself. Aeronautical airfoil data apply directly to these most critical parts of a torpedo.

The local pressure reduction is usually expressed as a certain fraction of the "stagnation pressure" $PV^2/_2$. This fraction (Cp) is called the "minimum pressure coefficient." It can be derived directly from airfoil data pertaining to "critical" flow conditions with respect to locally sonic flow. The range of favorable i.e. low values of Cp is smaller the thinner the airfoil.

On the other hand thin airfoils are necessary if low values of Cp are required. This simply means that the more refined the design to meet increased demands of good cavitation performance, the greater will be its sensitivity to departures from design operating conditions.

The practical significance of the pressure coefficients, given for example in Fig. 3, is illustrated in Fig. 4 by applying these data to the blades of a torpedo propeller. It was assumed that the peripheral velocity of the propeller is twice as great as the forward velocity of the torpedo so that the velocity of flow relative to the blades is $\sqrt{5}$ times the forward velocity (v) of the torpedo and its propeller. (This assumption corresponds to an "advanced ratio" J=V/n ∘ of 1.57) Fig. 4 gives the velocity of advance as a function of the depth of submergence for two different blade pressure coefficients (cp) as may be derived from Fig. 3. It is seen, for example, that a speed of 40 knots would demand for cavitation-free operation a submergence of over 50 ft. provided the thinnest blade section listed in Fig. 3 (6% thick) is used having a pressure coefficient of about 0.25. It should be noted that such a thin blade section will have such a low pressure coefficient only if the flow meets the blade within slightly less than ± ½ degree of the design angle of attack. This illustrates the precision with which design conditions must be met to avoid cavitation under actual operation.

It is also evident from Fig. 4 that with a higher blade pressure coefficient, say 0.50, as may be expected with blades of about 12% thickness, cavitation-free performance can be expected only at moderate speeds or very great depths of submergence. This explains why hydrodynamic propellers have usually rather thin blade profiles.

The sensitivity of a high-quality propeller, explained in the preceding section, makes it clear that cavitation-free operation may be difficult if not impossible to achieve on the basis of theoretical design procedures only.

Prior to field testing it is desirable to determine the hydrodynamic performance characteristics of a new torpedo under the controlled conditions of the laboratory. The "Towing Tank" has been successfully applied to the development of torpedoes.

For more detailed observation, particularly regarding the location of incipient cavitation, the Navy's Bureau of Ordnance has built a large Water Tunnel at the Pennsylvania State University.

The most important test variable with respect to cavitation is, of course, the pressure which can be changed over a wide range without affecting other test conditions.

It should be recognized that the simple description of the cavitation phenomenon given above is far from complete. It is not at all evident why cavitation should take place exactly at the vapor pressure of the liquid as measured under certain standardized and steady laboratory conditions.

Considering, for example, that cavitation might be expected to start with microsopically small bubbles, it is somewhat surprising to find that the surface tension of these bubbles apparently does not play a clearly definable role in cavitation inception.

Another problem is the possibility of scale effects in testing, whereas, pressure coefficient is a ratio of two pressures and as such is independent of absolute dimensions or of velocities, the question must be answered whether there are perhaps significant "scale effects" present when applying the test results obtained at one scale and velocity to another scale and velocity.

There are several other problems in the field of cavitation that are urgently in need of rational answers. For example, the effects of accidental departures of blade or body contours from their ideal design forms, such as surface roughnesses, certainly deserve careful attention, as such departures are in practice not to be avoided.

Another problem that still awaits a practical solution is that of the interaction between stationary control surfaces and rotating propeller blades.

Cavitation is by no means the only hydrodynamic problem. Hydrodynamic stability and control of the submerged body is of decisive importance, the more so since target seeking torpedoes must meet higher demands with respect to maneuverability than the old, straight-running weapons.

The towing tank as well as the water tunnel are available to test torpedo bodies under various inclinations against the direction of the flow and with various deflections of its control surfaces. Means for measuring the forces acting on the body under these operating conditions are available or under development.

It may be surprising that the problem of hydrodynamic efficiency has hardly been mentioned in this article. Today well designed torpedoes are hydrodynamically so efficient that no advancements in this respect are to be expected without correspondingly major developments in the control of the flow processes that are responsible for the hydrodynamic behavior and resistance of submerged bodies.

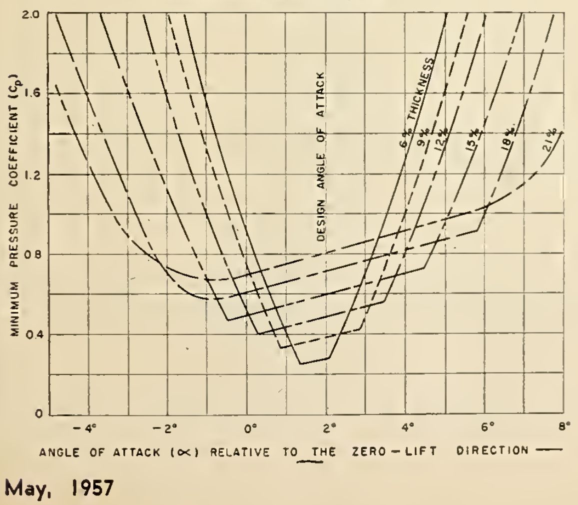
The question has frequently been raised whether certain kinds of nature's best swimmers, such as the porpoise or the barracuda, suffer none of the torpedo's limitations.

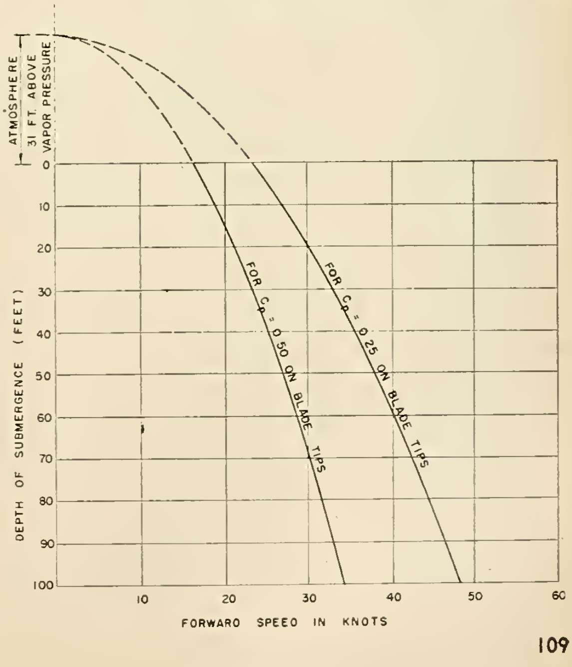
The only clearly foreseeable reason why such fish may have an appreciably higher hydrodynamic efficiency than torpedoes is the possibility of maintaining "laminar" flow over the entire body, which is certainly not true for torpedoes. The problem of maintaining laminar flow in the bounder layer of torpedoes has been much studied.

Laminar flow airfoils have been tested and found to perform in accordance with the theoretical predictions provided one is able to maintain an extraordinarily high quality of surface finish. Particles as small as small flies sticking to the surface of the wing were found to bring on turbulent flow.

Therefore the practicability of achieving such advances under actual operating conditions is as yet highly questionable. It is thus evident that far-reaching advances in the hydrodynamic efficiency of torpedoes will demand more than modern fluid mechanics can readily offer at the present time. In this respect the torpedo engineer is fighting on the very forefront of this broad field of applied science.★

Immediately below (in Fig. 3) is a plotting of the minimum pressure coefficients for a typical series of modern NACA airfoils (NACA Rpt. 824). These data are almost directly applicable to hydrodynamic phenomena. To the right (in Fig. 4) it is applied to torpedo propeller blades for which the peripheral velocity of the propeller is twice as great as the forward velocity of the torpedo so that the flow relative to the blades is $\sqrt{5}$ times the forward velocity of the torpedo.

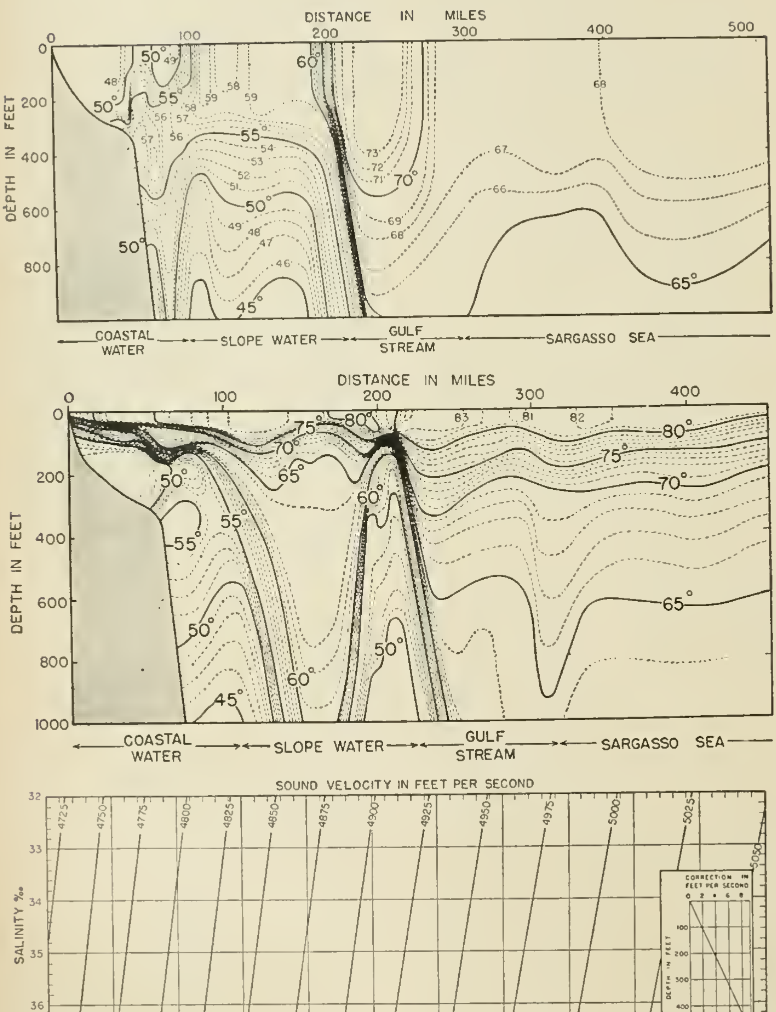




A Realm that Needs Only More Understanding

the OCEAN

By Seabrook Hull



Top diagram shows a temperature profile southeast from Montauk Point in midwinter. Below is a salinity profile taken simultaneously. Bottom chart shows how sound velocity varies with temperature and salinity, including depth correction. Changes take place daily and seasonally.

PURE WATER is a wonderful thing. In the metric system, at least, many of its constants are unity—one calorie of heat raises one gram (or one cubic centimeter) of water one degree centigrade. As a medium it's constant and reliable, and all of its properties are well known. To the laboratory chemist, it's tool, reference and standard medium.

But take 1,370,323,000 cubic meters of the stuff and dump it on an oblate sphere some 8000 miles in diameter so that it fills the valleys, ravines and low-lying plains until it covers nearly three quarters of the surface of that sphere to a mean depth of 3795 meters. Set the sphere spinning on a cocked axis at a rate of 15° of arc per hour, and orbit it in an ellipse around an immense white-hot sphere. Now load this nice simple chemical, water, with a heavy concentration of a miscellaneous mixture of salts. Envelop it in a thick layer of gas. Endow it with the greatest known concentration and variety of biological life. The one-time chemist's friend gains a new name—the ocean—and becomes the missile-man's nightmare.

As an environment for manned and unmanned vehicles the ocean has both desirable and hair-raising characteristics. But like space, it's a coming medium for man's endeavors, both military and peaceful. This article aims at providing missilemen of all types with a primer on its nature and properties. To cover it well took H. U. Sverdrup, M. W. Johnson and R. H. Fleming over 1000 pages in their book, "The Oceans." And even they will admit that the sea volumes of the world constitute one of the greatest unknowns known to men.

The major difference between the air and the oceans is biological life. Floating plants and small floating animals in the upper couple of hundred

Fabulous past... Exciting future!

8000 ACRES OF ISOLATION

Fifteen miles from Redlands, California, in 8000 mountainous acres once charted as part of a vast Spanish land grant, Grand Central Rocket Co. has set up a new rocket test facility.

This section of California has a colorful and romantic past. Nearby are graceful missions built by the Spanish padres nearly two hundred years ago. Among the mountains are deserted mines and "ghost towns" recalling the era of the gold rush. The test site itself has yielded the remains of an Indian settlement. This is the land that knew such men as Kit Carson and John C. Frémont.

Great men of the past depended on vision, daring, and leadership to accomplish their goals. Grand Central is using these same principles in the greatest adventure of our time — the conquest of outer space.

Minutes away, fertile valleys with prospering towns and cities beckon to the science adventurer of today. To investigate your career potential in healthful and friendly inland Southern California, contact the Personnel Manager.
Inquiries held confidential.

Grand Central
Rocket Co.
REDLANDS, CALIFORNIA

GRAND CENTRAL ROCKET CO.
REDLANDS CALIFORNIA

The X-10 lands with secrets brought in from the stratosphere.

X-10 missile test vehicle returns with good news for electrical engineers

New scientific data allows the Navaho Missile to leapfrog many R & D steps—go direct into advanced stages. Unprecedented success of the supersonic X-10 spells out this significant fact: The Navaho—an intercontinental strategic missile completely automated and constantly guided throughout its supersonic flight by self-contained control systems—is one of America's *most advanced* missile systems.

This news is important to you—whether you are a 10-year veteran or a recent BSEE. Why? Because now you can start at the very top of missile technology—and reap the rewards of being with a years-ahead company.

40 immediate career opportunities in electronic systems analysis

In Missile Engineering you'll investigate applications of automation that are literally strides ahead of the field. You'll pursue them in pre-flight, preparation, checkout, fueling, countdown and firing. You'll work on "in-flight" control and guidance systems so precise that even the environment within the missile must be rigidly controlled.

One of our immediate needs is for electrical engineers—especially those qualified in systems analysis, systems evaluation, component design and ground checkout. No matter what your experience has been it can be useful to us.

For complete details on these—and other engineering openings—please write: Mr. R. L. Cunningham, Engineering Personnel Manager, Dept 495MAR5 Missile Development Division, 12214 Lakewood Blvd., Downey, California.

MISSILE DEVELOPMENT DIVISION

NORTH AMERICAN AVIATION, INC.

Torpedo fired to simulate aerial launch at Naval Ordnance Test Station, Inyokern, Calif., cavitates and porpoises clear of the water and almost 90° off course. This sort of thing is one of the biggest problems in underwater missile design; is a big reason why more study of the ocean and fish is needed.

meters are so dense sometimes that they record on depth meters with the strength of a solid floor. Bigger swimmers—blue whales get over 100 feet in length; weigh up to 150 tons—live both both near the surface and at great depths. Those animals that spend all of their time in the dense black world several thousand feet below the ocean's surface are all mouth and stomach.

The deepest man has ever been in the ocean is 14,000 feet in a free, self-propelling device similar to a small submarine and known as a bathescape. Probably no submarines have ever been below 1000 feet and survived—their normal maximum operating depth being on the order of 500 feet.

The ocean covers 71 per cent of the earth's surface. It is a three dimensional medium, with mean depths in the Atlantic Ocean of 3926 meters; in the Pacific, 4282 meters; and in the Indian, 3963 meters. The Mindenao trench in the Western Pacific is 10,500 meters with an ambient pressure of 16,000 pounds per square inch. It's the deepest known.

The ocean is similar to the atmosphere in that: it is continually in motion (the jet stream is analogous to the Gulf stream); it has permanent current features; there are oceanic fronts, sharp thermal gradients over short distances; whereas in the atmosphere there are altitude layers known as the troposphere, tropopause and stratosphere, in the ocean (going down) there are the troposphere, thermocline and stratosphere; the two mediums have similar and common boundaries—the earth's surface and each other. Phenomena, in general however, are slower in the ocean than in the air.

The differences in the earth's two major fluid environments are mainly dependent on the fact that one is a gas and one a liquid. Ocean has many properties similar to water, but it is the presence of salt that makes the ocean what it is. Its major properties are a function of: temperatures ranging from —2° to 30° pressure, from zero to 10,000 db (a decibar equals 1.5 psi, one tenth atmosphere, and is the pressure increase per meter of depth); and salinity, 33 to 40 per cent.

Some physical properties of water are unique and apply generally to the ocean. Heat capacity, latent heat of fusion, latent heat of evaporation, surface tension, dielectric constant and heat conductivity of pure water are the highest for any fluid. However, the dielectric constant of sea water, because of dissolved salts, is obviously relatively low. Water also has good transparency and good dissolving power.

Circulation affects a number of the ocean's properties to a considerable degree, such as the distribution and concentration of suspended matter, chemical contents, organisms, transparency, eddy diffusivity, conductivity, etc. Independent of motion are: specific heat, osmotic pressure and density.

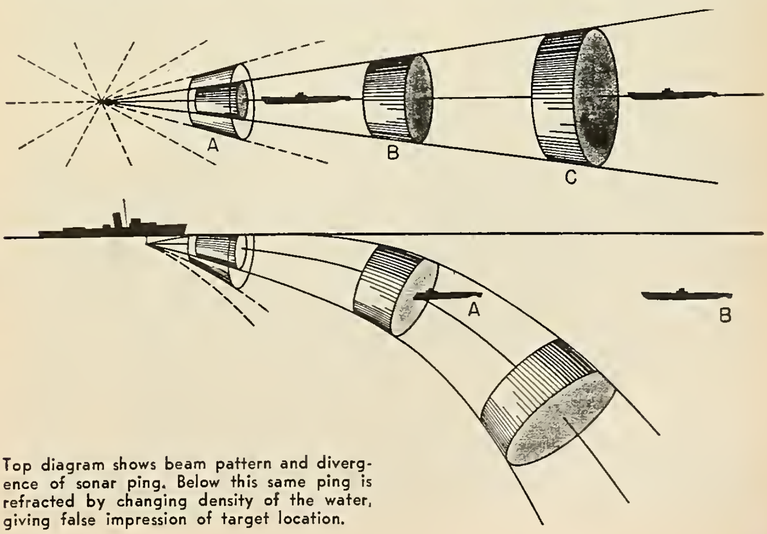
Electromagetic energy, generally speaking, finds the ocean is not its medium, though the strength of the earth's magnetic field remains unaltered. Infrared rays are 99 per cent in less than a meter. Of all electromagnetic energy most is reflected; the rest is quickly absorbed, with blues and yellows penetrating the deepest. These have been detected down to about 1000 feet.

The acoustic properties of the ocean are relatively good, being a function of temperature, pressure and salinity. Thermal radiation is poor due to high heat capacity and low thermal conductivity.

In terms of weapons systems, efficiency of radar is poor (to a point of complete uselessness); propulsion is relatively poor; acoustic devices work well; blast transmissibility is excellent; so is concealment, if silence is maintained.

Elsewhere in this issue, hydrodynamics is called the art of silence. The first effort of every submarine and underwater missile designer is to get greater performance with no noise. The characteristics of water that result in noise generally also retard speed, increase drag. The biggest of these is cavitation—a pecularity of a fluid.

A break-away of the medium from the surface of a body passing through the medium occurs when the pressure drops below the vapor pressure of the medium. In simple terms bubbles appear on the skin. Not only do they



Top diagram shows beam pattern and divergence of sonar ping. Below this same ping is refracted by changing density of the water, giving false impression of target location.

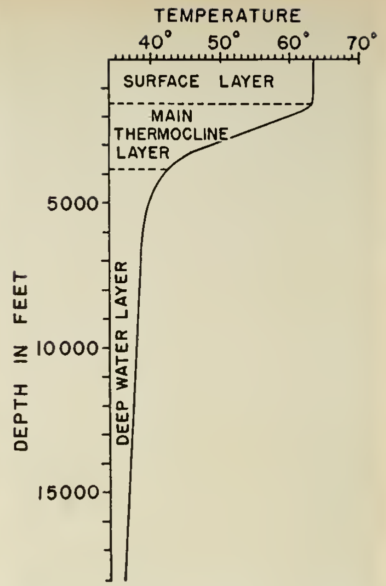


Chart of basic thermal structure of the ocean (typical midwinter conditions in mid-latitudes) shows sharply changing temperature.

reduce the efficiency of a propeller, for example, but when they collapse they do so explosively and make a racket. This phenomenon is basically similar to going from laminar to turbulent boundary layers in aeronautics. Perhaps the biggest underwater design objective is the development of high-speed, cavitation-free underwater flight.

But man isn't the only one to make noise underwater. Fish and their other underwater cousins are quite a vocal lot, and the noise they make doesn't help man's effort to detect, guide and communicate acoustically.

The speed at which sound travels underwater depends mainly on the water's density. This varies primarily with temperature and salinity. The variations are many, local and changing. Sound refracts in changing density. Thus, a target may appear to be in one direction but may actually be in another. These are just a few of the problems facing underwater missile designers.

Yet nature appears to have few of these problems. Fish swim at high speeds and don't cavitate. They travel great distances without any navigation problems. They maneuver rapidly and intricately en masse in complete unison, obviously having a highly efficient communications system all their own. The south Atlantic's diving petrel literally flies into the water and continues to fly underwater with his wings with complete ease—transitional missilemen take note!

So, that these things are possible is, in a way, proven. It only remains for man to discover the way.★

FICo engineers and produces the guidance for the Redstone Missile.
U.S. Army Photo

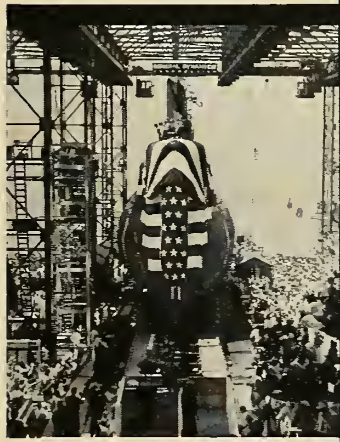
FICo navigational equipment goes into a wide range of aircraft.
U.S. Air Force Photo

FICo COMPUTER AND CONTROL SYSTEMS

- For Weapons Control
- For Processing of Data
- For Special Purpose Computer and Control Applications

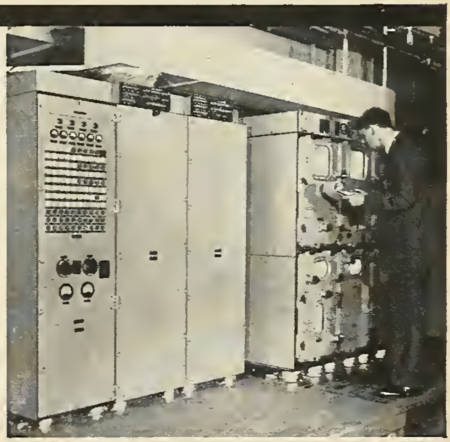
Ford Instrument Company develops and produces the most modern of special purpose computer and control systems—for missile, airborne, shipborne, land-based, and nuclear applications—for *government and industry.*

FICo is one of the foremost organizations in the United States working in the field of automatic control. Hundreds of engineers and extended precision mass production facilities enable FICo to handle complete systems contracts from start to finish.



FICo controls are used in the atomic submarine program. FICo is also working toward development of the closed-cycle gas-cooled reactor.
U.S. Navy Photo

FICo research and design led to improved safety and arming device for Army atomic cannon.
U.S. Army Photo



FICo analog and digital computers can be readily developed and produced—using modular techniques—for special purpose applications.

FICo launching and control order computers are used for Navy A-A missiles.—*U.S. Navy Photo*

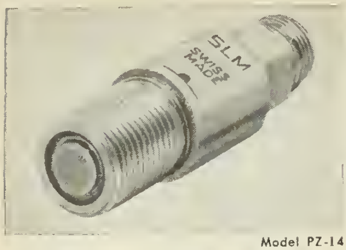
FORD INSTRUMENT CO.

DIVISION OF SPERRY RAND CORPORATION

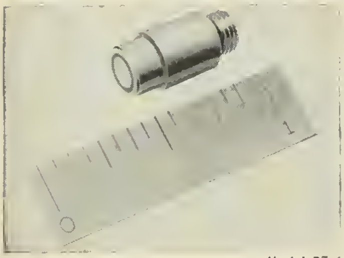
31-10 Thomson Ave., Long Island City 1, N. Y.

Beverly Hills, Cal. • Dayton, Ohio

ENGINEERS
of unusual abilities can find a future at FORD INSTRUMENT COMPANY. Write for information.



Model PZ-14



Model PZ-6

Kistler SLM Transducers measure combustion, detonation, hydraulic and pneumatic pressures precisely

Featuring extreme ruggedness, high sensitivity and fast response, the precision, Swiss-made SLM Pressure Transducers permit direct measurements of pressure and *rate* of pressure changes.

Providing continuous operation at steady temperatures up to 600° F, with intermittent gas temperatures on the diaphragm to above 3000° F, they give faithful response to fast or slow pressure variations in shock tubes, gun tubes, rocket motors, rocket sleds, aerodynamic models, gas turbines, diesel and gasoline engines, compressors, fuel pumps, hydraulic and pneumatic control systems.

Calibration is constant and practically independent of temperature. This is the only commercially available crystal type instrument that can be calibrated by conventional static methods.

Pressure changes generating an electrical charge in the pickup are measured by an electrostatic type Kistler amplifier and displayed on an oscilloscope. Voltage signals are about 1000 times higher than from a typical strain gage or inductive type instrument. The standard Model PZ-14 Transducer covers all pressure ranges from 0.1 psi to 3000 psi and measures full vacuum. A Kistler pickup adaptor extends this range to 30,000 psi. Response time is 15 microseconds, resolution .01 psi with linearity and repeatability better than 1% of the pressure being measured. Designed for relatively "hard-to-get-at" locations, the Sub-Miniature Model PZ-6 Transducer achieves response times to one microsecond. A new electrostatic feedback amplifier is available for use with this type pickup.

The SLM Pressure Pickup, combined with special low-noise cables and a Kistler Piezo-Calibrator-Amplifier (required to couple pickups to oscilloscopes or recorders) constitutes the Kistler SLM Pressure Indicator. For complete information, request Bulletins PI-114, PZ-14 and PZ-6.

Kistler Instrument Corp., Dept. MR, 15 Webster St., North Tonawanda, N. Y.

Circle No. 25 on Subscriber Service Card.

Space Medicine

by Hubertus Strughold, M. D.

For the first time, *space medicine* appears as a topic in the columns of m/r. *Space medicine* is a branch or an extension of *aviation medicine* which started some forty years ago. *Aviation medicine*, now an officially recognized specialty of medicine—studies the human factors involved in atmospheric flight. In contrast, *space medicine* studies the human factors in flights outside the atmosphere or in space flight.

From a medical point of view, outside the atmosphere is considered beyond the functional borders of the atmosphere which are found in the upper atmosphere and some even within the stratosphere. The cessation of the various atmospheric functions indicate that the larger portion of the atmosphere is partially or totally *space equivalent.*

The concepts of the atmosphere's functional borders and space equivalence within the atmosphere, both developed in *space medicine*, have removed the fictional connotation from space flight and have brought it to a down-to-earth reality. Therefore, *space medicine* studies not only the human factors involved in satellite flight, lunar operations, and interplanetary space travel, it concentrates its special attention upon *space equivalent* flight operations. The record flight of Capt. Iven C. Kincheloe in October 1956 was a space equivalent flight—to a very high degree.

Scope of *space medicine* also includes the study of ecological conditions on other planets, particularly atmospheric conditions. This field is called planetary ecology or more generally, *astrobiology*.

In 1949 Maj. Gen. Harry G. Armstrong created the Department of Space Medicine at the School of Aviation Medicine USAF, Randolph Air Force Base, Tex., to study the human factors involved in space flight.

At about the same time the Aeromedical Laboratory at Wright-Patterson AFB, Ohio, began preparations for animal studies in rockets. Since 1952 the Air Force has had a Space Biological Branch at the Aeromedical Field Laboratory at Holloman Air Force Base.

A decisive start into future human space flight was made in 1951 at the Symposium on the Physics and Medicine of the Upper Atmosphere, in San Antonio, Tex. The symposium was organized by Maj. Gen. Otis O. Benson, Commandant of the U.S.A.F's School of Aviation Medicine at Randolph Air Force Base, Tex. and Clayton S. White, M. D., Research Director of the Lovelace Foundation, Albuquerque, N. M.

At the 1951 annual meeting of the Aeromedical Association, a space medicine branch was founded. Each year it offers a special session at these meetings. Many space medicine meetings have been held since.

By action of the Board of Directors of the American Rocket Society, at its 1957 Spring Meeting, a new technical division was created, known as the Human Factors Division. Included in its purlieu are *space medicine* and *human engineering.*

It is apparent the field of *space medicine* is off to a solid start and an unlimited future.

Next meeting is the Symposium on the "The Age of Space," sponsored by the Southern Research Institute, Birmingham, Ala. It will feature a visit on May 16-17 to the Redstone Arsenal at Huntsville, Alabama. *Space medicine* will be the subject of the paper by the Surgeon General of the United States Air Force, Maj. Gen. Dan C. Ogle.

This and other *space medicine* conferences will receive thorough coverage by m/r in general and in this column in particular.

Russians Set Up Czech Missile Bases

The Soviet Union has established eight missile launching bases in Czechoslovakia according to the London Daily Telegraph.

One base is near Olomouc, Moravia. North of the Olsany Highway, an area of 500 acres has been enclosed since October. There are other sites about 10 miles west and slightly south of Zwittau, at Valasske Klobouky in Western Slovakia, near Tabor, and southwest of Strakonice. These have been completed.

Three other bases are understood to be under construction. One is 10 miles east of Pilsen, another 30 miles almost directly south of it, and a third slightly west of Litomerice.

The Litomerice site is reported to have been planned for eight rocket launchers. It is the largest.

The others appear to be about half the size. All the sites have their own anti-aircraft defense, radar installations and flight strips in the vicinity.

In none has rocket launching equipment yet been installed. But more than a dozen mobile air defense rocket launchers have already been shipped from Russia into Czchoslovakia.

It is believed that the rockets, or other missiles, for which the sites are designed will have ranges of 120, 360 and 480 miles and will be able to reach into West Germany, Austria and Italy.

It is reliably reported that in Smichov, southwest of Prague, a Russian training school for rocket technique has been established. It is said to be headed by Lt.-Gen. Pomarev, a Russian technical expert.

Swedes Get *Jindivik* Missile

First deliveries of a batch of Australian-built *Jindivik* pilotless target airplanes have been made to the Royal Swedish Air Force. The *Jindivik* will be used in Sweden for missile firing tests. It is considered by Swedish experts as the best design now available for this purpose. Sweden is understood to have bought ten *Jindiviks* at a cost of $1,200,000 as an initial order. Meanwhile, at the end of last month the Swedish Navy announced that it has fired the first Swedish naval missile—from the destroyer *Halland*. It will be used for naval artillery purposes.

World Astronautics

By Frederick C. Durant III

In Germany the world's first rocket society came into being thirty years ago. In less than fifteen years rocket technology evolved from an art to a practical science. The A-4 (or V-2) still stands as a monument to ingenuity and determination.

In early post war years strong anti-militaristic feeling dominated all activities of the reborn society, Gesellschaft für Weltraumforschung. However, the society kept abreast technically with rocket developments abroad and extrapolated data for ambitious space flight programs.

Recently, the society has been renamed: Deutsche Gesellschaft für Raketentechnik und Raumfahrt to indicate increased interest in rocket technology. In addition to their journal, WELTRAUMFAHRT, members will receive a new technical journal to be published entitled: RAKETENTECHNIK UND RAUMFAHRTFORSCHUNG. For those rocket engineers and laymen who read German, membership is a bargain; about $6.25.

In Bremen, the Arbeitsgemeinschaft für Raketentechnik is designing, in addition to the "oil-spray" rockets (m/r April '57, pg. 88), a static test stand, a liquid propellant motor, a hybrid (solid-liquid) motor and an inexpensive multi-staged sounding rocket.

In Stuttgart, Dr. Ing. Eugen Sänger and his mathematician wife, Dr. Irène Sänger-Bredt, head a small study group at the Forschungsinstitut für Physik der Strahlantriebe e.V. Stuttgart which has developed a hot-water RATO unit. But the major production of the FPS has been outstanding papers in ramjet combustion equilibria calculations and ultra-advanced treatises on atomic and photonic rockets. The Sängers, it will be remembered, authored the famous hypersonic rocket-powered globe-circling "skip-bomber" study in 1944.

At a number of universities excellent graduate and post graduate research is being carried out in a number of related fields. Some of this work is under USAF contract.

In the background, reported only through rumor, are indications of interest by the Army and industry. There is natural hesitation but short range anti-tank and anti-aircraft missiles are considered a safe bet to be under development.

•

Twelve official station sites have been picked by the Smithsonian Astrophysical Observatory for optical tracking of the earth satellites. Only two of the sites are on U.S. soil (White Sands Proving Ground and West Palm Beach). Surprisingly, just one of these stations is to be shared jointly with the official NRL Minitrack program; this site is in Australia.

The first station to be ready will be at White Sands this August. The next will be the important one in South Africa which will first see the satellite appearing out of the northeast from Florida about 30 minutes after launching. The rest of the stations will be activated every 2—4 weeks as the specially designed super-Schmidt cameras and crystal clocks are delivered and checked out. Station operators will be trained at White Sands. It is expected that with good weather, the optical tracking stations will be kept busy throughout the IGY. The Minitrack stations will have little to do after the two-week—duration batteries in the satellites have ended their transmissions.

•

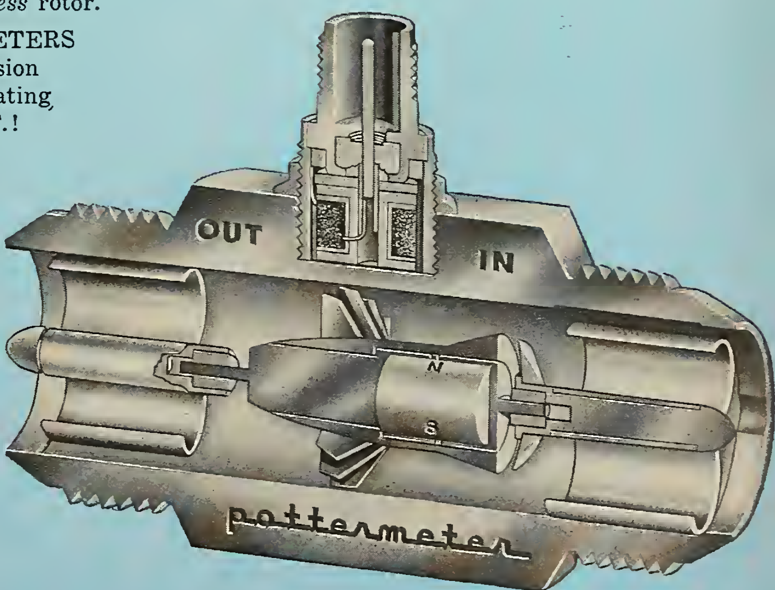
In a radio interview broadcast beamed at Western Europe, Russian scientist Anatoly Blagonravov has concluded that man will suffer no physical consequences from flight into space. These conclusions were based upon data from six years of experimentation with dogs carried aloft in sounding rockets.

COCKTAILS FOR ROCKETS

Well blended! Rockets are meticulous drinkers. They like their liquids mixed in precise proportions. That's why in missile and rocket ground testing and airborne telemetering, Potter Electronic Flowmetering Systems have become standard equipment. The POTTERMETER is the only flowmeter which features the hydraulically positioned, *bearingless* rotor.

For more than 15 years, POTTERMETERS have been successfully used for precision measurement of continuous and pulsating flow of fluids from –455°F. to 1000°F.!

Write TODAY for Bulletin A-2



POTTER
engineered

POTTER AERONAUTICAL CORP.
U. S. ROUTE #22 • Union, New Jersey • MUrdock 6-3010

International Scene

By Anthony Vandyk

The long-awaited confirmation has come that guided weapons are being included in the U.S. mutual aid program for the NATO nations in fiscal 1957. The missiles include the *Honest John* and *Matador* SSMs and the *Nike* SAM. These three models are already being used by U.S. forces in Europe. Which European nations will get which missiles and when? There has been no official answer but Dutch War Minister Staf stated last month that the *Honest John* is to be supplied to the Dutch Army and that personnel would soon go to Germany for training. The *Honest John* will replace the army's heavy artillery.

•

Britain's *Sea Slug* naval SAM now in the test stage is being built by two components of the giant Hawker Siddeley Group—Sir W. G. Armstrong Whitworth Aircraft Ltd., and Armstrong Siddeley Motors Ltd. Armstrong Whitworth is responsible for the airframe while Armstrong Siddeley is producing the rocket engine for the missile. The guidance system comes from a company outside the group, the General Electric Co. which has no connection whatsoever with the U.S. firm of that name.

•

Australia's first SAM unit will be established, Prime Minister Menzies disclosed at the same time as he announced the alignment of his nation's armaments with those of the U.S. Mobile control and reporting units will be established at Darwin and Perth, he revealed. An Australian defense mission will visit Washington in a few weeks to seek details of available short and medium-range missiles. It may also discuss the use by the U.S. of Australia's Woomera range for testing long-range American missiles.

•

British counterpart of North American's Santa Susana, Calif. rocket testing facility is an establishment in the north of England at Spadeadam, Cumberland. This desolately located test facility is being operated by Rolls-Royce Ltd. under contract to the Ministry of Supply. The engines to be tested there will be North American rocket units built under license by Rolls-Royce.

•

The Canadian government's guided missile program was the subject of brief baiting in the House of Commons recently. Opposition members asked Defense Minister Campney if any guided missiles "apart from the obsolete *Sparrow*" were to be made available to Canada by the U.S. He indicated that this was the case. There has been no official word from the Canadian government on the companies participating in the *Sparrow* license program, although Avro Aircraft and Canadair have both been given contracts for the development of a missiles system.

•

The de Havilland export organization is working on a program to enable the various DH companies to conserve the important position they have won since the war in the military export field. Much of de Havilland's bread and butter has come from the export of the Vampire, both the fighter and trainer versions, which is powered by a "house product"—the DH Goblin engine. It is hoped to replace Vampire exports with overseas sales of the highly efficient DH AAM which uses an infra-red guidance system developed by Mullard, British affiliate of the giant Dutch Philips electronics group.

Underwater Missile and Torpedo TEST EVALUATION

by Gilbert L. Maton
John I. Thompson & Co.

THE DETERMINATION of whether a developmental weapon possesses the required operational characteristics needed is largely based on evidence resulting from test. The fundamental procedure is to subject the proposed design to as rigorous a test program as possible. The results of this testing are then carefully scrutinized and appraised in light of tactical adequacy and technical practicality to determine whether the design is adequate, needs work, or is impractical.

Since the decision established from such evaluation is based on test data, it is intuitively apparent that the data accumulated from such testing must be reliable and useful. To best illustrate how this may be accomplished, it will help to review the scientific method or general experimental procedure which can be recognized as intrinsic to any test program. This method delineates that the planning and conduct of any experimentation follows a set step-by-step plan.

(1) A clear and unambiguous statement of the objective of the test is made.
(2) All available background information regarding the item to be tested is assembled and scrutinized.
(3) The specific test program is carefully planned.
(4) The test program is executed.
(5) The resulting data is assembled and analyzed.
(6) The analytical results are interpreted.
(7) The conclusions are reported.

In order to bring the importance of each step of this procedure into proper perspective, each of these steps and its specific application to torpedo testing and evaluation is discussed in some detail in the following paragraphs.

Test Objectives

A clear statement of the objective of the test in advance serves two purposes; (1) it defines the scope of the program and makes subsequent planning administratively practical, and (2) it meets the requirement of a valid conclusion that the objective be stated without reference to the result.

The general objective of an underwater missile and torpedo test is largely influenced by the development stage of the weapon. The evolution of the weapons system can be divided into distinct phases: Formulative; Planning; Research; Experimental; Design, Production Engineering; Pilot Production; Full Production.

The formulative phase is devoted to establishing the operational requirements of the weapon. As a background, it is probable that the requirements arise from the planning and operating elements of the military service. Occassionally they may come from a technical agency or laboratory in which a well known operational problem is examined from the viewpoint of a specialized science. In any case, these requirements represent the basic purpose and need for an improved weapon.

The planning phase is used to establish the objectives of the program in light of time and economic considerations. The organizational structure is delineated and the basic scope of the program is outlined. It is mainly an administrative control period.

The research phase is concerned with "filling in gaps" in existing fields of knowledge. In general, it is a measurements program of experimental elements and components having unknown features in order to determine the practicality of meeting the operational requirements of the weapon. The measurements program is planned and scheduled to support the selection of specific design parameters which are incorporated into a design specification.

The experimental phase is the most complex and critical in the developmental program. It is mainly concerned with demonstrating the workability or sufficiency of a proposed design. The consecutive steps of this phase may be outlined as follows:

(1) Integration of the design by sketch
(2) Layouts (on paper)
(3) Details (on paper)
(4) Parts fabrication
(5) Assembly and adjustment of parts
(6) Adjustment of assembly and corrections
(7) Tentative investigation and dynamic tests

The design phase of the program consists of the same general steps as the experimental phase. The purpose of this phase is to provide a number of similar models for use in the rigorous technical evaluation which concludes the phase. This evaluation is a dynamic test which subjects the "service test" models to realistic exercises which closely duplicate the requirements imposed by the operational application of the weapon rather than to any arbitrary or indirect standards of a laboratory.

It is not unusual for the first few steps of this phase to be repeated many times. Eventually, however, a number of supposedly identical units, or service test models, are available for technical evaluation.

The production engineering phase may be combined in some cases with the design phase previously described. However, scrutiny of the program will invariably enable them to be differentiated. In a sense it is an analytical phase, since it is mainly concerned with analyzing *if* and *how* manufacturing operations influence the design. Three viewpoints are involved, with the designer, the manufacturer, and the military service (user) each contributing a facet to the analysis.

A developmental production lot of the item is manufactured in accordance with preliminary production techniques, and using preliminary tools, jigs, and fixtures. These developmental models are used in product demonstration tests and operational evaluation tests. The former determines if production tech-

The author has drawn freely on the substance of reports prepared under U.S. Navy Bureau of Ordnance contracts with John I. Thompson & Co. for studies, design of experiments, and evaluation of developmental torpedo testing. Procedures outlined are the author's own, however, and may not be construed as constituting the Bureau's official procedures.

niques have affected performance in any way; the latter ascertains the operational characteristics of the weapon and represents the final test action of the phase.

The pilot production phase is devoted to smoothing out any remaining production problems. A prototype production lot is manufactured at this time, and these prototype models are used for familiarization and type tests. In addition, the preliminary proofing procedures for production lot units are determined and documented.

The full production phase is concerned with the quantity production of the design in its final form. The manufacture and all detailed steps of assembly and inspection are dictated by the outcome of all previous evaluations and uses of the weapon.

The chart illustrates this fundamental phase concept of a developmental program by outlining the general configuration of developmental effort previously discussed.

Although conscious separation of phases is shown with a constant progress in one direction, phase combinations and reversals must be appropriately considered in actual cases. It must also be recognized that the degree of overlap between phases may vary. This imbrication is more noticeable in cases where the ultimate manufacturer is chosen at the start of the development.

Of the phases discussed, the research, experimental, design, and production engineering phases are of primary interest because they represent the main portion of the developmental program in which some manner of physical testing of the proposed weapon is done. The general test objective of each of these phases may be defined as follows:

Research:

To determine if the basic design idea shows promise as a solution to the operational requirement.

Experimental:

To determine if the design idea can be incorporated into a device to fill the technical requirements.

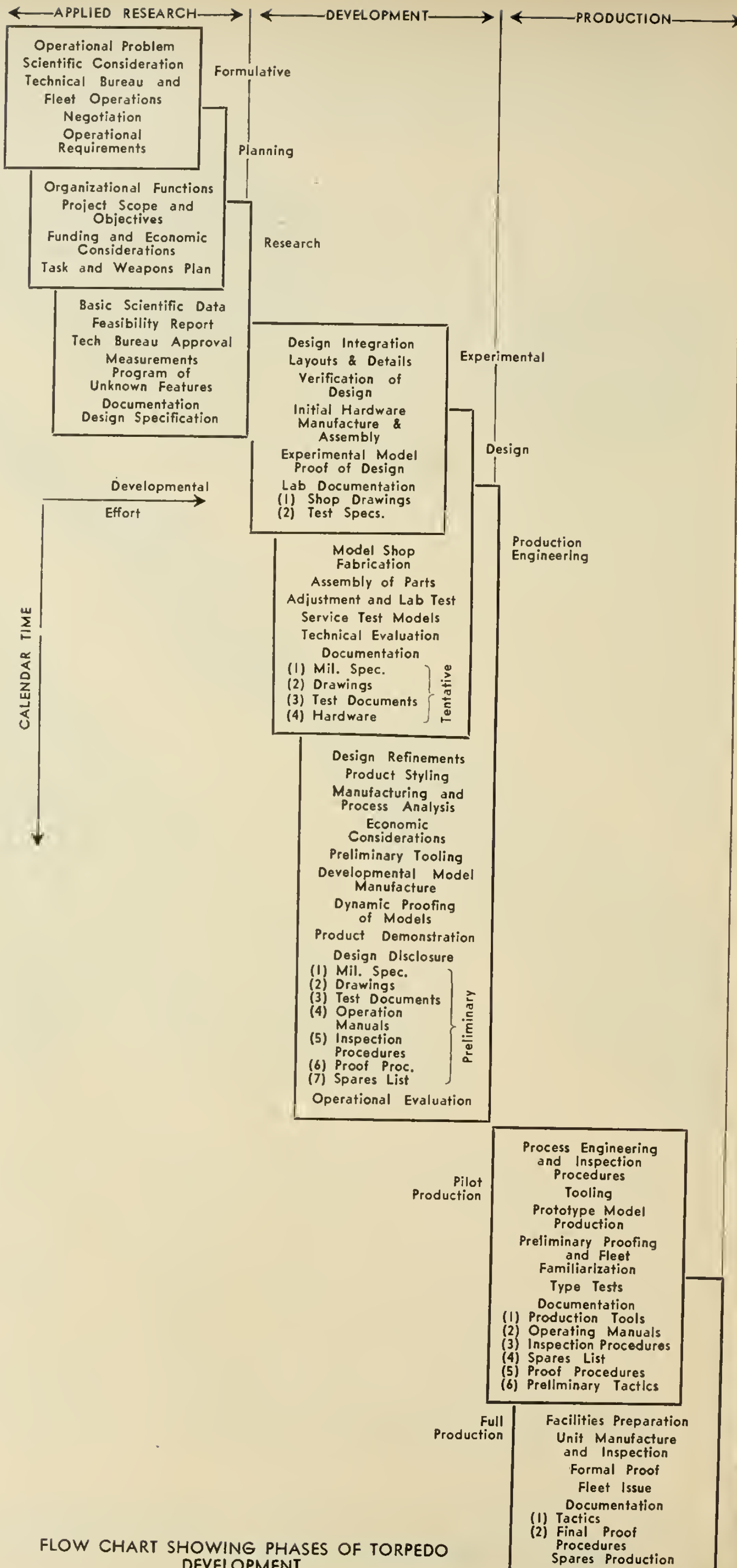
Design:

To determine if the mechanically (technically) configured design will provide a satisfactory solution to the operational requirements.

Production Engineering:

To determine the compatibility of the design to manufacturing techniques and to establish the basic operational characteristics of the design.

A sound scientific approach to a test calls for the general objective to be more explicitly delineated than outlined in the preceding paragraph. If this is not done, analyzing personnel may be confronted with the task of determining



FLOW CHART SHOWING PHASES OF TORPEDO DEVELOPMENT.

from the test criteria just what the original test objectives were. In view of the extremely high cost of developmental testing and the possible universal expenditure of the test units it is apparent that the omission of this initial consideration can seriously jeopardize the success of any test program.

Test Background Information

This step in experimental procedure involves collecting all existing information relating to the test objective from the best available sources. Tabulation of pertinent data from earlier testing work on the item has three specific advantages:

(1) It avoids the necessity of repeating work previously done

(2) It increases the certainty with which the new test may be planned and may reduce substantially the work required to disclose new facts

(3) It reduces the tendency to take calculated risks in the planning which would be based on engineering intuition rather than known facts.

During development, nearly every torpedo produced is in several ways different from torpedoes of the same group. Most units assembled in the experimental and design phases are handmade by highly trained engineers and technicians. Each man concerned in the fabrication of a model is, by his training and experience, competent to devise appropriate functional tests to check and adjust the assembly after each step in the construction of the unit. These tests are seldom written, and two equally competent men are not likely to devise and perform tests which are identical in conduct or precision. Since the tests and adjustments are often duplicated by different men and frequently at entirely different activities, it is desirable—even necessary—from the standpoint of getting useful and comparable data for analysis to document and standardize such test procedures as early as possible.

The test design step involves planning of specific details of the program in light of the test objectives. As such, it is concerned with the planning, control, conduct, analysis, and interpretive aspects of the test, rather than the specific test origin alone. In a broad sense, this step is the most crucial of those in the testing procedure since the selection of a test design imposes a selection of the possible methods of analyzing the results, and this, in turn, dictates the entire interpretive function.

The planning of a specific test design consists of four basic steps:

(1) Compilation of all test variables

(2) Compilation of all test criteria

(3) Experimental test design in preliminary form

(4) Review and revision of the design in light of analytical techniques and possible results.

Test variables are all the environmental and operational factors which might possibly affect the test results, including factors which can be controlled and those which cannot. Test criteria are the data which translate general test objectives into objectives involving measurable quantities. This requires that the background information of the weapon be analyzed to determine which parameters can most validly provide data which will verify the test objectives.

The experimental design, itself, incorporates the test criteria with particular selections of the controllable operating and environmental factors into a comprehensive test. A multitude of possible combinations of factors and criteria is possible, but a single "optimum" design is generally not possible for at least three reasons: (1) the analytical problem posed may be extremely complex; (2) the complete solution may involve parameters which are not economically measurable; and (3) the time to formulate and determine the "optimum" design is not always available.

The most practical approach to the test design problem is to select an experimental design from a family of "good" ones; that is, designs which have desirable characteristics with respect to the particular test. One such class of designs has been given the name "factoral" designs. A second class is "latin square" designs. Such general designs must be examined to establish specific applicability to the test under consideration and the class exhibiting the most favorable characteristics selected.

Test Conduct

This step of scientific testing procedure requires little explanation. It should be emphasized, though, that an orderly and conservative approach is essential. This especially applies to the taking of measurements and collecting of data where every precaution must be taken to assure that valid, unbiased, and accurate results are obtained. These precautions may be most properly assured if a systematic and inclusive schedule, spelling out clearly each test step to be followed, is prepared prior to conducting the test.

Test Reports

This step of the testing procedure requires that the test performed be described clearly and with full explanation of the background and pertinence of the problem and the meaning of the results. In all testing work, whatever the details of the method, it is essential that another person or activity be able to repeat the test and check what has been done or observed. Despite the authority or convictions upon which they rest, conclusions are of questionable value unless they can be verified.

Although much could be said concerning specific report content and arrangement, it seems sufficient to say that report preparation should be viewed in terms of three objectives:

(1) Conclusions should be limited to an objective summary of the evidence so the work recommends itself for prompt consideration and action.

(2) Sufficient information should be supplied to permit the reader to verify the results and draw his own conclusions.

(3) Data should be presented in good form for future use.

All testing and evaluation reports should follow the same general form, tailored to the particular needs.

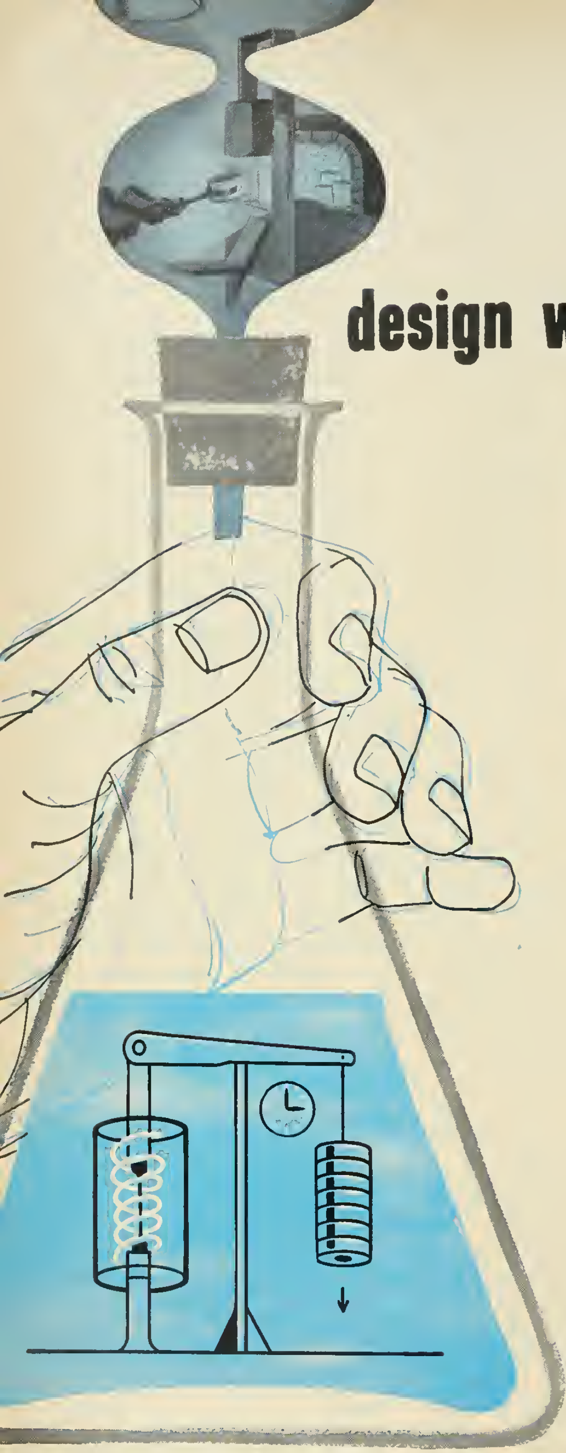
Test Data Analysis

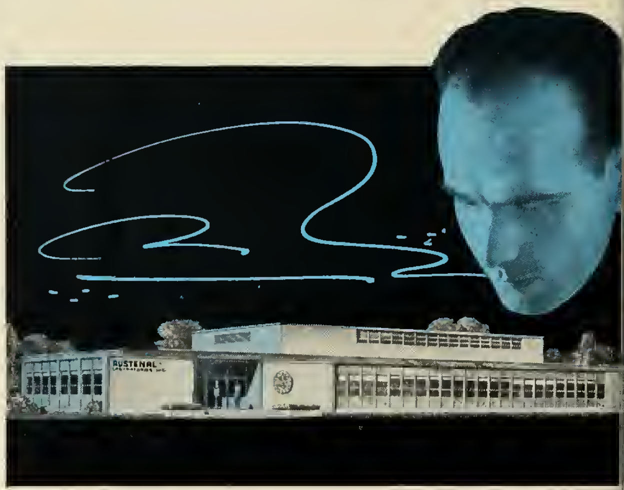
This step in procedure represents the reduction of the recorded data into numerical form and application of proper mathematical and statistical techniques to the results. As mentioned previously, this step is not really a separate consideration, since it is so largely simultaneous to the test design step. Selection of test design imposes a selection of methods of analyzing the test results. It has been found that when a test program is run before the question of analyzing the results is examined, the result invariably is a low efficiency in information per observation.

Experience has also proven that the statistical approach to test design and test analysis is highly rewarding. This is particularly true in dynamic torpedo exercises where random variations in performance are of comparable magnitude to the effects to be established by a change in system parameter. In these cases, *statistical methods offer the only sound and logical means of analysis; there is no question of any alternative which is equally satisfactory.*

Test Result Interpretation

This step concerns correlating test results with initial test objectives. It cannot be too strongly emphasized that any numerical analysis of test data is only a convenient way of detecting and separating the effects of varied factors. The process of interpreting the results, that is, of telling administrative and management personnel what conclusions can be drawn or what should be done next, is by no means automatic. The process requires that personnel who interpret the statistical computations have a thorough knowledge of mathematical techniques and a clear understanding of the technical and tactical aspects of the weapon.★





AUSTENAL

design
microcast

Torpedo Terms and Terminology

Underwater Missile Glossary

THE RAPID PROGRESS of torpedo development in recent years has brought with it a flood of terms. In many cases differentiation in the meanings has not been clear: different terms were found to have identical definitions; terms were so specialized that they had little general usefulness in torpedo development and evaluation programs; or a single term might be used to denote two or more different things. Up to this time, there has been no common basis for terms used.

The Bureau of Ordnance felt that because the program was carried out by many separate facilities and contractors, standard language would improve the ease and accuracy with which torpedo information could be exchanged.

In compiling a glossary of torpedo terms, John I. Thompson & Co., under the auspices of BuOrd, reviewed more than 100 reports and applicable documents. This material reviewed covered almost all current advance undersea-weapons programs, as well as some of the related science of guided missiles. The following is a digest of this glossary.

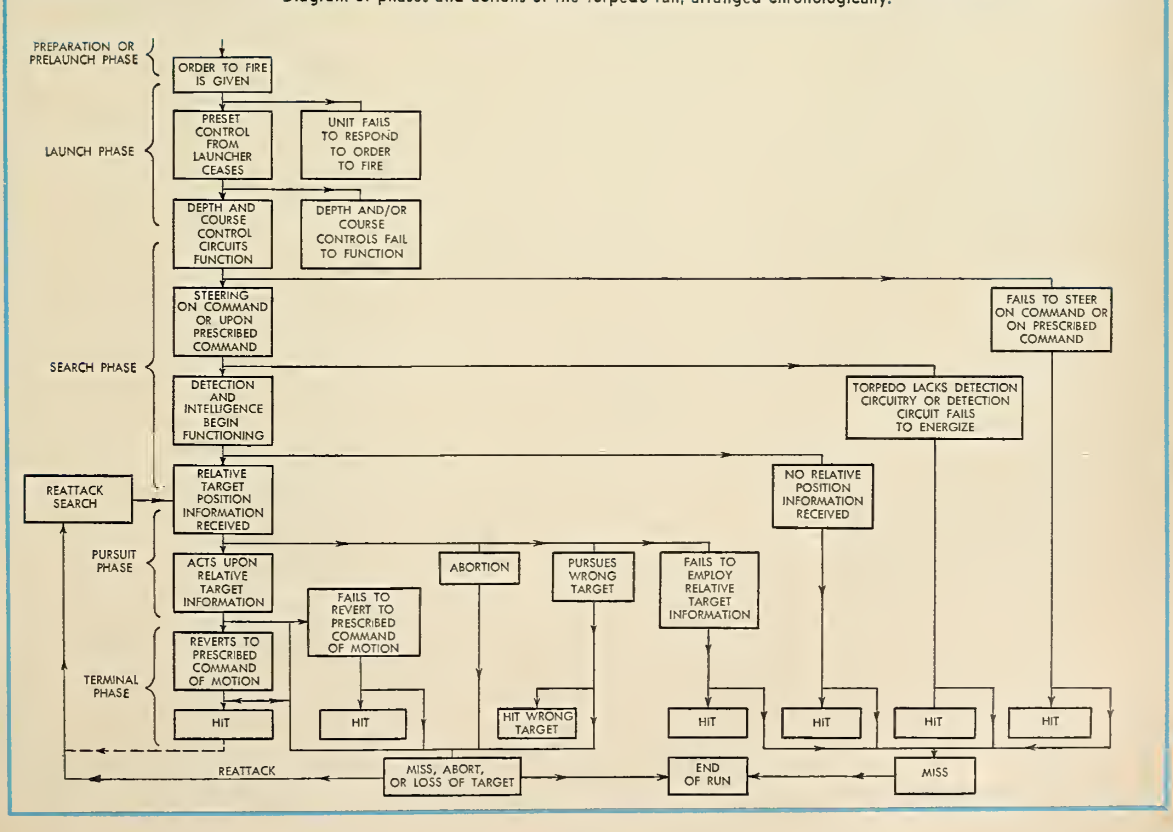
Two types of terms normally associated with *time* in a torpedo exercise are (1) terms that define the unique *instant* of a specific action or event and (2) terms that refer to the *interval,* or period, of time between two such actions. The latter terms are, of course, dictated by and subordinate to the former.

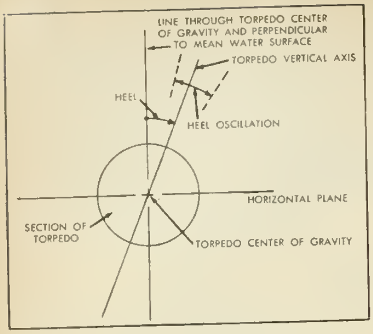
The sequential history of a general torpedo run divides logically into at least six distinct phases: (1) the preparation phase, (2) the launch phase, (3) the search phase, (4) the adquisitive phase, (5) the pursuit phase, (6) the terminal phase. A seventh phase, reattack, may exist under certain circumstances and for certain torpedoes.

The simplest torpedo has depth and direction (gyro) senses. The more complex torpedo can sense in some manner the presence of the target. A basic analysis of these relationships should be made in terms of the relatively new science of cybernetics. Such an analysis was beyond the scope of the present compilation.

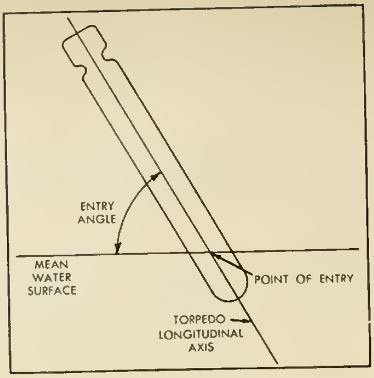
The study on which this glossary is based discovered that terms currently used to describe the intelligence

Diagram of phases and actions of the torpedo run, arranged chronologically.

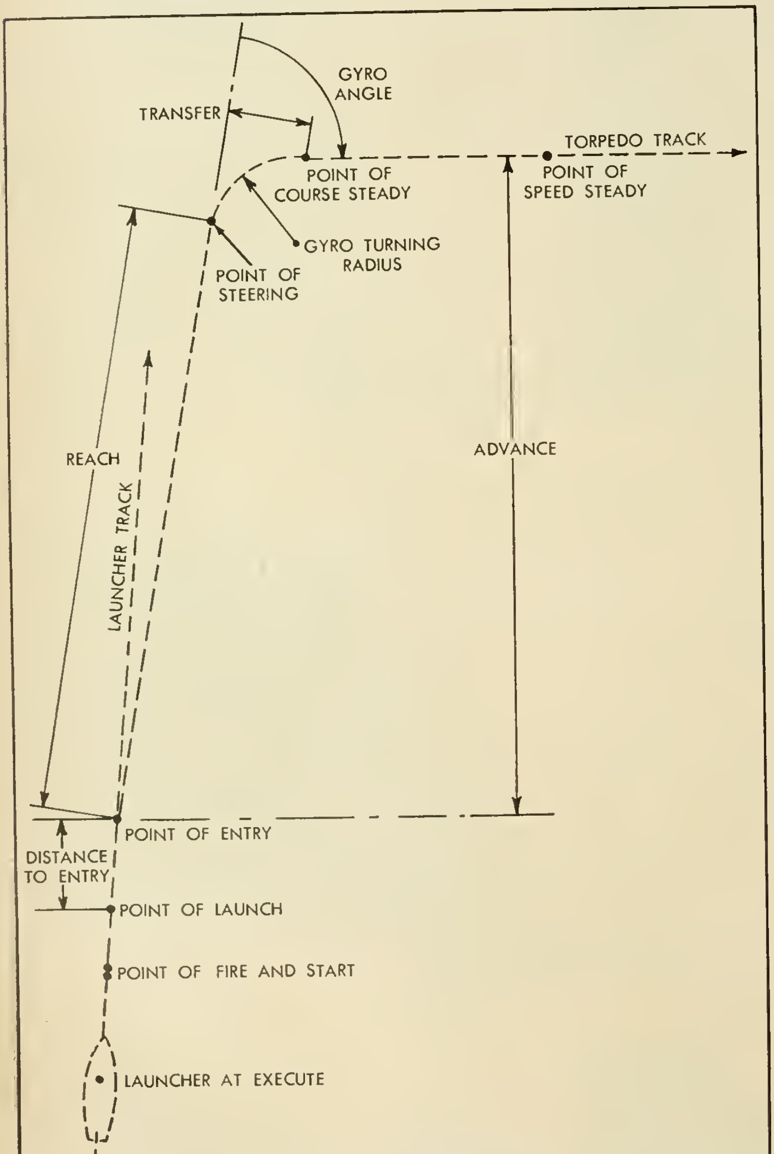




Rotation Terminology—Heel. (Some typical terms required to define rotation. Heel is designated as port or starboard.)



Rotation Terminology—Pitch.



Horizontal trajectory showing advance, distance to entry, gyro angle, gyro turning radius, reach and transfer.

characteristics of torpedoes have been generated more from the individual characteristics of particular torpedoes than from consideration of the fundamental cybernetics involved. It has not been possible to organize them into a system upon which a basic control language can be constructed. Consequently the terms defined largely represent only those in current usage.

Prior art has made the expression "acoustics" practically synonymous with intelligence, since development work has developed most rapidly in the field of acoustics. The terms listed in the glossary to define intelligence characteristics are, therefore, principally acoustic terms. This listing is not meant to preclude the use of analagous terms for other fields of development but simply reflects the fact that terms for other fields are not available for use at this time.

DEFINITIONS OF TERMS

Time Terms

READY. The instant that marks the completion of the preparation procedures for the exercise.

EXECUTE. The instant that marks the beginning of the torpedo exercise, normally considered zero time.

FIRE. The instant the verbal order to fire the torpedo is given.

START. The instant at which preset control from the launching vessel ceases.

LAUNCH. The instant the torpedo clears the launcher muzzle. For air or surface rack launchings, it is the instant the torpedo parts from the rack. In underwater launchings, launch marks the end of the launch phase.

ENTRY. The instant at which an air-launched or surface-launched torpedo strikes the water. For air-launched and surface-launched torpedoes, entry marks the end of the launch phase.

INSTANT OF STEERING. The instant at which the torpedo's direction controls become fully effective.

COURSE STEADY. The instant the torpedo is established on its preset gyro course.

DEPTH STEADY. The instant at which the torpedo is established at its preset depth.

SPEED STEADY. The instant at which the torpedo attains its constant running speed.

INSTANT OF ENABLING. The instant at which the torpedo becomes capable of making any control response to a detection.

INSTANT OF ARMING. The instant at which the firing device becomes fully capable of exploding the charge.

LOOK. The instant within a period of opportunity at which there is the maximum probability of target detection.

FLOOR REVERSAL. The instant at which the torpedo changes motion in depth search from down to up.

INSTANT OF DETECTION. The instant at which the stimulus of the target field becomes evident above the ambient field in the sensory system of the torpedo.

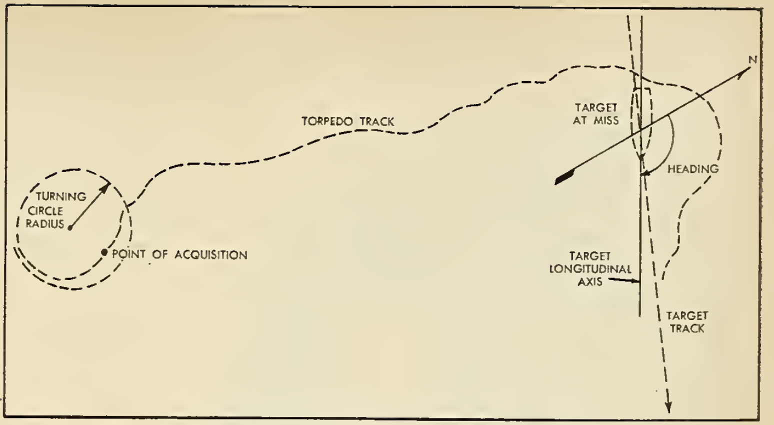
CEILING REVERSAL. The instant at which the torpedo changes motion in depth search from up to down.

INSTANT OF CONTACT. The instant at which the torpedo control mechanism first makes, in response to a detection, an action which would result in a change of direction of the torpedo.

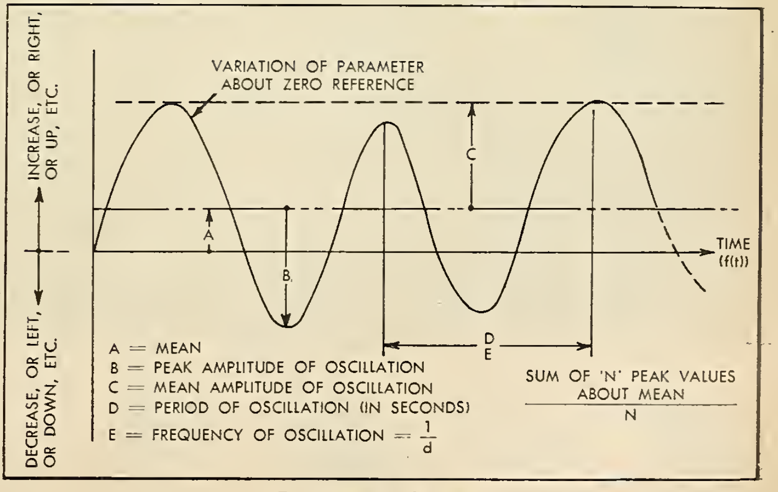
Instant of acquisition. The instant at which the torpedo has completed accumulation of sufficient information to establish a trajectory which is compatible with its homing control law. Usually, three discreet points of the trajectory curve must have been established.
Instant of abortion. The instant at which the torpedo, having lost its guidance information due to malfunction, initiates a new search phase.
Instant of loss. The instant at which the torpedo, having lost its guidance information due to inherent limitations, initiates action for a new search phase.
Instant of blanking. The instant when the torpedo reverts to memory control because external stimuli have saturated the sensing mechanism.
Instant of hit. The instant the torpedo physically strikes the target.
Instant of miss. The instant when the torpedo, in the terminal phase, passes the point of closest approach to the target.
Run end. The instant the torpedo propulsion motor is shut down, generally signifies the end of the exercise.

Time Intervals

Preparation phase. The period between the time the torpedo test is first designed and start. The term has little significance as a descriptive expression of the exercise.
Reach time. The interval between start and instant of steering.
Advance time. The interval between start and course steady.
Transit time. The interval between start and depth steady.
Plunge time. The interval between start and speed steady.
Time to enable. The interval between start and instant of enabling.
Time to arm. The interval between start and instant of arming.
Time to 1st (2nd, 3rd, etc.) look. The interval between start and the numbered look.
Period of opportunity. The interval during which the target is continuously in the field of perception of the torpedo.
Time to 1st (2nd, 3rd, etc.) detection. The interval between start and the numbered instant of detection.
Time to floor reversal. The interval between start and floor reversal.
Time to ceiling reversal. The interval between start and ceiling reversal.
Time to 1st (2nd, 3rd, etc.) Contact The interval between start and the numbered instant of contact.
Time to 1st (2nd, 3rd, etc.) acquisition. The interval between start and the numbered instant of acquisition or between miss and the number instant of acquisition.
Acquisitive phase. The interval between instant of contact and instant of acquisition while the torpedo maintains continuous sensory contact with the target.
Pursuit phase. The period during which the torpedo is maneuvering along its trajectory in response to its guidance information. It occurs between the instant of acquisition and the instant of abortion, loss, or blanking. Pursuit phases occurring during a reattack are designated "reattack" and are identified by an ordinal number (1st reattack pursuit phase, 2nd reattack pursuit phase, etc.)
Prelaunch phase. The period between execute or ready, whichever occurs first, and start.
Prelaunch warm-up time. The interval between the instant the electronic circuits are partially energized and start.
Time to fire. The interval between execute and fire.
Time to start. The interval between fire and start.
Launching phase. The period between start and launch or between start and entry, whichever occurs last.
Time to launch. The interval between fire and launch.
Swim-out time. The interval between start and launch for underwater launchings in which expulsion is accomplished solely by means of the propulsion mechanism of the torpedo.
Air-travel time. The interval between launch and entry. The term applies for air and surface-launched torpedoes.
Time to entry. The interval between start and entry.
Attack phase. The period of initial search, pursuit, and terminal phases of a run, or initial search and pursuit phase alone if no terminal phase exists.
Search phase. The period during which the torpedo is maneuvering into position to receive information of relative target position. It occurs between launch and the instant of acquisition (underwater firings), entry and the instant of acquisition (air and surface firings), or miss and the instant of acquisition. Search phases occurring after a miss are designated "reattack" and are identified by an ordinal number (1st reattack search phase, 2nd reattack search phase, etc.).
Time to abortion. The interval between start and instant of abortion or between instant of miss and instant of abortion.
Time to loss. The interval between start and instant of loss or miss and loss.
Time to blanking. The interval between start and blanking or miss and instant of blanking.
Terminal phase. The period following the last effective target-position indication in which the torpedo holds by memory the established collision course. It occurs between instant of blanking and instant of hit or miss. Terminal phases occurring during a reattack are designated "reattack" and are identified by an ordinal number (1st reattack terminal phase, 2nd reattack terminal phase, etc.).
Time to hit. The interval between start and instant of hit.
Time to (1st, 2nd, 3rd, etc.) miss. The interval between start and instant of miss.
Reattack phase. The period during which the torpedo, recognizing that it has missed the target, initiates a new search phase to relocate it and ends at instant of hit or miss. A reattack phase will normally consist of a reattack search, pursuit, and terminal phase. Reattack phases are usually identified by an ordinal number, as 1st reattack phase, 2nd reattack phase, etc.



Horizontal trajectory—heading, turning circle radius.



Time variation of motion.

ELECTRO-SNAP SWITCH & MFG. CO.

HE KNOWS

A pilot firmly prods a panel button: Wingtip tanks fall clear—or, perhaps, fire-choking fog explodes into a burning engine compartment. He *knows* what to expect and rely on, because a tough, tiny Electro-Snap aircraft switch is behind the panel.

Regardless of G-loading, temperature, speed, altitude, or weather conditions, Electro-Snap switches deliver a *known* performance for a *known* number of operations ...make certain of safe functioning for a predictable period of time.

This same predictability is built into every Electro-Snap switch—aircraft or industrial—though the jobs they do may not always be so critical. In any case, reliability is delivered with the minimum size, weight and cost consistent with the job requirements.

Electro-Snap "standard" switches are available for most requirements, and our engineered "specials" are solving many unique problems. If *you* have a switching problem, send it to us; our engineers will work with you closely in producing it *in any quantity* ...economically. THIS IS OUR ONLY BUSINESS!

SEND US YOUR SWITCHING PROBLEMS
and write for catalog details on our standard switches...TODAY

ELECTRO-SNAP SWITCH & MFG. CO.
4252 West Lake Street
Chicago 24, Illinois

ELECTRO SNAP

HS-25 Rocket Salety Switch

HS-20 "Self-De-Icer" Switch

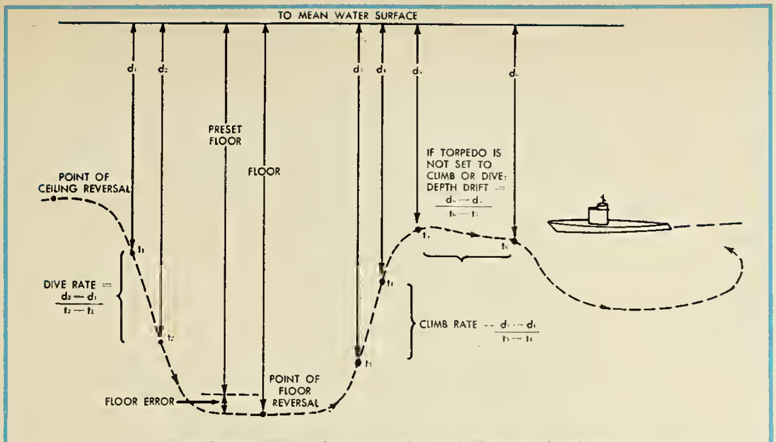
H10-7 Rotary Switch with Positive Shaft Seal

H1-43 Adjustable-Arm Landing Gear Switch

EF-3 Sealed Sub Miniature

J2-4 Sealed DPDT 4 Ckt.

H1-8 Original "Landing Gear Switch"



Vertical trajectory—dive rate, floor, climb rate, depth drift.

Run time. The interval between start and run end.

Position and Motion Terms

Heel. The angle between the vertical axis and a line perpendicular to the mean water surface through the torpedo's center of gravity. Heel is designated as port or starboard.

Pitch. The angle between the torpedo's longitudinal axis and a line parallel to the mean water surface in the longitudinal-vertical plane of the torpedo. Pitch is designated as up or down.

Yaw. The angle between the torpedo's longitudinal axis and the velocity vector in the longitudinal-lateral plane of the torpedo; port or starboard.

Roll. Heel oscillation.

Entry angle. The angle between the longitudinal axis of the torpedo and the mean water surface at the point of entry.

Trajectory Terms

Track. The line generated from point to point on the horizontal plane by the motion of the center of gravity of the vessel.

Advance. The distance between the mean torpedo track following the point of course steady and a line paralleled to this track passing through the point of entry.

Distance to (arm, enable, contact, entry). The distance along the torpedo track between point of start and point of arm, enable, contact, or entry.

Gyro angle. The angle between the intended (preset) torpedo track and the direction of launch.

Gyro turning radius. The radius, in yards, of a theoretical circle through the arc described by the torpedo track from the point of steering to course steady.

Reach. The distance along the torpedo track between point of launch (underwater firing) or entry (surface or air firing) and the point of steering.

Transfer. The distance between a vertical plane through the torpedo's longitudinal axis at launch and a plane parallel to this plane through course steady.

Course. The angle measured clockwise from true north to the positive direction of the mean track of the vessel.

Course error. The angle between the positive direction of the intended (present) mean track of the torpedo and the positive direction of the actual track.

Rate of turn. The mean angular rate with which the torpedo changes course during a specified interval.

Heading. The angle measured clockwise from true north to the positive direction of the longitudinal axis of the vessel at any instant.

Turning circle radius. The radius of a circle maneuver of a torpedo.

Path in depth. The line generated from point to point on the depth plane by the motion of the center of gravity of the torpedo or target, as designated (torpedo path in depth, target path in depth, etc.).

Climb angle. The angle between the mean torpedo path in depth during a climb and a horizontal plane through the torpedo's center of gravity.

Ceiling. The vertical distance between the mean water surface and the center of gravity of the torpedo at the point of ceiling reversal.

Ceiling error. The deviation between the preset or intended characteristic and the value observed.

Dive angle. The angle between the mean torpedo path in depth during a dive and a horizontal plane through the torpedo's center of gravity.

Dive rate. The rate of change of depth during a programmed dive.

Floor. The vertical distance between the mean water surface and the center of gravity of the torpedo at the point of floor reversal.

Floor error. The deviation between the preset or intended characteristic and the value observed.

Climb rate. The rate of change of depth during a programmed climb.

Depth drift. The rate of change of depth error when the torpedo is not preset to dive or climb.

Depth cut-off. The vertical distance from the mean water surface to the center of gravity of the torpedo at which the energy to the propulsion motor is automatically cut off.

Location

Launcher (at arm, enable, fire, etc.) The instantaneous location of the center of gravity of the firing vessel projected upon the course or depth plane at the instant of arm, enable, fire, etc. Any time instant may be employed with this term.

Target (at arm, enable, fire, etc.) The instantaneous location of the center of gravity of the target projected upon the course or depth plane at the instant of arm, enable, fire, etc. Any time instant may be employed with this term.

Range. The distance, in yards, between the centers of gravity of the target and the reporting vehicle.

Relative bearing. The angle measured clockwise from the positive direction of the longitudinal axis of the reporting vehicle (launcher, target, or torpedo) to a straight line connecting it with the other vehicle concerned.

True bearing. The angle, measured clockwise from true north to a straight line connecting the reporting vehicle with the other vehicle concerned.

Launcher depth. The vertical distance from the center of gravity of the torpedo to the mean water surface at fire. Applies to underwater launcher only.

Launcher height. The vertical distance from the mean water surface to the center of gravity of the torpedo at fire. Applies to above-water launchings only.

Target depth. The vertical distance from the center of gravity of the target to the mean water surface. Applies to underwater target only.

Torpedo depth. The vertical distance from the center of gravity of the torpedo to the mean water surface.

Launcher torpedo bearing. The true bearing from the launcher to the torpedo.

Launcher torpedo range. The range from the launcher to the torpedo.

Launcher target range. The range from the launcher to the target.

Launcher target bearing. The true bearing from the launcher to the target.

Target torpedo bearing. The true bearing from the target to the torpedo.

Target torpedo distance. The directed straight line distance between the center of gravity of the target and torpedo, equivalent to torpedo target range.

Target launcher distance. The directed straight line distance between the center of gravity of the target and launcher, equivalent to launcher target range.

Target launcher bearing. The true bearing from the target to the launcher.

Torpedo target bearing. The true bearing from the torpedo to the target.

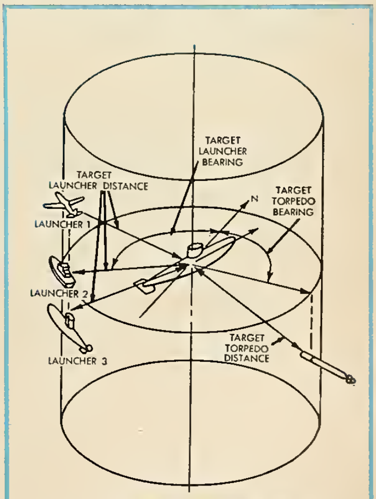
Depth differential. The vertical difference in depth between the target and the torpedo, measured in feet.

Time Variation of Motion

Mean. The arithmetic average of the instantaneous values of the characteristic over a specified interval.

Mean amplitude of oscillation. The arithmetic average of the maximum displacements of the characteristic with respect to the mean over the same interval specified for the mean.

Peak amplitude of oscillation. The



Location—target origin.

maximum displacement of the characteristic indicated with respect to the mean over the same interval specified for the mean.
Frequency of oscillation. The average number of cycles per second of a characteristic during the same interval specified for the mean.
Period of oscillation. The mean time, in seconds, for one complete cycle of the characteristic indicated during the same interval specified for the mean.

Information and Control Terms

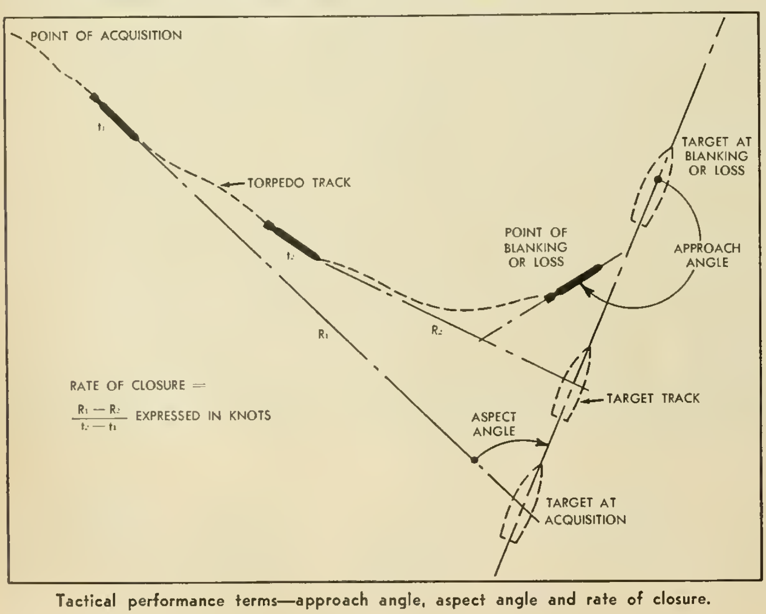
Steering. Steering occurs when direction of the torpedo is controlled in both course and depth.
Enabling. Enabling occurs when the torpedo becomes capable of making a control response to a detection.
Arming. Arming occurs when the exploding device of the torpedo becomes capable of detonating the explosive charge.
Opportunity. An opportunity occurs when the target lies in the field of perception of the torpedo during a search phase. A period of opportunity is an interval during which the target is continuously in the field of perception of the torpedo. A look is the instant at which there is the maximum probability of target detection.
Detection. A detection occurs when the torpedo senses the target, receiving a signal that can be distinguished from the ambient field.
Contact. A contact occurs when the torpedo makes a control response as a result of a target detection.
Acquisition. An acquisition occurs when a contact endures long enough to establish a trajectory.
Loss. A loss occurs when a torpedo enters a new search phase after having lost its guidance information during a pursuit phase because of inherent limitations.
Abortion. An abortion occurs when a torpedo enters a new search phase or discontinues pursuit after having lost its guidance information during a pursuit phase because of torpedo malfunction.
Blanking (Guidance Information Blanking). Blanking is an automatic electronic switch-off designed to occur when the intelligence system of the torpedo becomes so saturated that it can no longer make an effective control interpretation of the information received.
Blanking range. The distance from the torpedo to the target at which the target field is strong enough to operate the guidance information blanking circuit.
Hold-in. The action of a memory device that causes a torpedo to remember and continue upon the same trajectory during gaps in its guidance information.
Course hold-in applies to memory guidance in course only.
Depth hold-in applies to memory guidance in depth only.
Acoustic range. The range as determined by analysis of the transmitted and reflected signal.
Course dynamic response time. The time delay, in seconds, between receipt of a turn command and the first indication of its dynamic effect.
Depth dynamic response time. The time delay, in seconds, between receipt of an elevation command and the first indication of its dynamic effect.
Echo amplitude. The average of the peak amplitudes of the pulses of energy which are reflected from the target and received at the torpedo.
Echo frequency. The number of reflected signals received in one second.
Echo period. The time between corresponding parts of two successive reflected signals.
Echo time. The duration of a single reflected signal in milliseconds.
Field of perception. The nappe within which the directional sensory sensitivity of the torpedo is at least equal to one-half of the maximum.
Gating sensitivity. The maximum amount of signal which may be received by the torpedo's control system which will not cause a gate circuit to function.
Ping amplitude. The average of the peak amplitudes of the pulses of energy which are transmitted from the torpedo.
Ping frequency. The number of pulses of energy transmitted per second.
Ping period. The time between corresponding parts of two successive transmitted pulses.
Ping time. The duration of a single transmitted pulse in milliseconds.
Trip differential. The number of decibels by which the sum of echo and/or target noise from a target must exceed the sum of ambient and torpedo noise in order to cause a command response.
Trip level angle down. The minimum number of degrees below the longitudinal axis of the torpedo from which a signal must come in order to obtain a down-trip of the depth signal relay.
Trip level angle up. The minimum number of degrees above the longitudinal axis of the torpedo from which a signal must come in order to obtain an up-trip of the depth signal relay.
Trip sensitivity. The maximum amount of sound which may be received by the torpedo's control system which will not cause pick-up or energizing action of the course and/or depth command relays.
Homing control law. The mathematical expression which most clearly describes the torpedo's track in the pursuit phase.

Environment Terms

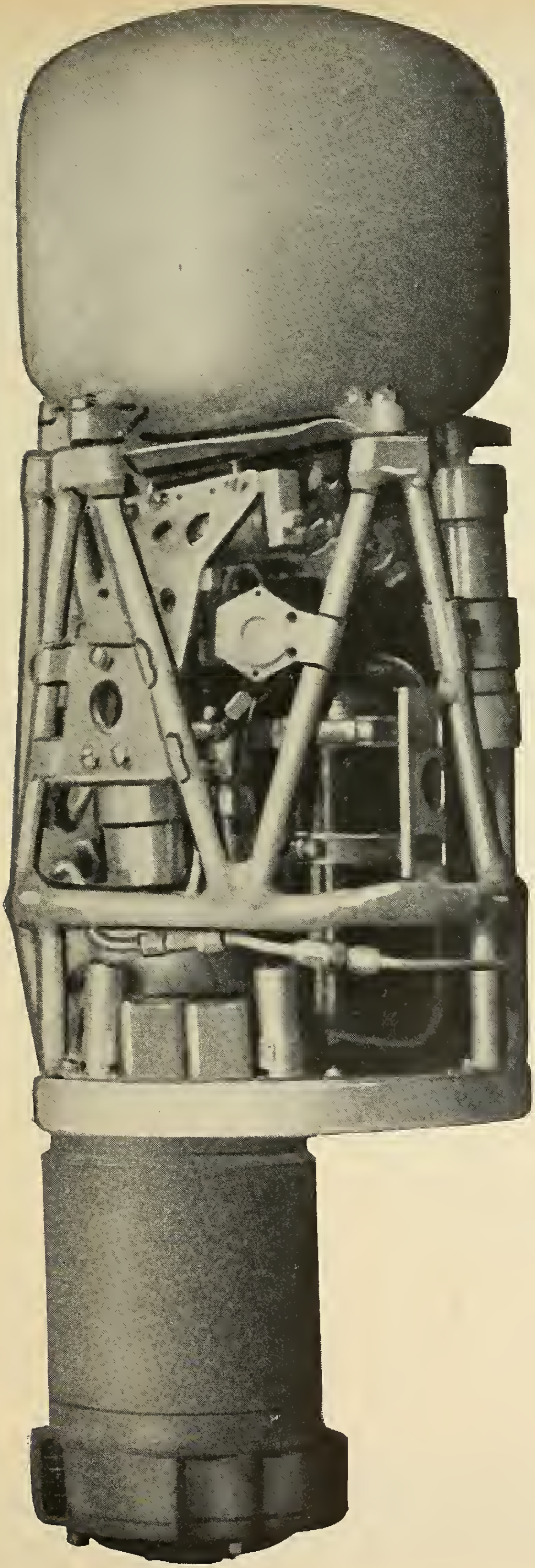
Ambient field. The absolute potential of the total field of influence, excepting the target and torpedo fields, within the perception capability of the torpedo.
Ambient noise level. The acoustic potential of all noise except that generated by the target and torpedo expressed as the equivalent pure tone pressure level in a band width of one cycle per second.
Target noise level. The acoustic potential of the target noise expressed as the equivalent pure tone pressure level in a band width of one cycle per second.
Torpedo noise level. The acoustic potential of the torpedo noise expressed as the equivalent pure tone pressure level in a band width of one cycle per second.
Surface temperature. The temperature of the sea, at or near the surface, in the area of the torpedo run.
Maximum temperature gradient. The maximum rate of change of temperature with vertical distance. A 25-foot band within 100 feet of the depth limits of the run is normally used for measuring the maximum temperature gradient.
Depth of break. The vertical distance below the mean water surface at which an abrupt change in temperature occurs.
Sea state. The condition of the surface of the sea by Beaufort number.

Tactical Performance Terms

Search pattern. The predetermined course the torpedo takes during the search phase.
Aspect angle. The angle measured from the positive direction of the longitudinal axis of the target to a line joining centers of gravity of the target and torpedo.
Approach angle. The average angle measured clockwise from the positive direction of the longitudinal axis of the target to the longitudinal axis of the torpedo during the terminal phase, or at the point of hit or point of miss if no terminal phase exists.
Rate of closure. The mean rate, in knots, with which the range between the target and the torpedo decreases from point of acquisition to point of blanking, or from point of acquisition to point of hit or point of miss if no point of blanking exists.
Miss. Occurs when the torpedo, in the terminal phase, is no longer directed toward the target.
Hit. Occurs when the torpedo comes in physical contact with the target. ★



Tactical performance terms—approach angle, aspect angle and rate of closure.



Scott AIR-PAK

as much a part of the Weapons System as the Rocket

Fueling is one of the most important operations in the successful launching of a rocket. Since propellants are poisonous, breathing protection equipment must be worn. The Scott Air-Pak Model 8100-A2 has been designed to meet the exacting requirements of this hazardous operation. It delivers pure, fresh air, instantaneously "on demand" as required by the wearer regardless of the degree of exertion.

Special attention has been given to the metallurgy of the component parts to insure unfailing service in atmospheres of dangerous propellants such as fuming red nitric acid and unsymmetrical dimethyl-hydrazine.

The Scott Air-Pak has been established as standard equipment by Army Chemical Corps and Army Ordnance for launching crew protection.

Write for complete information.

The Scott 8100-A2 Air Pak incorporates the latest advances in chemical resisting materials. Two small compressed air cylinders are used instead of one large cylinder. This reduces bulk and makes the unit easier to wear with protective clothing.

The Scottoramic Mask which is standard equipment completely protects the eyes and face. It provides unlimited vision in all directions and helps the wearer to spot danger zones for maximum safety.

SINCE 1932 Scott FOR SAFETY—FOR SERVICE

SCOTT AVIATION CORP.

8333 ERIE STREET LANCASTER, N. Y.

Export Southern Oxygen Co., 15 West 57th Street, New York 19, N. Y.

Circle No. 45 on Subscriber Service Card.

NEW MISSILE PRODUCTS

LOX TRANSPORTERS

A variety of highway transport units for liquid oxygen and nitrogen handling is being built by Hofman Laboratories in sizes from 500 to 2,500 gal. capacity. All units are built to ASME and ICC specifications and feature use of company's powder-in-vacuum insulated equipment.

Among design features are a quick pressure build-up system, extended stem valves on liquid lines and use of Hofman quick disconnect couplings.

Circle No. 205 on Reoder Service Cord.

ROTARY TRANSDUCERS

A new line of rotary transducers for sensing angular displacement which utilizes unique construction features to obtain a high degree of instrument stability and accuracy has been announced by Crescent Engineering & Research Co. of El Monte, Calif. Different models exhibit linearity of ± 0.5% or better through 60° of best linear range, and of ± 1% over entire 120° linear range. Special design provides comparative insensitivity to ambient temperature changes.

Miniature precision ball bearings support shaft, otherwise there are no mechanical contacts between rotor assembly and bridge housing to produce friction or electrical noise. Sensitivity is 1 mv/v/o rotation, reproducibility is better than 0.1% and resolution is limited only by external circuitry. Operates in ambient temperatures from —70° to 180°F.

Circle No. 210 on Subscriber Service Card.

"BLINDRILLER"

The problem of locating "blind" holes in non-ferrous structural parts has been solved by the development of a tool named "Blindriller," according to an announcement of the Boeing Airplane Co., Seattle, Washington.

The new tool operates on a magnetic detection principle. A small magnet is inserted in the hidden hole in the structural member and the new device which contains a sensing tube housing a jewel-mounted pointer is placed on the outside skin. Since the pointer is tipped with a magnet having a polarity opposite that of the small magnet marking the hidden hole, the pointer seeks the hidden magnet as the tool is moved slowly around the surface. The hidden hole is accurately located when the pointer is "zeroed."

A slide arrangement supports both the pointer and a drill bushing. Once the hidden hole is located, this slide is shifted to the left as far as it will go and the drill bushing is brought directly over the center.

Although the locator is for use on non-ferrous structures, the close proximity of magnetic materials does not affect its operation. The tool is designed to give 90° angularity within 15 minutes of arc and a maximum .005-inch error in hole.

Circle No. 213 on Subscriber Service Card.

PUSHBUTTON SWITCH

A new "typewriter" pushbutton switch for manual keyboard control of electric equipment is being marketed by Micro Switch, Freeport, Ill., Division of Minneapolis-Honeywell Regulator.

It was developed for rapid-repeat, one-finger operation such as found in the keyboard of electric typewriters, adding machines and similar equipment. Extremely precise, low-force characteristics give the new switch both snap-action and "tap-action."

The new switch (designated the IPB81-T2) employs a single-pole double-throw precision subminiature basic switch for snap-action reliability. Switch and actuator can be operated at frequencies up to 300 times per minute.

The precision subminiature switch incorporated in the switch is listed by Underwriters Laboratories at 5 amperes 125 or 250 volts ac. The 30-volt dc rating is as follows: inductive, 3 amperes at sea level and 2.5 amperes at 50,000 feet; resistive, 4 amperes at sea level and 50,000 feet. Maximum inrush rating is 15 amperes, 30 volts dc.

Circle No. 250 on Subscriber Service Card.

SPEED REDUCERS

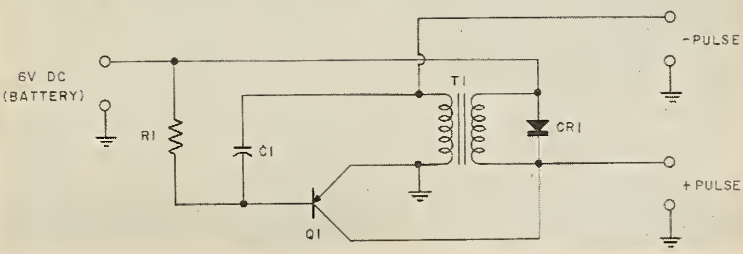
Western Gear Corp. announces the design and manufacture of a new in-line series of speed reducers to be marketed under the trade name "Straitline." Straitline reducers are available in double and triple reduction. Double reduction units

SUBMINIATURE OSCILLATOR

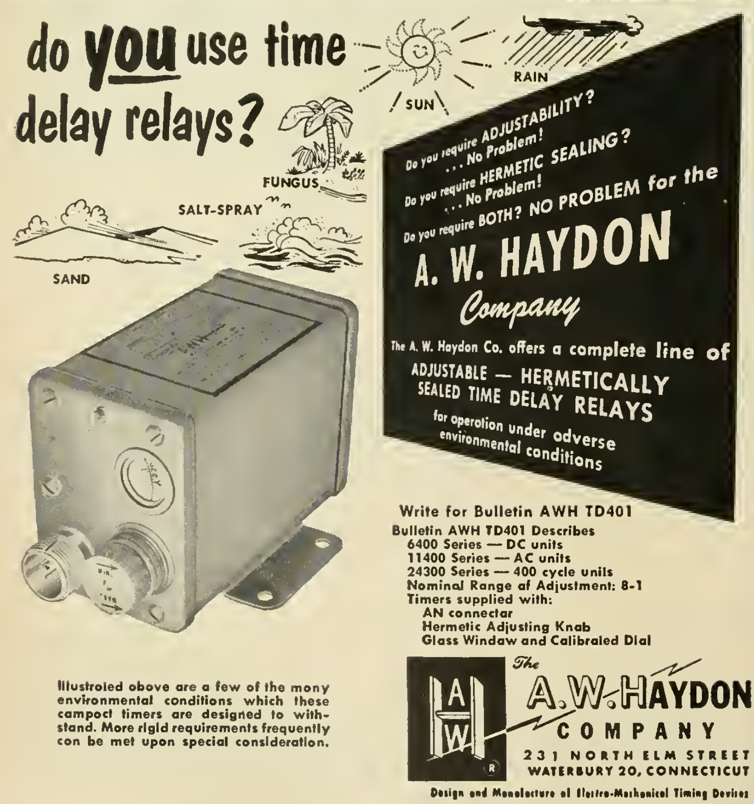
A blocking oscillator contained in an epoxy resin cube measuring ¾" has been produced by Allen B. DuMont Laboratories, Inc. The unit produces a pulse of three miscroseconds duration with a rise time of 0.08 microseconds. Repetition rate is 25 kc.

A six volt mercury cell will power the oscillator for about 1000 hours. Variations of the unit are available to give repetition rates from a fixed 1 kc or variable rates from 400 cps to 24 kc. Operating temperature is from —55°C to 66°C. Either external trigger or free running types may be obtained. Also, plug-in or solder in units can be furnished.

Circle No. 227 on Subscriber Service Card.



Circle No. 29 on Subscriber Service Card.



Circle No. 37 on Subscriber Service Card.

are offered in 15 standard ratios from 3.39:1 to 57.3:1 with ratings up to 100 HP. Triple reduction units are available in 9 ratios from 82.1:1 to 190.7:1 with ratings up to 50 HP. Straitline reducers feature complete interchangeability of individual parts throughout frame sizes as well as packaged sub-assemblies.

Circle No. 214 on Subscriber Service Card.

FLOATED RATE GYRO

Norden-Ketay Corp. has developed a floated rate gyro, Model 55,000 to meet current missile requirements with an accuracy better than ±½% full scale while the unit is subjected to a severe environment. The gyro can be supplied in a variety of maximum rate ranges from 6°/sec/ to 400°/ sec.

Damping is maintained without use of a heater by an arrangement which varies the gap between the gyro rotor float chamber and an adjacent member. Damping rate constant can be varied to suit customer needs. Size is 2" diameter by 2¾" long.

Circle No. 229 on Subscriber Service Card.

ROD END BEARINGS

Production of a new line of two-piece (ball and body only) self-aligning, plain, spherical, rod end bearings for the aircraft, missile and related industries is announced by Southwest Products Co., Monrovia, California. Patterned closely after Southwest Products' "Monoball" self-aligning rod end bearings, the new two-piece rod end bearings are said by the company to have longer cycle life compared to three-piece rod end bearings due to the construction and tougher materials used.

Circle No. 208 on Subscriber Service Card.

PRECISION GEARS

Precision gears especially suitable for servomechanism use are now offered by Beckman/Helipot Corp. as part of its standard electromechanical breadboard parts line. Spur, spring and clutch gears, and bevel and miter gears are among the types available.

In stock are 48- and 64-pitch spur gears, in tooth multiples of 8 and 10, with 14½° pressure angle, and minimum and

TECHNIQUES and DEVELOPMENTS in oscillographic recording

FROM SANBORN

RECORDING METHOD USED IN SANBORN DIRECT WRITERS, AND A REVIEW OF THEORETICAL AND ACTUAL ERROR FACTORS

Figure 1 shows the basic scheme by which Sanborn oscillographic recording galvanometers produce graphic records of electrical signal values. If the rapid deflection action of the heated ribbon tip stylus is visualized when current flows in the coil, it can be seen that a straight line at right angles to the chart length is recorded on the chart, at the point where the chart is drawn over a knife edge. The trace, therefore, is a true rectangular co-ordinate graph.

Since this is essentially a process of expressing coil (or stylus) deflection *angles* in terms of *distances* on a chart, the trigonometry of the situation (Fig. 2) must be examined to ascertain the accuracy of the method. Initially, and when θ is small, the tangent and the angle are almost equal numerically. The expression $D = R \tan \theta$ can, therefore, be rewritten $D = R\theta$ (approx.). To the extent this latter expression is true, deflection distances (rather than deflection angles) are an accurate measure of signal values. But to determine the extent of error resulting from using this approximation, the following data have been calculated*, using a chart width of 25 mm either side of zero ("D" in Fig. 2) and effective stylus length of 100 mm ("R" in Fig. 2) in the series expansion for the tangent function. Error as a function of deflection then becomes:

FIG. 2

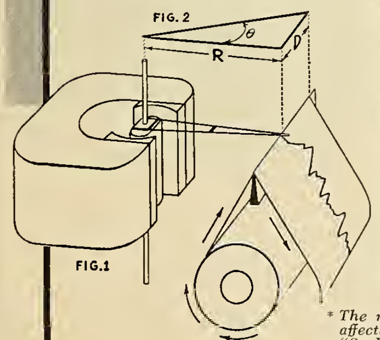


FIG. 1

D mms	Radians	Theoretical Error ϵ	Corrected Error δ	Corrected Error in mms
10	.10	.0033	0	0
15	.15	.0075	.004	.06
20	.20	.0133	.010	.20
25	.25	.0209	.018	.45

When the recording system is calibrated, that calibration is often made on the basis of a one centimeter deflection from the chart center, or by means of a two centimeter deflection starting one centimeter below chart center and finishing one centimeter above chart center. In either case the deflection at one centimeter from chart center is accepted as the standard, and, therefore, is without error. The foregoing table can therefore be corrected by subtracting .0033 from each of the error terms to show the error, δ, to be expected in actual use. The final column in the table shows this error in mms.

Since the active length of the stylus increases as θ increases, deflection D increases more rapidly than θ. All positive error terms in the series expansion bear this out, but the error terms would occur as predicted only if the galvanometer produced deflections exactly proportional to coil currents (that is, ideal spring properties in the torsion rods and uniformity of magnetic field). Pole tips in Sanborn galvanometers are proportioned so that in maximum deflections, galvanometer sensitivity *decreases* slightly, the compensation resulting in *actual* linearity better than that predicted in the table.

* *The mathematics involved here, as well as a discussion of fixed length stylii, design parameters affecting over-all galvanometer performance, etc., are contained in an article by Dr. Arthur Miller "Sanborn Recording Galvanometers," published in the May 1956 Sanborn RIGHT ANGLE. Copies are available on request.*

RECOGNIZE A "150" RECORD BY THESE *THREE* FEATURES...

1% Linearity

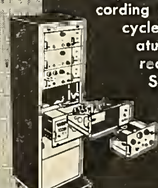
. . . resulting from use of current feedback Driver Amplifier in each channel, high torque galvanometers of new shorted coil frame design. Coil current of 10 ma develops 200,000 dyne cm torque, sensitivity is 10 ma/cm deflection.

Rectangular Coordinates

. . . save analysis time, simplify interpretation and correlation of multichannel records. No waveform curvature, negative time lines, etc.

Permanent Inkless Traces

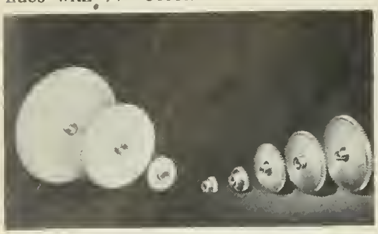
. . . made by hot nichrome ribbon tip of stylus on heat-sensitive Sanborn Permapaper. Clear, smudge-proof traces that clearly reveal minute signal changes.



Call on Sanborn engineers for help with your oscillographic recording application in the 0-100 cycle range. Descriptive literature is also available on request, providing data on Sanborn 1-, 2-, 4-, 6- and 8-channel Systems, choice of 12 interchangeable plug-in Preamplifiers, Separate and Supplementary Instruments.

SANBORN COMPANY
Industrial Division
175 Wyman Street, Waltham 54, Mass.

maximum pitch diameters of 9/16" and 4" respectively. Stock gears have clamp hubs with ¼" bores.



Made-to-order spur gears are available in 32, 48, 64 and 96 pitches, with a choice of 14½° or 20° pressure angles and 1/8", 3/16" or ¼" bores, either clamp type or pin type. The latter are drilled and tapped for set screws and spot-drilled for taper-pin use. Delivery of made-to-order gears is within two to three weeks after receipt of order.

Gears with pitch diameter of 1" or less are stainless steel and have a 3/16" face width. Gears with pitch diameter over 1" are aluminum with stainless steel insert hubs, and have a 1/8" face width.

Circle No. 212 on Subscriber Service Card.

PLATFORM TRUCK

A new 20,000 lb. capacity low-lift platform truck, Model L-15, has been developed by the Elwell-Parker Electric Company, Cleveland.

The truck is available with either electric or gasoline-electric power, has two-wheel drive and all-wheel steer. It is designed for handling odd-shaped and/or extra long loads, particularly where rugged duty is required.

The frame is built of heavy steel plate, formed and electrically welded. Center sill construction is used with all major units attached directly to the heavily reinforced alloy steel bars which form the sills.

The platform is raised by a double-acting hydraulic cylinder.

The truck features a rocking link type platform life with powered lowering accomplished with full inching control through a control valve. A safety link protects the lift mechanism in the event the platform is rammed against an obstruction. A heavy-duty, oversize electric motor drives a tandem hydraulic pump so that a separate oil supply is assured for both the hydraulic lift and the hydraulic steer cylinder.

Circle No. 224 on Subscriber Service Card.

TELEMETERING FILTERS

A new line of subminiature, lightweight telemetering filters for missile applications has been announced by the Pacific Coast Division of Aerovox Corporation. They are 2 cubic inches or less per unit. Telemetering filters for channels 1 through 6 are 1.562" high by .75" by 1.187"; weight is 71 grams (plus/minus 1 gram). Channels 7 through 18 are only 1.375" high by .75" by .75"; weight is 36 grams (plus/minus 1 gram).

Cast in an epoxy-filled resin, all units are hermetically-sealed and will meet applicable MIL Specifications for immersion, shock and environmental tests. All channels will pass 30 G's at 2000 cycles for 2 hours. Temperature range is —55°C. Channel points have standard Johns Hopkins band-pass telemetering call-outs.

Units are made to plug into standard 4-pin Winchester sockets. Standard input impedance is 20K and output impedance is 100K, and can be varied to meet customers' specific requirements.

Circle No. 228 on Subscriber Service Card.

SHUT-OFF VALVES

A new series of high performance shut-off valves for airborne and ground use is now in production at Hydromatics, Inc. These units are designed for applications that require reliable, bubble-tight flow control of extremely low temperature (—320F) and high pressure (3000 psi) media. Typical gases and liquids handled include: oxygen, liquid oxygen, nitrogen, liquid nitrogen, air, liquid air, and helium.

Current is automatically shut off at the end of each valve cycle. In their open or closed position, the valve is positively locked by a Geneva-Lock

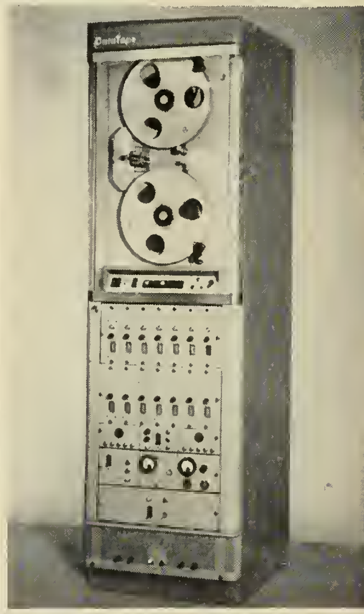
mechanism. Operating times from 0.5 sec to 5.0 sec are available.

Aluminum body; Aluminum and Hard Chromed Stainless Steel internal parts; Mylar, Kel-F and Teflon seals. Available per AND 10050, and 10056, or MS 33514. Elbows and other special configurations can also be specified. A complete range of line sizes is available, from ¼″ to 1½″. A typical ¾″ model weighs 2.7 lbs. including motor actuator and valve unit.

Circle No. 217 on Subscriber Service Card.

MAGNETIC TAPE SYSTEM

Tape recorder and producer system for analog, PDM and FM telemetering has been introduced by Consolidated Electrodynamics Corp. The system provides for recording of seven separate tracks of signals on ½-inch tape.



Reels up to 14 inches are handled to give a capacity of 5000 feet of 1.5-mil tape. Tape widths of ¼, ½, ¾ and 1 inch can be handled. Frequency range is 0 to 100 kc at input levels from 0.25 volts rms to 25 volts rms. The new Type 5-752 unit weighs 880 pounds and operates from 115 volt supply.

Circle No. 223 on Subscriber Service Card.

GEAR MOTOR

Electro Products Division of Western Gear Corp. has developed a 30-volt dc permanent magnet governed planetary gearmotor measuring only 1¼ in. in diameter and weighing seven ounces.

The Model PG5B81RP65 motor requires one ampere current at 30 volts dc and has a 1.2 rmp output speed (±1%) with an output torque of 16 oz. in.

Circle No. 206 on Subscriber Service Card.

ROCKET SWITCHES

Line of precision switches introduced by Micro Switch, division of Minneapolis-Honeywell Regulator Co., are designed to resist effects of highly-corrosive gasses in rocket and missile applications.

Micro series 21AS is essentially an environment-proof, high-capacity switch unit attached to a rugged, cam-type actuator capable of withstanding heavy im-

Afterburner Cooling Assembly Gangs Straight Wall Tubing For High Strength, Light Weight

A minimum weight plus complex fabricating problems were critical factors in the development of this afterburner cooling blast tube assembly.

The space envelope was shallow and wide and over six feet long. The assembly was required to be tested at 28 psig with collapsing pressure of −2.5 psig and at a temperature of 250° F.

Flexonics answered the need by forming standard High Strength welded tubing into a gang. Ends of the tubes were formed to a rectangular shape to adapt them to the required end fittings. The tubes are held together with welded bands as the illustration of the unit shows. Tabs are provided for mounting in the airframe.

End view of afterburner cooling assembly. Note rectangular shape of ends.

Tubing used in the assembly is 1.625″ O.D. by .011″ wall thickness. Type 321 High Strength stainless steel is used, with ultimate of 100,000 psi.

Facilities are the Key Factor

In the engineering, fabrication and proving of assemblies such as this, facilities are all important. As the pioneer and leading manufacturer of light weight corrosion resistant flexible assemblies and ducting, Flexonics Corporation has facilities second to none.

The engineering skill of Flexonics Corporation is proved by the scores of developments already made ranging from single flex connectors to entire aircraft ducting systems.

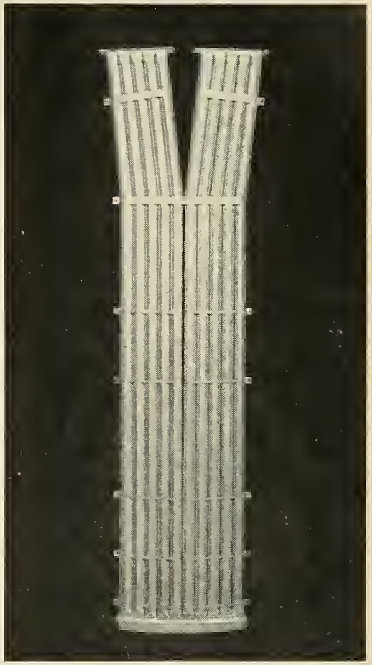
The manufacturing know-how of Flexonics Corporation is proved by the daily trouble free production of intricate assemblies and by such developments as the re-deposition process of forming ducting components.

The ability to prove assemblies before their installation in aircraft and engines is assured by the extensive Flexonics laboratories capable of the most advanced testing procedures.

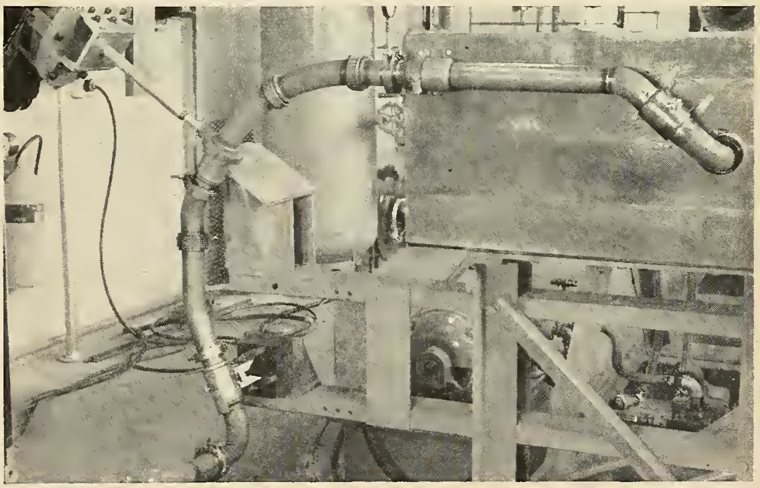
Engineering Assistance

Whenever you have a problem involving aircraft plumbing, take advantage of the know-how and facilities of Flexonics Corporation. For specific recommendations send an outline of your requirements.

For help right at your desk, write for information on how qualified persons can secure copies of the new Flexonics Engineering Manual.



Complete afterburner cooling assembly. Note use of straps to gang the tubing.



Ducting system test in the Flexonics labs. Shown is a portion of vibration and flow under pressure tests of assemblies in a bleed air system for a current fighter aircraft.

NOW, FROM FLEXONICS A COMPLETE LINE OF FLEXIBLE CONNECTORS AND DUCTING

With the acquisition of FLEX-O-TUBE Division, Flexonics Corporation is now able to offer a complete line of rubber, synthetic and Teflon hose assemblies and crimped-on and re-usable fittings. Write for full information.

AIRCRAFT DIVISION

Flexonics Corporation

1414 S. Third Ave., Maywood, Ill.

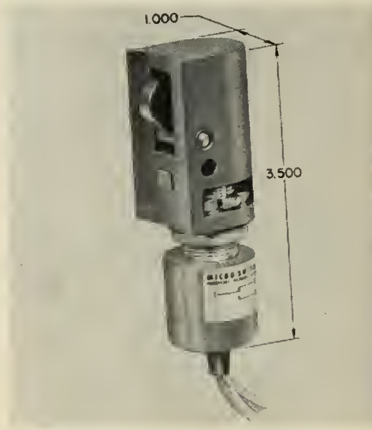
In Canada: Flexonics Corporation of Canada, Limited, Brampton, Ontario

Also Manufacturers of: Industrial Hose • Expansion Joints • Bellows • Thermostats

A-34

Circle No. 33 on Subscriber Service Card pact or hammer-type blows, according to its producer. Typical of its proposed use is an installation of the switch at the firing end of a tandem tube.

In this application, a front rocket holds the switch depressed, keeping the firing circuits to the aft rocket open until the forward rocket has left the tube. Once front rocket is fired, the switch releases and completes the firing circuit to the second rocket.

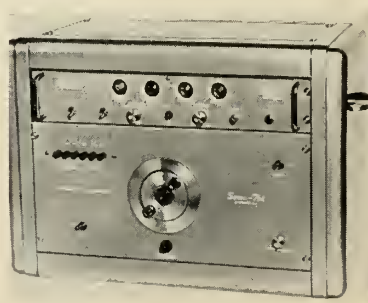


Design feature includes location of lead wires at bottom of switch for flexibility in mounting, two 0.120 in. diameter mounting holes, a 0.195 in. dia. mounting hole, and a 0.04 in. position stud to aid installation.

Circle No. 204 on Subscriber Service Card.

TACHOMETER CALIBRATOR

A new type of test instrument is announced by Servo-Tek Products Co., Model ST-901 Tachometer Calibrator. It is basically an electronic decade type counter combined with the maker's precision electronic adjustable-speed drive. The tachometer under test is driven at a speed (usually from 0 to 5000 rpm) that is infinitely adjustable by means of a 10-turn potentiometer. For rapid production testing, a push-button switch will select any one of five pre-determined test speeds.



The driving speed is continuously displayed with an accuracy of 1 rpm, plus line frequency error. Provisions are made for use of the counter for other purposes such as checking inverter frequency, telemetering switch counts, etc. Counting speeds up to 50,000 per second are possible. An electronic pick up is supplied as a standard accessory to permit checking the rotational or lineal speed of various motors, gear trains, etc.

Circle No. 215 on Subscriber Service Card.

TIME ACCELERATION SWITCH

An acceleration-time integrating switch for missile and rocket applications is available from the Magnavox Co. The unit is self-contained and is actuated by sustained acceleration in excess of the external biasing system. The unit is hermetically sealed and is said to conform to Air Force environmental specifications.

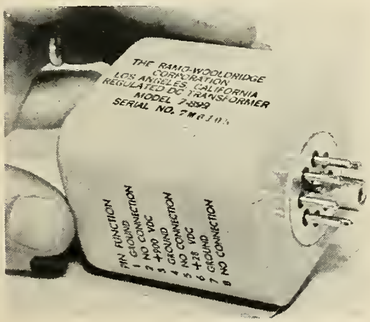
The switch can be adapted to a wide range of acceleration and time parameters for specific requirements. The available units give contact closure when the vehicle has reached a velocity of about 460 ft./sec. at between 4 and 15 g. Volume of the unit is 3 cubic inches and it weighs about 9 ounces.

Circle No. 222 on Subscriber Service Card.

CURRENT TRANSFORMER

A 900-volt regulated direct current transformer has been added to the selection of transistorized, DC power supplies manufactured by the Electronic Instrumentation Division, the Ramo-Wooldridge Corp.

Designed for use in high-performance aircraft, missile systems and other applications in extreme environmental conditions, the unit is potted in epoxy resin and sealed. It operates over an ambient temperature range of —55 to 70°C, and is unaffected by extremes of shock and vibration.



The new power package operates on 24 to 32-volt DC input and delivers 900-volt DC at 30 microamperes, regulated within 3%. Output ripple is regulated within 3 volts peak to peak. The entire unit—transistorized switching circuit, transformer, rectifier and regulator—is integrated in a 2" x 2¼" x 2¾" package.

Circle No. 216 on Subscriber Service Card.

CERAMIC INSULATORS

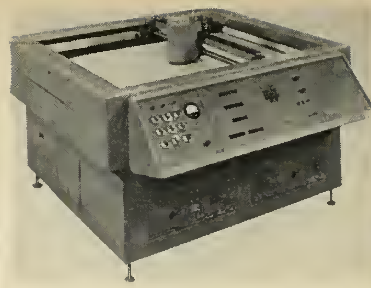
Special magnesium oxide tubing for insulating electric resistance wiring inside the metal sheathing of heating elements is being offered by Saxonburg Ceramics. New tubing is available in specified diameters and lengths, and with one or two holes for wire installation. Material used is said to be an excellent heat conductor and to be serviceable at temperatures up to 1,900°F.

Circle No. 200 on Subscriber Service Card.

ELECTROPLOTTER

A flexible high-speed plotter has been developed by Benson-Lehner Corp. which offers users of general purpose computers four degrees of freedom in presenting output data in graphic form. The "S" plotter accepts information from punched tape, cards or magnetic tape.

For flight trajectory tracing of mis-



siles, plotting of areodynamic pressures and stresses, etc. the plotter operates at rates of between 70 and 100 complete displays per minute. Digital and graphic information can be displayed.

Circle No. 225 on Subscriber Service Card.

MEMORY DRUM

Over 12,000 bits of data and associated clock and reference information can be stored in a new miniaturized, magnetic memory drum developed by BJ Electronics, Borg-Warner Corp., Santa Ana, Calif. The device may be incorporated in data-handling systems and computer systems or utilized as a laboratory testing instrument.

The standard laboratory drum measures 3½ in. diameter and contains 12 information channels plus clock and fiducial channels. Each channel is 0.070 in. in width with a capacity of 1024 bits. Clock and fiducial channels are an integral part of the aluminum drum.

Circle No. 209 on Subscriber Service Card.

BRIDGE BALANCE UNIT

A new Automatic-Calibrating Bridge Balance Unit, 24-202, recently developed by B & F Instruments, Inc., Philadelphia, Pa., for use in missile range instrumentation systems and in flight test programs of advanced military aircraft.

The new instrument is of value when recording dithering type information and provides calibration steps that are square wave for clearer interpretation.

Circle No. 207 on Subscriber Service Card.

DOUBLE WALL CONTAINER

Hoffman Laboratories, Inc. of Newark, N. J. has unveiled a container which will help companies operating in the Low Temperature Field to avoid repairs and evaporation losses. They feature a double wall separated by a high vacuum and highly polished internal surfaces for greater reduction of radiant heat losses.

Circle No. 230 on Subscriber Service Card.

INDUSTRY SPOTLIGHT

By Joseph S. Murphy

Guided Missile Firms Again High on Defense Contract Lists

Guided missile airframe, guidance and powerplant producers ranked high on the list last month as Defense Department tabulated its top contract award winners for the 18-months from January 1, 1955 through June 30, 1956.

In all, some 19 of the first 20 firms are playing a prominent role in one or more missile or rocket programs. The only exception, Ford Motor Co., can hardly be considered an outsider in the missile business with the establishment last year of its new subsidiary, Aeronutronics Systems, Inc.

Heading the Defense list was North American Aviation, Inc. (*Navaho*, X-10 and liquid rocket engine producer) with $1,340.6 millions in contracts. General Dynamics (Convair) ranked second at $1,339.7 and is prime contractor for the *Terrier* and *Atlas* plus other missile projects.

Rounding out the billion-dollar group are United Aircraft (J57 engine for *Snark*) at $1,273.6 million; General Electric (*Hermes, Atlas* nose cone and guidance, J79 engine for *Regulus II*) at $1,051.2 million; and Boeing Airplane Co. *Bomarc* at $1,016.1 million.

Here's how missile firms shaped up in the million-dollar class of award winners: American Telephone & Telegraph Co. (Western Electric in *Nike* and Bell Laboratories in ICBM guidance)—$747.1 million.

Lockheed Aircraft Corp. (X-7, X-17 and *Polaris*)—$657.5 million.

Douglas Aircraft Co. (*Nike, Honest John, Thor* and *Ding Dong*)—$592.8 million.

McDonnell Aircraft Corp. (*Talos* and *Green Quail*)—$522.4 million.

Hughes Aircraft Co. (*Falcon*)—$477.1 million.

Curtiss-Wright Corp.—(Aerophysics HTV and *Dart*, ramjet for *Navaho*)—$464.2 million.

The Martin Co. (*Matador, Bullpup, Lacrosse* and *Titan*)—$406.0 million.

General Motors—(Allison J33 for *Regulus* and *Matador*, AC Spark Plug guidance for ICBM)—$326.3 million.

Bendix Aviation Corp. (*Talos* and *Loki*)—$295.4 million.

International Business Machines (computers for various projects)—$275.3 million.

Chance Vought Aircraft, Inc. (*Regulus* I and II)—$221.5 million.

Radio Corp. of America (*Talos* systems)—$221.3 million.

Sperry Rand Corp. (*Sparrow*)—$209.2 million.

Republic Aviation Corp.—(*Terrapin* rocket, ICBM nose cone subcontractor)—$200.8 million.

Missile representation throughout Defense's top 100 contractors includes some 13 other firms involved in major projects. On this list are Raytheon Mfg. Co. (*Sparrow* and *Hawk*); General Tire & Rubber Co. (Aerojet-General rockets); Goodyear Tire & Rubber Co. (Goodyear Aircraft's *Matador B* guidance and ground support); Northrop Aircraft, Inc. (*Snark*); Philco Corp. (*Sidewinder*); and Avco Mfg. Corp. (*Titan* ICBM nose cone).

Remaining seven included Westinghouse Electric Corp. (*Bomarc* guidance); Fairchild Engine and Airplane Corp. (*Goose* and *Petrel*); Bell Aircraft Corp. (*Rascal*); Firestone Tire & Rubber Co. (*Corporal*); Minneapolis-Honeywell Regulator Co. (ICBM guidance); Gilfillan Bros. (*Corporal*) (ground guidance system); American Bosch Arma Corp. (ICBM guidance); and Chrysler Corp. (*Redstone*).

General Electric Sets First Quarter Record In Sales and Earnings, President Reports

General Electric Co. set new first-quarter records in both sales and earnings during the first three months of 1957, President Ralph J. Cordiner has announced. Sales billed, he said, amounted to $1,048,850,000, an increase of 11 per cent over the previous first-quarter record of $946,458,000 set in 1956, and a 26 per cent increase over the first quarter of 1955.

Cordiner reported that General Electric plans to invest approximately $185 million in new plant and equipment during 1957. This, on top of expenditures of $205 million last year, indicates that the Co. will invest "substantially more" than the $500 million originally scheduled for expansion and modernization in its three-year program for 1956-58, he said.

Cordiner reported net earnings for the quarter of $64,006,000, up 16 per cent over comparable 1956 earnings of $54,962,000, and 22 per cent higher than first-quarter 1955 earnings. The earnings were equivalent to 73 cents per share of common stock and 6.1 cents per dollar of sales as compared with 63 cents per share and 5.8 cents per sales dollar for first quarter 1956, and 6.3 cents per sales dollar in the first quarter of 1955.

Also set new records in employee earnings and in payments to suppliers during the quarter, Cordiner said. Employee pay and benefits applicable to sales, during the quarter reached a record $399,141,000. Purchases of materials, supplies and services from the Company's approximately 42,000 suppliers amounted to approximately $485 million. Also made provision during the quarter for payment of $100,143,000 in direct federal, state and local taxes and renegotiation in addition to indirect taxes included in prices paid to suppliers.

Thiokol Builds *Nike* Sustainer

Nike-Hercules surface-to-air missile is to incorporate a Thiokol solid-propellant sustainer unit.

The new missile is scheduled to be in the hands of operational *Nike* batteries in the very near future. Its higher velocity will permit swifter interception of the most advanced types of aircraft, and its increased lethality will make *Nike-Hercules* one of the most effective weapons in American defense areas.

The sustainer unit is one of the many solid-propellant powerplants recently developed by Thiokol Chemical Corporation.

The *LaCrosse, Falcon, Matador B,* and RV-A-10 all incorporate this type of powerplant. According to a recent announcement by the U.S. Army and the Western Electric Company, prime contractor for the *Nike System,* this new version of the *Nike* missile is now undergoing final tests.

Although longer, heavier, and more than double the diameter of *Nike-Ajax,* the *Hercules* model will have extreme maneuverability at altitudes far in excess of those capable of being reached by *Ajax.*

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, North Carolina. Nuclear capability will be incorporated into the *Nike-Hercules* surface-to-air guided missile system.

Reaction Motors Builds X-15 Engine

Air Force has confirmed that Reaction Motors, Inc., is developing an "advanced-design liquid propellant rocket engine" for the North American Aviation X-15 research airplane.

Missile Obligations Exceed $10 Billion In Eight Years, Aircraft Assn. Reports

Guided missile obligations for the eight years starting in June 1950 and ending June 1958 will total $10,173,930,000 or 8.2% of the $124,348,916,000 total Defense and procurement monies for the period, according to Aircraft Industries Assn.

However, the last half of this period accounts for better than 80% of the missile dollar obligations — $8,359,406,000 for fiscal years 1944 through 1958.

By individual service, AIA shows this summary of obligations:

Army—For eight-year period obligated $2,784,045,000 of which about $2.1 billion was obligated during fiscal 1955-58.

Navy — obligated $1,808,082,000 for eight years and, of this, $1,254,165,00 was for fiscal 1955-58.

Air Force—Eight-year obligations for missiles amounted to $5,581,803,000 of which $4,985,653,000 was obligated in the fiscal 1955-58 period.

Here's how missile obligations compared with total procurement and production monies for fiscal 1950 through 1958:

	Major Procurement & Production Funds ($000's)	Missile Obligations ($000's)
Fiscal 1951		
Army	$6,953,064	$34,600
Navy	6,092,476	119,090
Air Force ..	8,789,349	121,292
Total	21,844,889	274,982
Fiscal 1952		
Army	8,909,576	190,687
Navy	7,813,797	141,332
Air Force ..	11,979,814	68,417
Total	28,703,186	400,436
Fiscal 1953		
Army	3,489,999	212,915
Navy	5,009,174	154,124
Air Force ..	10,235,253	228,594
Total	18,734,426	504,633
Fiscal 1954		
Army	515,237	317,255
Navy	1,878,358	139,371
Air Force ..	1,928,592	177,847
Total	4,322,187	634,473
Fiscal 1955		
Army	2,185,568	349,554
Navy	1,404,537	116,589
Air Force ..	5,981,853	547,934
Total	9,648,793	1,014,077
Fiscal 1956		
Army	1,150,118	354,034
Navy	4,199,653	232,576
Air Force ..	7,141,587	859,719
Total	12,891,435	1,446,329
Fiscal 1957 (Estimated)		
Army	1,601,000	743,000
Navy	4,093,000	440,000
Air Force ..	8,425,000	1,888,000
Total	14,119,000	3,071,000
Fiscal 1958		
Army	1,359,000	673,000
Navy	4,245,000	465,000
Air Force ..	8,479,000	1,690,000
Total	$14,085,000	$2,828,000

SAM Details Revealed In Released Pix

English Electric has been permitted to release three photographs of its Napier-rocket powered SAM ordered for UK defense. The photographs have been released before, but not identified with English Electric. The missile has cruciform wings of 1.0 aspect ratio and cruciform tail guidance blades. Dipole antenna are featured both fore and aft. Take-off boosters are in four pairs on wrap-around explosive cord or bolt mount, each pair with a guidance fin. This type of booster is used on Napier's RJTV experimental ramjet.

Industry Highlights

By Fred S. Hunter

At the time of this writing—in April—the initial test firing of the Convair/Ramo-Wooldridge/Western Development Division *Atlas* prototype had not taken place at the Air Force missile test center in Florida, but perhaps by the time you read this the big event may have occurred. So let's call this *Atlas* month and talk about the big ICBM.

Karel J. (Charlie) Bossart, now technical director of Convair's Astronautics Division, named it the *Atlas*. It's a fitting name. Holds up the world. But there was an additional consideration at the time Bossart picked Atlas out of the dictionary. Convair's controlling stockholder then was Floyd Odlum's Atlas Corp.

Model number for the *Atlas* is SM-65, weapons system designation is WS-107A and Convair's house number for it is Model 7. Latter shows that Convair actually started on the ballistic missile project before its delta wing F-102 all-weather interceptor came along. The F-102 is the Model 8 on the Convair books.

Convair's Astronautics division currently is conducting its operations in the company's Plant 1 at San Diego—that's where the commercial Model 440 Metropolitans are assembled—but it expects to be fully established in its new home on Kearny Mesa in January next year. This $40-million domicile for Convair's prize bird includes a manufacturing facility, due for completion in November, an engineering building and two six-story office buildings.

Astronautics now has about 6,000 employes, and it will peak at about 7,000 in the new facility. It will have a couple of thousand more, however, at outside test locations. The division payroll will exceed $50 million a year.

Only recently did General Dynamics Corp. give Convair's Astronautics division full division status, like that of the company's Pomona Navy missile enterprise, but Convair has been working on an intercontinental ballistics missile program ever since April 22, 1946. That's when the Air Force gave it a study contract of very modest proportions—something less than $2 million, as we recall—for the MX-774. "Charlie" Bossert was the project engineer. Now, if you think the projected *Atlas* prototype test in Florida represents Convair's first test firing of a ballistic-type missile. You're wrong. There were three test vehicle firings of the MX-774 at White Sands in 1948. Reaction Motors made the four rocket motors powering the test vehicle.

The MX-774 was ordered terminated in the Louis Johnson economy program of 1947, but Convair was permitted to continue the project as long as the money originally budgeted held out. That's how it got in the subsequent test firings. But Convair was so thoroughly convinced of the nation's need for the "ultimate weapon" that even when the last dollar was spent it kept an engineering group on the project with its own funds. This was the situation when the Air Force came through in January, 1951, with a new contract for the MX-1593. This was the *Atlas*.

Atlas has grown considerably over the years. The MX-774, as we recollect, was 34 feet long. When Convair was ready to ship the *Atlas* prototype to Florida last December it had to truck it—a 10-day journey. Strangely enough, it attracted practically no curiosity en route. The people have become accustomed to seeing almost anything on the highway so those who passed the big canvas-covered shape on the road apparently didn't give it a second thought. One reason we were somewhat surprised when the Air Force shot down the Douglas C-132 for lack of funds the other day, was we had assumed all along that a primary function of the big turboprop would be to airlift such large-scale items as the *Atlas* and the Martin *Titan*. We understand the C-133 will hold the *Atlas*, but it's a tight fit—or so we hear.

Crucible Sales Top $70 Million

Crucible Steel Co. of America's sales of $70,598,795 in the first quarter of 1957 were the largest for any first quarter, but moderately below the level of the previous quarter, President Joel Hunter announced.

Net earnings for the first quarter amounted to $0.93 per share as compared with $1.01 per share in the 1956 quarter, based on the 3,638,562 common shares currently outstanding.

Directors elected for a three-year term of office were Joel Hunter, President; Walter H. Wiewel, Senior Vice President; Lawrence N. Murray, President, Mellon National Bank and Trust Co., and William H. Rea, President, Oliver Tyrone Corporation.

Honeywell Tests Guidance System

Minneapolis-Honeywell Regulator Co. has flight tested a new "pure" inertial navigating system for automatic guidance of manned or unmanned aircraft, it has been announced.

Several tests have been made from Honeywell's flight operations center at the Minneapolis-St. Paul Municipal Airport. The airplane which transported the highly-intricate aerial "brain" has ranged over several-hundred mile courses in Minnesota and Wisconsin.

Work on the system (designated ISIP, short for Inertial System, Indicating Position) has been going on for several years in the Aeronautical Division's research facility under a Navy development contract. The Air Force, too, has shown an interest in Honeywell's ISIP self-navigator.

Grumman Launches Bid For Subcontracting

Grumman Aircraft Engineering Corp., one of the few major aircraft firms not playing a major role in the current missile program, has launched a permanent subcontracting program that presumably will include missile work.

Company officials report that work complete and underway totals more than $7 million, with one order from General Electric worth in excess of $500,000 already delivered. Grumman also holds subcontracts from Sperry Gyroscope Co., Fairchild Aircraft Division, Chance Vought Aircraft and McDonnell Aircraft Corp.

All are active in one or more missile programs including Sperry (*Sparrow*), Fairchild (*Goose*), Chance Vought (*Regulus*) and McDonnell (*Tales* and *Green Quail*).

The Martin Co. Drops the "Glenn"

The Glenn L. Martin Co.'s stockholders have voted at their annual meeting to shorten the firm's name to "The Martin Company." This was done, the company said, "in keeping with industry's growing recognition of the greater impact of foreshortening company names."

Other formal business at the meeting included the re-election, as Directors, of George M. Bunker, Duncan M. Spencer and John L. Sullivan. Other Directors of the Company include Howard Bruce, William A. Burns, Jr., John E. Parker, Everett H. Pixley, Alexander B. Royce and Frank F. Russell.

At the meeting, it was announced that sales for the first quarter of 1957 were $98,748,234, an increase of 93 per cent over sales of $51,132,853 for the same period of 1956. Sales volume is approximately in line with the rate forecast for the full year.

The increase reflects both the higher current rate of activity as well as the fact that last year's first quarter

sales were somewhat less than normal.

Net income for the first quarter of 1957 was $2,009,535, equivalent to 69 cents per share compared to $1,586,725 and 56 cents per share last year. Net income, although ahead of last year's first quarter, is lower than expected for the rest of the year.

Bell Earns Slightly Less Sales Hit Peacetime High

Bell Aircraft Corp., manufacturer of the *Rascal* long-range air-to-surface missile, reports 1956 earnings of $5,761,103, down slightly from 1955. Sales of $216,033,290 plus other income of $1,040,937 marked a new peacetime high for the company.

Leston Faneuf, Bell president, attributed the decline in earnings to increased wage rates and material costs, unusually high starting load costs on products being built under fixed-price contracts, plus continually growing development and engineering expense.

In its annual report, Bell reported its engineers have designed and developed rocket engines for five guided missiles only one of which is now operational. It also reported completion of laboratory evaluation of more than 50 rocket propellants over a three-year period and some 15,000 rocket thrust chamber runs in more than 50 test cells it operates.

Bell now estimates it consumes about 350,000 pounds of oxidizer and 100,000 pounds of fuel each month in such testing.

Army Lets Contracts For New Lox Plants

Army Corps of Engineers has awarded a contract to Air Products, Inc. of Allentown, Pa. for construction of two liquid oxygen generator plants.

Each unit will be capable of producing a 50-ton daily supply of high-purity Lox for missile use, yet will be designed for dismantling and shipment via cargo aircraft. According to API officials, the largest air-transportable oxygen plant now in operations is rated to produce only 10 tons per day.

GE Sets Up Group For Missile Arming

Missile and Ordnance Dept. of General Electric Co. at Philadelphia has been expanded to include a special organization for R&D in nuclear arming and fuzing devices for missiles.

Group is designated the Nuclear Ordnance Projects Operation and will be responsible for all arming and fuzing development work including electro-mechanical devices used to arm and detonate missile warheads.

G. F. Metcalf, department general manager, said the group has contracts requiring production of recently developed system designs for current Army Ordnance missile warheads, as well as R&D into new and improved systems for future operational missiles.

Farnsworth Contracts Over $12 Million

I. G. Haggerty, President of Farnsworth Electronics Co., Fort Wayne, Ind., a division of IT&T, announced that the company had received additional orders amounting to more than $12-million from the Boeing Airplane Co. in Seattle, Wash.

The contract calls for the provision of additional ground support and operational test equipment for the Bomarc Missile, currently being produced by Boeing for the USAF. According to Mr. Haggerty, Farnsworth, long active in the production of automatic and specialized test equipment for missiles and for other complex electronic and electro-mechanical devices, did the original prototype development of the equipment just ordered.

Small Business Contracts Hit $1.6 Billion

Subcontract awards by 163 large firms to small business almost matched the dollar volume received directly from the Defense Department in prime contracts during the last half of 1956, Defense officials report.

Major companies participating in Pentagon's Small Business Subcontracting Program reported $1.430 billion awarded small business during the period compared to $1.616 billion awarded by Defense as prime contracts.

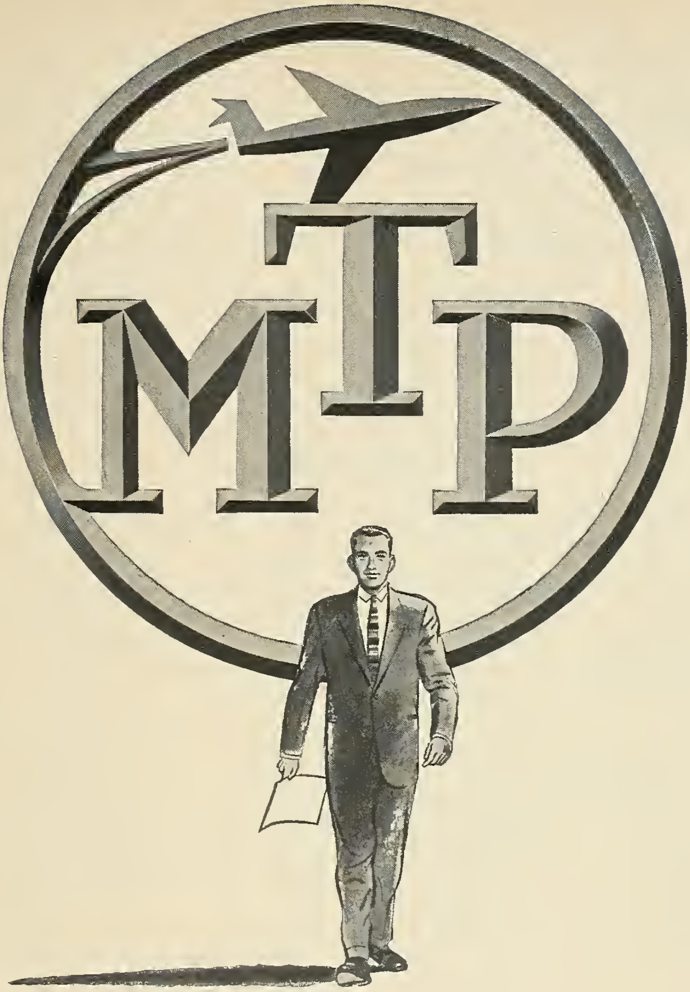
According to Pentagon estimates, the $1.430 billion represents 20.9% of the total military prime and subcontract receipts of the 163 firms reporting receipts and payments under Army, Navy and Air Force contracts.

Brush Sets Up Branch in L.A.

Brush Electronics Co., Cleveland, Ohio, manufacturers of industrial and research instruments, has established a factory branch office in Los Angeles.

This new facility will serve as western regional headquarters for service and repairs in the western states and will be the headquarters for the western regional sales manager.

The team of sales engineers is already on the job and additional per-


MTP

sonnel will be added as required, said C. B. Hoffman, sales vice president.

Martin Awards Contract For New Orlando Plant

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* manufacture in interim facilities near Orlando and presumably will shift this activity to the new plant when completed later this year.

Plan 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.

Southwestern Gets Convair Contract

Southwestern Industries Inc., Los Angeles, has received a contract from Convair, a division of General Dynamics Corp., for design and manufacture of pressure switches, Southwestern President F. P. Jenks has announced. The switches will be used in classified missile applications by Convair-Astronautics in San Diego, Jenks added. Dollar value of the contract was not disclosed.

Texas Nuclear Installs Atom Smasher

Texas Nuclear has completed installation of its "atom smasher" at Austin, Tex.

The company initially is using its 2-million-volt positive-ion accelerator purchased from High Voltage Engineering Corporation, Burlington, Mass., in programs dealing with elastic and inelastic scattering of neutrons.

Missiles Support Functions to go to San Bernardino

Transfer of the Ballistic Missiles logistical support functions, now at Maywood Air Force Depot to Norton Air Force Base at San Bernardino, Calif. will take place in the near future, it has been announced.

The Ballistic Missile Management

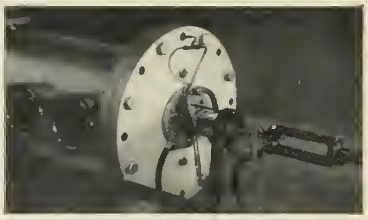
ENGINEERS-SCIENTISTS: TEMPERATURES TWICE AS HOT AS SUN'S SURFACE NOW PRODUCED AT G.E.'S AEROSCIENCE LAB

New "Water Arc" Advances Nose Cone Technology at Missile & Ordnance Systems Department of General Electric

When MOSD became prime contractor for ICBM Nose Cone development, engineers and scientists here were faced with the necessity of creating not only new systems concepts, new components, new materials and new fabrication techniques, but also the *very tools and facilities to evaluate them.*

Meteors may melt on entering the earth's atmosphere, but the relatively thin-skinned nose cone must come through in full functional order. To test out heat-resistant materials capable of withstanding re-entry temperatures, a new instrument was devised under the direction of the research staff of MOSD.

STABILIZED WATER ARC and G-E designed TUNNEL shown during operation. Material undergoing test is held in front of the arc orifice by means of a rod or "sting" running through the tunnel.



3,000 KW used in operating this stabilized arc and evacuation tunnel. (Shown idle.) Has 1/4" nozzle diameter. Present plans call for construction of a 3" diameter model, requiring 8,000 KW for operation.

View of fluid-stabilized arc in operation. The liquid revolving inside the glass or plastic cylinder flowing at high velocity offers insulation as well as the material of which the plastic beam is composed.

...the WATER-STABILIZED ARC

How does the new water arc differ from the conventional electric arc? It is controlled—or stabilized—by a whirling blanket of water, which produces a "squeezing" effect, forcing the arc into the shape of a column. By causing a great amount of electrical current to flow across the column, extreme temperatures may be maintained continuously, subject only to the limitations of available power.

Valuable experiments are now being conducted at MOSD's Aeroscience Laboratory with the stabilized water arc. The most advanced heat-resistant materials are subjected to temperatures as high as 25,660°F—more than twice the heat of the sun's surface.

OTHER WAYS OF CREATING HYPERSONIC ENVIRONMENT AT MOSD

G.E. has built the largest, most powerful Shock Tunnel in the country in Philadelphia. Here free flight conditions in the order of Mach 20 can be matched. MOSD also utilizes a high power Centrifuge to test behavior of electromechanical and structural components under gravity loads up to 100 G's.

OPENINGS FOR MEN WHO CAN EXPLORE NEW TECHNICAL AREAS

Engineers and scientists find an ideal research environment at MOSD. They work in small groups on problems of prime scientific interest – in close contact with managers and top specialists.

Located in downtown Philadelphia, adjacent to University of Pennsylvania and Drexel Institute, it is easy to take advantage of G.E.'s Tuition Refund Plan for graduate study.

EXCEPTIONAL GROWTH OPPORTUNITIES:

Organized only in '56, MOSD has been growing phenomenally, and continued expansion is scheduled for '57. This expansion creates many opportunities to rise to positions of higher responsibility and income level. All of the managers of technical groups are themselves engineers or scientists and the majority have come up from within this or other departments of General Electric.

YOUR INQUIRIES INVITED:

If you are a Graduate Engineer or Scientist and have experience in these or related fields:

MATERIALS AND PROCESSES • AERODYNAMICS • AEROPHYSICS • THERMODYNAMICS • ELECTRICAL DESIGN • ELECTRONIC OR ELECTROMECHANICAL COMPONENT DESIGN • STRUCTURAL DESIGN • STRESS ANALYSIS • DATA PROCESSING • SYSTEMS • SYSTEMS TEST • FIELD TEST • VIBRATION • INSTRUMENTATION • CONTROLS • GROUND SUPPORT EQUIPMENT DESIGN • TECHNICAL WRITING • ARMING AND FUZING • INERTIAL GUIDANCE

...send us your resume or, if you prefer, write us for a convenient application form.

Your resume will be carefully reviewed by the MANAGERS of our various technical components. If qualified, you will be invited to visit our offices and discuss the work we are doing directly with the managers with whom you would be working. All communications will be entirely confidential.

Mr. John Watt, Professional Placement, Room 590-6

MISSILE & ORDNANCE SYSTEMS DEPARTMENT

GENERAL ELECTRIC

1617 Pennsylvania Boulevard, Philadelphia 3, Pennsylvania

Group, which comprises approximately 50 people, will go to the San Bernardino Air Materiel Area where Col. Philip B. Foote will be designated as Deputy Commander for Ballistic Missiles. Brig. Gen. Ben. I. Funk will remain as overall Ballistic Missiles Weapon System Manager. No successor to Col. Foote as Commander of Maywood has as yet been named.

In his new assignment, Col. Foote will report to Gen. Anderson and receive directional control from Gen. Funk.

Staff and operating elements of the San Bernardino Air Material Area under the command of Gen. Anderson will render all necessary services to the Ballistic Missiles Weapon System Management contingent when it moves to San Bernardino.

Maywood Air Force Depot will continue to provide administrative services for the time being for the Ballistic Missiles Office at Inglewood in areas of personnel support, accounting, statistical services, transportation, legal advice, and security clearance.

$20 Million Navy Contract or Terrier Launchers

Navy has placed two contracts totalling $20 million with Northern Ordnance, Inc., Minneapolis, Mich. for *Terrier* Launching equipment. This gear is to be installed on the aircraft carriers *Kitty Hawk* and *Constellation,* as on a nuclear powered guided missile cruiser and a new class of guided missile frigate.

Beckman Forms Missile Subsystems Group

Beckman Instruments, Inc. has announced formation of a new contract engineering department in its Helipot Division. Group will be headed by Frederick Marsh under technical director O. C. Bixler.

Role of the new department will be specialization in design and production of electro-mechanical subsystems for aircraft and missiles.

New Martin *Matador* Announced by AF

The US Air Force has announced that the Martin *Matador* ground-to-ground tactical missile presently in operational use is being replaced by a new, improved version of the missile.

The TM-61C incorporates a vastly improved guidance system, designed and developed by the Martin Co. Range of the *Matador* will be substantially increased over the original version according to Martin, enabling a much deeper penetration behind enemy lines and use over wide expanses of water. Traffic capabilities—the ability to control more than one missile in the air at the same time—will be greater, thus making the firepower of a missile squadron much stronger. Accuracy with the new guidance system will be improved.

The system provides complete all-weather operation of the missiles. One of the most important improvements in the TM-61C guidance system is its high resistance to electronic countermeasures. As in other *Matador* missiles, the TM-61C can be launched from rough inaccessible terrain, by the use of rugged, highly mobile launching platforms.

The TM-61C is 39.6 feet long, 54 inches in diameter and has a wing span of 28.7 feet. Operating at speeds of more than 650-miles-an-hour, the missile is capable of altitudes over 35,000 feet. The Martin Co. is producing this version of the *Matador* under an Air Force Production Contract at an approximate cost of $60,000 per missile.

Heath Breaks Ground For New Plant

Ground has been broken for the construction of a new 142,000 square foot plant for Heath Co., manufacturer of electronic equipment in kit form, Robert Erickson, president, announced recently Heath is a subsidiary of Daystrom, Inc.

The modern one-story building will house all of Heath's operations and, upon completion, will be one of the largest plants in the nation devoted to specialized direct mail selling. It will occupy a 16 acre tract in St. Joseph. Mich.

Facilities in the new plant will include specialized equipment for handling mail orders, a product research department with a new anechoic chamber for research with all types of sound equipment and a branch US Post Office.

The company presently operates in six different locations in the Benton Harbor area. Francisco and Jacobus, New York, are the architects.

M-H Reports High Earning

Minneapolis-Honeywell Regulator Co. reports highest first quarter sales and earnings in its history. Sales increased to $76,307,511, compared to $58,166,724 last year.

Largest rocket and satellite exposition ever was sponsored by the American Rocket Society and held at the Sheraton Park Hotel in Washington, April 3-6, in connection with the Society's Spring Meeting. Above is a glimpse of Allied Chemical's booth. Most of the major propellant manufacturers were represented.

Bell's Howard Jansen, right, proudly demonstrates liquid rocket pump to Rocket Society member Darrell C. Romick.

William R. Roennau of the National Capital Section of the American Rocket Society pays visit to Aerojet-General booth. Washington representative, Robert Hirsch, right, was on hand demonstrating Aerojet products.

The three Services and NACA had interesting booths, illustrating their missile efforts and their support on the VANGUARD program.

Among the many materials exhibitors was HAVEG Corporation, displaying their high-temperature insulation materials for missiles and rockets and other applications. Exposition was first of its kind and it was one of the more popular features of the ARS Spring Meeting. The exposition was not open to the general public. Why not?

ARS Spring Meeting hosts, Mrs. Jean Bergaust, Chairman of the National Capital Section's Auxiliary and National Capital Section President, Erik Bergaust, welcome special guest Jimmy Stewart to cocktail party the first day.

Rear Admiral Rawson Bennett, Chief of Naval Research, chats with fellow satellite enthusiasts. Left, Dr. John P. Hagen, and Mrs. Kurt R. Stehling. Right, Dr. A. F. Spilhaus and Kurt R. Stehling.

Rear Admiral John E. Clark, Navy's No. 1 missile man, right and Dr. Thomas Hope Johnson of the Atomic Energy Commission, talk with the Rocket Society's Executive Secretary, Jim Harford, left.

ARS Spring Meeting banquet was held in Sheraton Hall the last day of the meeting. Alan T. Waterman, Director, National Science Foundation, left, at the head table with Meeting Chairman, Andrew G. Haley; guest speaker Athelstan F. Spilhaus, Dean, Institute of Technology, University of Minnesota; and Comdr. Robert C. Truax, ARS National President.

Major General Patrick J. Ryan, right, who gave the Invocation at the banquet, converse with The Reverend Edward L. R. Elson, who gave the Benediction.

ARDC's Brigadier General Don R. Ostrander and Mrs. Ostrander at head table reception with Grand Central Rocket Co. president, Charles Bartley.

Busy National Capital Section Vice President, Robert Hirsch of Aerojet, right, never stayed anywhere more than a few minutes, his duties ranging from entertaining in Aerojet's suite to supplying press typewriters.

Mr. Rosel H. Hyde, Commissioner, Federal Communications Commission, left, with Commissioner Robert T. Bartley, and Dr. Alan T. Waterman, right.

Washington personality Col. M. Robert Guggenheim, right, had many points to stress during his lively conversation with Commissioner Bartley at banquet.

New ARS Fellow Member Rear Admiral Rawson Bennett, Chief of Naval Research, left, with National Capital Section's Erik Bergaust, m/r Managing Editor; Army Engineer and Fort Belvoir Commanding General David H. Tulley and ARS Program Chairman, Kurt R. Stehling, Naval Research Laboratories' VANGUARD propulsion head.

Popular feature was introducing Washington's Cherry Blossom Queen, her court and escorts to the ARS members at the banquet. The meeting was held during Cherry Blossom Week.

ARS Spring Meeting banquet was opened in typical Washington style, a color guard marching in with drums beating. The presence of guard, which included one representative from each service, symbolized the importance of missiles to our integrated defense system.

As usual, making the rounds of the hospitality suites was tough. Traditionally, Chrysler's headquarters, where Paul Stewart (left) was host, bristled with rocket engineer visitors. . .

. . . and such talented ambassadors as old-timer Lovell Lawrence, left, who said this was "the finest meeting the Rocket Society had ever put on" and should be held annually.

One of the most popular social functions was sponsored by Harvey Aluminum Company. At swanky reception, Harvey's Director of Research and Development, G. Howard Teetor, right, with head of company's Washington office, Keith Linden, welcome guests. Left, ARS' two Bob's: Truax and Hirsch.

The Dean himself, Dr. Theodore von Karman, talks space to Aircraft Industries Association's Jean Ross Howard at Harvey reception.

Rear Adm. John Clark congratulates Bob Truax on a fine meeting. "Thanks, and come again!" Next meeting San Francisco, June 10-13.

people

Lt. Gen. Laurence C. Craigie, former commander of the Allied Air Force in Southern Europe, has joined American Machine & Foundry Co. as asst. to the defense products group executive, in charge of long range planning.

A. V. Cleaver, chief engineer of the Rocket Division of de Havilland Engine Co., has joined the Aero Engine Div. of Rolls-Royce Limited as asst. chief engineer to supervise engineering of rocket motor projects.

Robert M. Hawley has been appointed director of sales and customer relations for Bell Aircraft Corp.'s Weapon Systems Division.

William G. Alexander was named chief engineer at the San Diego plant of Stromberg-Carlson, a division of General Dynamics Corp. He was formerly manager of the high resolution radar section at Westinghouse Electric Corp.'s Air Arm Div.

Paul Frankfurt has been appointed information services officer at the Ballistic Missiles Office of Air Materiel Command.

FRANKFURT

Jack Wright has been promoted to Manager of The Garrett Corp.'s Aero Engineering Div.

Haywood C. Smith, formerly manager of the Raleigh Laboratory of American Machine & Foundry Co., has been appointed technical manager, research and development dept., office of the vice president-engineering. He will be responsible for planning and directing new product development for all lines.

Andrew H. Bergeson, vice president-engineering at Stromberg-Carlson, is returning to Washington, D. C. to serve as vice president in charge of the capital city office.

Thomas Allinson has been elected vice president of marketing of Daystrom, Inc.

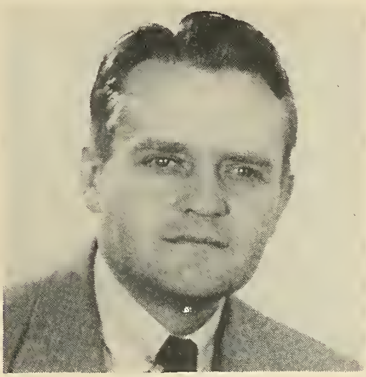
John R. McLeod, formerly with the Office of Naval Research, has been appointed manager of public relations for the Research and Advanced Development Div. of Avco Mfg. Corp.

J. W. Stack was named director of sales and contracts for the Milwaukee plants of AC Spark Plug Div. of General Motors. He succeeds **Howard W. Brandt,** who is leaving AC to go into business.

Sherman M. Fairchild, founder and board chairman of Fairchild Camera and Instrument Corp., has been elected president.

Robert P. Gira, general contracts manager for Topp Industries, Inc., has been elected a vice president.

John W. Johnson, formerly director of advertising for Chance Vought Aircraft, has been named director of the advertising and public relations department in a reorganization move.



JOHNSON

Richard W. Powell was named asst manager of the Avionics Div., Aerojet-General Corp.

Dr. Marshall G. Holloway heads the new Nuclear Energy Products and Erco Division of ACF Industries, Inc.

Charles E. Burns has joined the Ralph M. Parsons Co., Los Angeles, as manager, Aircraft & Missiles Dept., Project Development Div.

Frank R. Carver will head Hughes Aircraft Co.'s radar development dept.; E. E. Herman will head radar systems dept.; **John C. Bailey** has been named head of scientific and general recruitment for the systems development laboratories.

Frederick A. Henry has joined the Associated Missile Products Corp. as staff asst. to the general manager.

Ronald Smelt has been named director of the New Design Office in the Research and Development Branch of Lockheed's Missile Systems Division.

Alfred Schaff, Jr. has been named manager of Aerojet-General Corp.'s Test and Field Service for the Solid Rocket Plant at Sacramento.

SCHAFT

Joseph M. Johnston has been appointed operations supt. of instruments and components for The Victoreen Instrument Co.; **William A. McCarthy** was named sales manager for the company.

Norman P. Hays will head the new eastern office of Autonetics, div. of North American Aviation, in Washington, D.C.

people

John C. Howe has been appointed district sales manager in the Dayton office of General Electric's Light Military Electronic Equipment Dept.

Donald M. Allison, Jr. has been named asst. manager of military products of Radio Div., Bendix Aviation Corp.

Thomas L. Douglas has been appointed senior sales engineer, Finn Aeronautical Div., T. R. Finn & Company, Inc.

Robert C. Gibson has been appointed asst. weapon system manager at Lockheed Missile Systems Div.

Dr. Royal Weller, chief scientist at Naval Air Missile Test Center, Point Mugu, Calif., joins Stromberg-Carlson as vice president-engineering.

Kenneth P. Bowen, formerly vice president-manufacturing and material for Northrop Aircraft, has been appointed gen. manager for Summers Gyroscope Co.

Mr. G. Norris Shaw, formerly with Navy's BuAer in Washington, joins Temco Aircraft Corp. as senior military liaison engineer.

Donald L. Blessing has been named general manager of the Metal Products Div. of Modglin Co., Inc.

Donald C. Webster, chief engineer of Librascope, Inc., has been elected vice president.

WEBSTER

Maurice A. Broner has been named managing editor of the Journal of Astronautics, official organ of the American Astronautical Society, Inc.

David W. Moore was named manager of Servomechanisms' new components division.

Weaver Barnett has been named technical group engineer and **G. Norris Shaw** has been appointed senior military liaison engineer for Temco Aircraft Corp.

Robert J. Brown is sales manager for the Mincom Div. of Minnesota Mining and Mfg. Co.

Fred H. Edgar has joined Olin Mathieson Chemical Corp. as sales manager, Detroit-Cleveland Div. for Olin Aluminum; **Lt. Cmdr. Enoch D. Blackwell** has joined the contract administration staff of the High Energy Fuels Organization of Olin Mathieson.

Andrew McMillan has been appointed sales engineer for Narelco products by the Instruments Div., Philips Electronics, Inc.

Marshall P. Bearce has been named asst. to the general manager, public relations div., Elgin National Watch Co.

Don MacIver is the new public relations mgr. for Texas Instruments Inc.

John D. Saint-Amour has been elected president of Assembly Products, Inc. **Robert H. Pugsley** was elected vice president, sales mgr., and director.

Michael Gerald O'Neil was elected vice president and exec. asst. to the president of General Tire & Rubber Co.

John K. Gossland has been appointed exec. vice president and general manager of Electromation Co., Inc.

GOSSLAND

George J. Costello has been appointed mgr. of the ordnance products dept. of The W. L. Maxson Corp.

William V. Crowley has been named sales mgr. for the Western Div. of ALWAC Corp.

Dr. John C. Clark has resigned as associate leader of the Test Div., Los Alamos Scientific Laboratory, to become staff asst. to the manager of Convair-Astronautics.

J. B. Van Der Werff has been appointed chief engineer, Gladden Aircraft Products Corporation.

Norman C. Anderson, manager of the Photoconductor-Transistor Div. of Electronics Corp. of America, has been appointed vice president of the division.

ANDERSON

Daniel Darnell, Jr., former North American Engineering test pilot, has been appointed chief of customer relations for Autonetics, a division of North American Aviation, Inc.

Dr. Eugene Miller, formerly chief of research laboratories at Redstone Arsenal, has been appointed director of research and development of solid propellants in the Explosives Div. of Olin Mathieson Chemical Corp.

Chandler C. Ross and **Robert B. Young** have been elected vice presidents of Aerojet-General Corporation in charge of engineering and the Liquid Rocket Plant, Sacramento, respectively.

missile literature

TUBULAR PARTS. Facilities for design and production of specialized metal tubular parts are described in Bulletin No. 2056 issued by H&H Machine Co.

Circle No. 100 on Subscriber Service Card.

SILICONE PRODUCTS. Illustrated catalog prepared by General Electric Co.'s Silicone Products Dept. describes more than 115 different applications for silicones it now produces.

Circle No. 101 on Subscriber Service Card.

HIGH TEMPERATURE RESEARCH. New continuous heat source providing controlled temperatures up to 15,000°K is fully illustrated in brochure issued by Plasmatron. Process described is development of Giannini Research Laboratories (m/r, March 1957).

Circle No. 102 on Subscriber Service Card.

TEFLON INSULATION. American Super-Temperature Wires, Inc. has published a 30-page catalog describing Teflon insulated wires and cables for high temperature applications.

Circle No. 103 on Subscriber Service Card.

EXPLOSIVE VALVES. New brochure issued by Conax Corp. describes its series of explosive actuated valves for aircraft and missile use.

Circle No. 104 on Subscriber Service Card.

THRUST STANDS. Series of three brochures available from Hunter-Bristol Corp. describes thrust measuring units for complete jet aircraft or missiles; for jet engines; and, for rocket-powered test systems including test sleds, monorail and free-flight vehicles.

Circle No. 105 on Subscriber Service Card.

OPTICAL TOOLING. Specialized optical tooling and testing equipment available from Keuffel & Esser Co. are described in new 17-page bulletin.

Circle No. 106 on Subscriber Service Card.

POWER RECTIFIERS. The Christie Electric Corp. has announced the availability of a new bulletin covering their three lines of D C Power Rectifiers.

Circle No. 107 on Subscriber Service Card.

WIRE WOUND RESISTORS. Comprehensive data on construction, characteristics, coating, winding, insulation identification, mechanical strength, terminals and brackets—detailed charts and graphs, is given in a 12 page booklet by International Resistance Co.

Circle No. 108 on Subscriber Service Card.

POTENTIOMETERS MEASUREMENT. Helipot Corp.'s new 30-page booklet takes up a practical approach to predicting, measuring and compensating for quadrature voltage and phase shift in copper-mandrel potentiometers used in AC circuits.

Circle No. 109 on Subscriber Service Card.

WELDED BELLOWS. Belfab Corp. has published an 8 page catalog on welded bellows in stainless steel and similar alloys.

Circle No. 110 on Subscriber Service Card.

AMPLIFIER. 400 and 60 cycle magnetic amplifier data and specifications are given in a 16 page Product Catalog from Litton Industries.

Circle No. 111 on Subscriber Service Card.

JOINTS. Rubber, neoprene and Teflon-lined expansion joints their construction, sizes and uses are explained in a bulletin issued by The Garlock Packing Co.

Circle No. 112 on Subscriber Service Card.

VIBRASWITCH. A device that protects rotating and reciprocating machinery by anticipating any malfunction, is described in a four page bulletin available from Fielden Instrument Division of Robert Shaw-Fulton Controls Co.

Circle No. 113 on Subscriber Service Card.

TRANSFORMERS. A new four-page brochure describing a line of military and special commercial transformers has just been released by Laboratory for Electronics, Inc. and describes, high power pulse, hermetically sealed military and open type military, subminiature binary and toroids.

Circle No. 114 on Subscriber Service Card.

HITEMP WIRE. Characteristics of Altemp Teflon high-temperature, insulated hook-up wire and contained in Catalog T-1 available from Alpha Wire Corp.

Circle No. 115 on Subscriber Service Card.

SOLENOID COIL. Folder 210-3 issued by Hays Manufacturing Co. describes its "Kast-Coil" waterproof, shock-resistant solenoid coil.

Circle No. 116 on Subscriber Service Card.

Advertisers Index

TAKE ADVANTAGE OF MISSILES AND ROCKETS NEW SUBSCRIBER SERVICE

DO YOU WANT MORE INFORMATION ABOUT NEW MISSILE AND ROCKET PRODUCTS?

All you do is circle the number on the card to the right that corresponds to the number following the items mentioned inside this magazine.

DO YOU WANT MORE DETAILS ABOUT THE ADVERTISED PRODUCTS OR SERVICES IN MISSILES AND ROCKETS?

These data are yours for the asking. Just circle off the proper number indicated below or next to the particular advertisement you want to know more about. Your request for information will be forwarded promptly to the companies concerned.

MAIL YOUR SUBSCRIBER SERVICE CARD

Today

MISSILES AND ROCKETS

MAY, 1957

Expires 30 Days After Above Date

NAME________

TITLE/POSITION________

COMPANY________

ADDRESS________

CITY________ ZONE____ STATE____

Card cannot be processed unless all information is given.

CIRCLE NUMBERS BELOW FOR INFORMATION ON PRODUCTS, LITERATURE OR ADVERTISEMENTS

• • **Advertisements**

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50

• • **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

NO POSTAGE STAMP NECESSARY IF MAILED IN THE UNITED STATES

POSTAGE WILL BE PAID BY ADDRESSEE

BUSINESS REPLY CARD

First Class Permit No. 2455-R (Sec. 510 P.L.&R.) Washington, D.C.

AMERICAN AVIATION PUBLICATIONS

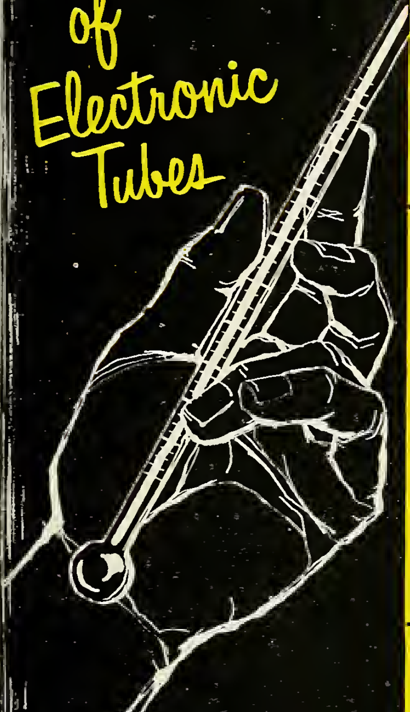
17 EAST 48TH STREET,

NEW YORK 17, N. Y.

SUBSCRIBER SERVICE DEPT.

LIQUID COOLING

of Electronic Tubes



WITH Eastern COOLING UNITS

By a sustained program of research, Eastern continuously extends the uses of the latest units in electronic tube cooling, pressurizing electronic equipment, and pumping fuels and hydraulic fluids. Research and testing laboratories, a model shop, and three manufacturing plants provide the specialized equipment and manpower to turn out fully qualified units to meet appropriate government specifications.

From our extensive line of existing units, adaptations of these units, or completely new designs, Eastern can provide equipment to handle your project well. Your inquiry is welcomed.

EASTERN AVIATION PRODUCTS

EASTERN INDUSTRIES, INC.
100 SKIFF STREET
HAMDEN 14, CONNECTICUT

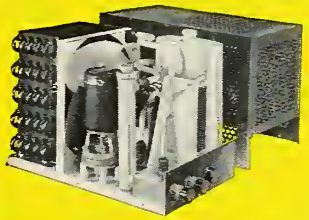
Eastern Cooling Units provide coolant liquid for maintaining within safe operating temperature limits liquid cooled electronic tubes or similar devices. The units are completely self-contained and usually comprise such components as heat exchangers, fans or blowers, liquid pumps, reservoirs, flow switch, thermostat, etc.

Cooling units can be modified as required for varying conditions encountered in land or sea as well as aircraft service. Almost all units are designed to meet such specification as MIL-E-5400 and MIL-E-5272.

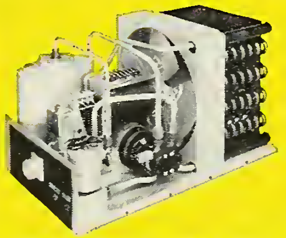
The units shown below are intended only to illustrate the varying requirements which can be satisfied. By utilizing fairly standard components and designs based on broad experience in this field, Eastern is able to provide at minimum cost equipment exactly suiting a specific requirement.

Eastern welcomes your consultation on liquid cooling problems ranging from 200 to 20,000 watts dissipation.

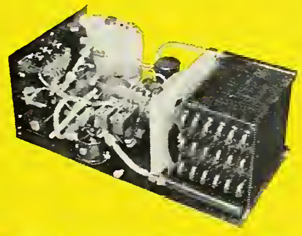
Write for Aviation Products Bulletin 350.



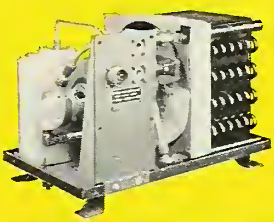
MODEL MB-175, TYPE 200 DISSIPATION: 2,000 watts. ALTITUDE RANGE: sea level to 50,000 feet. POWER REQUIRED: 28 volts D.C. WEIGHT: 25 pounds. SIZE: 10" x 15-15/16" x 10¾" high.



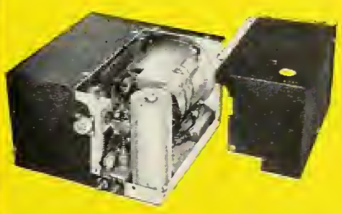
MODEL E/HT-205, TYPE 200A DISSIPATION: 1600 watts. ALTITUDE RANGE: sea level to 5,000 feet. POWER REQUIRED: 28 volts D.C. WEIGHT: 25 pounds. SIZE: 10" x 21" x 10" high.



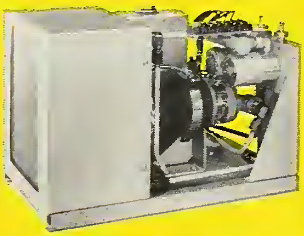
MODEL MB-177, TYPE 202 DISSIPATION: 1700 watts. ALTITUDE RANGE: sea level to 50,000 feet. POWER REQUIRED: 110 volt, 400 cycle, 3 phase. WEIGHT: 27 pounds. SIZE: 10" x 19 15/32" x 7⅝" high, per JAN-C-1720A, size B1-D1.



MODEL E/HT-210, TYPE 200 DISSIPATION: 1500 watts. ALTITUDE RANGE: sea level to 10,000 feet. POWER REQUIRED: 208 volts, 400 cycle, 3 phase. WEIGHT: 35 pounds. SIZE: 11¼" x 19½" x 12½" high.



MODEL E/HT-200, TYPE 201 DISSIPATION: 1,000 watts. ALTITUDE RANGE: sea level to 50,000 feet. POWER REQUIRED: 28 volts D.C. WEIGHT: 14½ pounds. SIZE: 10" x 10" x 6" high.



MODEL NO. 5-A DISSIPATION: 1,000 watts. ALTITUDE RANGE: sea level to 5,000 feet. POWER REQUIRED: 100 to 110 volts D.C. WEIGHT: 10 pounds. SIZE: 7⅞" x 13½" x 9-1/16" high.