m/r JUNE, 1957

EXPERIMENT INCORPORATED.

missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS

AN AMERICAN AVIATION PUBLICATION

In This Issue:

NUCLEAR POWER AND ION PROPULSION

"FOLLOW THROUGH"

During more than ten years of pioneering the use of structural adhesives and laminating materials, Narmco has found that the airframe and missile manufacturer requires much more than the simple delivery of materials to his receiving department. He expects more . . . and rightly so! In today's complex business of producing supersonic aircraft and missiles, close supplier-user cooperation is essential. That's why Narmco has developed, and continues to emphasize as a policy, the use of "control" records for every customer . . . no matter how large or small.

Although Narmco inspects and tests products 100% . . . with over 27 separate checkpoints established in the production lines for performing precise, in-process and final control tests . . . Narmco goes even farther in its efforts to provide the ultimate in "down to earth" quality assurance to its customers. Generous physical samples of all Narmco production . . . structural adhesives . . . laminating materials . . . coating solutions and coated materials . . . and putties and resins are randomly selected during production and retained a minimum of 90 days after every shipment.

This makes it possible to provide the customer sample characteristics data on the specific material he received. This procedure affords the manufacturer an important "follow through" service in analyzing his own handling, storage, and use of the product and has frequently resulted in direct savings in manhours and materials when solving "stubborn" production control problems.

This unusual customer service "plus" is another important element in Narmco's assistance to the manufacturer . . . another reason why more and more Narmco products are being used in the airframe and missile industry . . . *doing jobs every day that metals alone can't do!*

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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 . . .

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missiles and rockets

Magazine of World Astronautics

June, 1957 Volume II, No. 6

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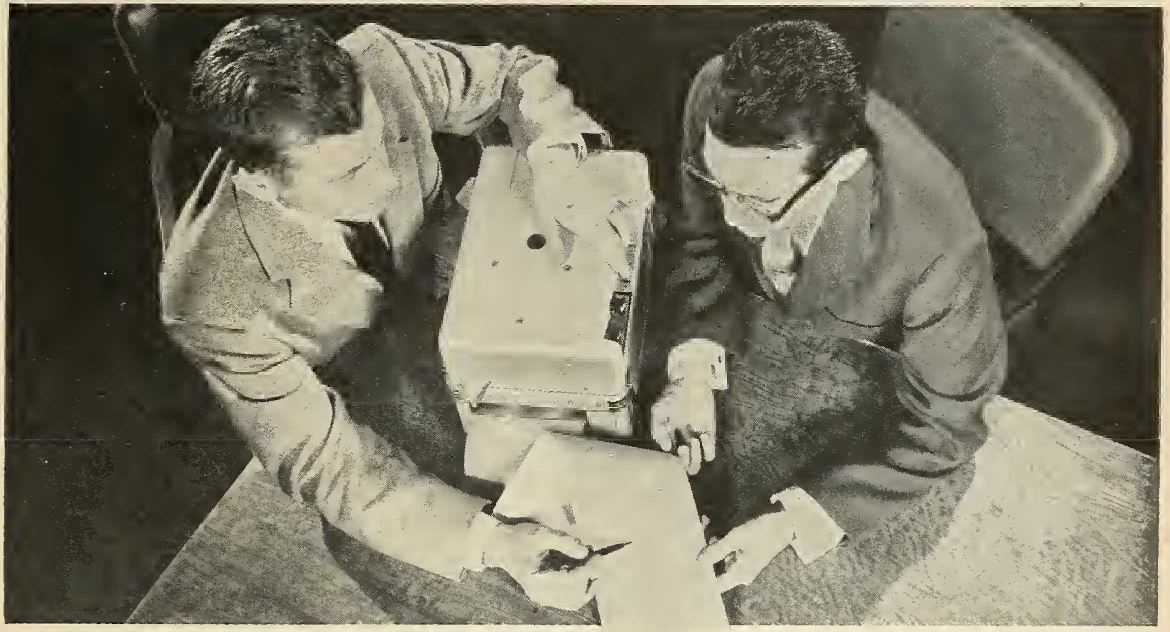

We're sure, once you've seen the fabulous new Visicorder demonstrated, that you'll be as enthusiastic as the thousands of others who have watched the Visicorder in operation.

That's why we're inviting *you* to be the judge . . . to call your nearest Honeywell Industrial Sales Engineer.* He will set up a Visicorder demonstration in your office, plant, or laboratory . . . at your convenience.

The Visicorder, in the short months since its introduction has become the most wanted oscillograph in America. Why? Because the Visicorder records at frequencies from DC to 2000 CPS, with sensitivities that compare to photographic oscillographs. Because the stable, direct-reading Visicorder records are reproducible, and permanent under ordinary usage. Because the Visicorder bridges the gap between mechanical direct-writing oscillographs and photographic-type instruments.

So accept this invitation: Call your nearest Honeywell Industrial Sales Engineer today. He will arrange for you to operate the Visicorder yourself so that you can see for yourself how the Visicorder fits your most complex recording application.

also ANNOUNCING . . .

The high-frequency Visicorder galvanometers have been redesigned to provide sensitivity improvements as great as 4 times, and a new 1000-cycle galvanometer has been added. All high-frequency galvanometers shipped after March 15 are to the new specifications.

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*Visicorder demonstrators are now based in these Honeywell Industrial Sales Offices: Albuquerque • Atlanta • Baltimore • Boston • Buffalo • Cleveland • Dallas • Dayton Denver • Detroit • El Paso • Hammond, Ind. • Hartford • Long Island City • Los Angeles • Omaha • Pittsburgh • Philadelphia • Richmond • San Diego • San Francisco Seattle • St. Louis • Syracuse • Toronto, Ont. • Union, N. J. • Washington D. C. • Amsterdam, Netherlands • and more on the way.

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New E-I transistorized plug-in modules give maximum flexibility for custom applications with standard off-the-shelf modules.

This latest E-I development provides the maximum versatility in digital instrumentation. From a few basic modules a host of instruments can be constructed. Basic modules never become obsolete. To do new jobs, simply add new modules. Equipment can be easily kept current at minimum cost and engineering.

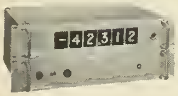
But versatility is only part of the story. These new modules also boast dramatically new engineering specifications, fully transistorized circuits and numerous other features which were incorporated as the result of our experience with more than 1,000 digital instruments in the field.

Your E-I representative has complete information on this latest E-I development. Ask him about it...today!

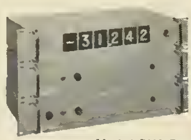
Any precision instrument for measuring DC, AC-DC, Ohms, DC and AC ratios can be constructed from these five basic units!

whether it be a DC digital voltmeter...

Model DVA-500



an AC-DC digital voltmeter...

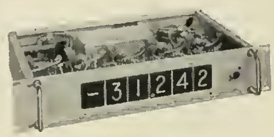


Model DVA-510

or a complete check-out system.

BASIC MODULES

Universal Power Module
Supplies all power and reference voltages for other E-I modules. Power and reference supplies and stepper drive amplifier are transistorized. Powers one or more modules. Automatic calibration; stability of 0.01% from 40° to 125° F.; input power: 115 volts, 50 to 400 cycles.



DC Switch Modules, 4 or 5 digits
Visual in-line read-out of digits, polarity, decimal point. All contacts accessible at rear panel connector. Front and rear panel input connectors. Power supplied by Universal Power Module.

DC Pre-Amp Module
Input: 1 range scale, gain of 10.
Output: 0.001 to .9999 volts.
Linearity: 0.01%.
Gain Multiplication Accuracy: 0.01%.
Input Power: 115 volt, 50 to 400 cycles.
Orift: 10 microvolts per hour.

AC — DC Converter Module
A fully transistorized AC — OC converter.
Accuracy: 0.1% of reading, or 2 mv.
Frequency Response: 30 to 10,000 cycles.
Range: .0001 to 999.9 volts.
Zin, AC: 1 meg. on the 1 volt scale, 10 megs. on other scales; 20 mmf.
Ranging: Automatic
Reading Time: 3 seconds, average.

Resistance Switch Modules, 4 or 5 digits
Contains balance circuit, bridge ratio arms. Provides visual in-line read-out digits, range. All contacts accessible at rear panel connector. Power supplied by Universal Power Module.

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A TYPICAL INTRICATE JOB

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You have the largest facilities exclusively devoted to your guided missile and rocket hardware problems at Diversey Engineering. In missile metal machining we know what works and what won't. Contact us on your intricate jobs.

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This is Not the Time to Cut

Three years ago the U.S. did not have a ballistic missile and none was in sight.

Just lately the Army's intermediate range ballistic missile, *Jupiter*, went the full distance of its immediate objective—1500 miles. It was the first long range U.S. ballistic missile to do so.

The USAF inter-continental ballistic missile, *Atlas*, sits on its launching pad, ready for a first try at the 5000-mile mark. The more sophisticated *Titan* has cut months from its schedule and is reported to be almost as far along as *Atlas*.

Within the next fiscal year these super-weapons should begin to be fed into America's arsenal. Without doubt they represent the greatest contribution to deterrent military power since the original concept of the USAF Strategic Air Command a decade ago.

This state of the ballistic missile art and science has been achieved in fewer than 36 months from the original go-ahead. It is truly a remarkable and commendable record.

But—

Just at this critical time when the results of a crash program of achievement are being realized, the entire missile program is endangered by an economy ax wielded by Congress.

The same Congress that "viewed with alarm" and gave its wholehearted all-out approval to the crash missile program only several years ago, is now in the mood to chop off the program during its crowning period of producing tangible results.

The same Congress that urged duplication of effort in order to obtain maximum results with greatest speed, is now concerned about overlapping of missile efforts.

Industry accepted the challenge three years ago. And it was only through duplication—permitting several simultaneous approaches to the problem—that ballistic missiles have reached their present stages of development in such a short space of time.

There are times when economy is extremely shortsighted. This is one of them. It would be foolhardy to trim at this crucial juncture of missile development. It would be like calling off a race in the last tenth of a mile simply because one or two horses stopped running.

Except that the missile race is not a horse race. This is no sports event. We are participants in a world-wide struggle for survival. And the struggle for survival leaves no margin of error for whims or budget-cutting for political purposes. There is no margin left in this struggle for anything except actual achievement in missile power.

Wayne W. Parrish

typical data presentation

of Spectrum Recorder. Instrumentation consisted of Accelerometer, Vibration Pickup Preamplifier, and Spectrum Recorder.

CONVAIR CUTS JET LINER ENGINEERING TIME WITH AUTOMATIC SOUND INSTRUMENTATION

The noise problems of the jet age are receiving special attention in development of the Convair 880. Materials and components are being tested for acoustical properties in a new Sound Laboratory using Brush-Bruel & Kjaer instrumentation.

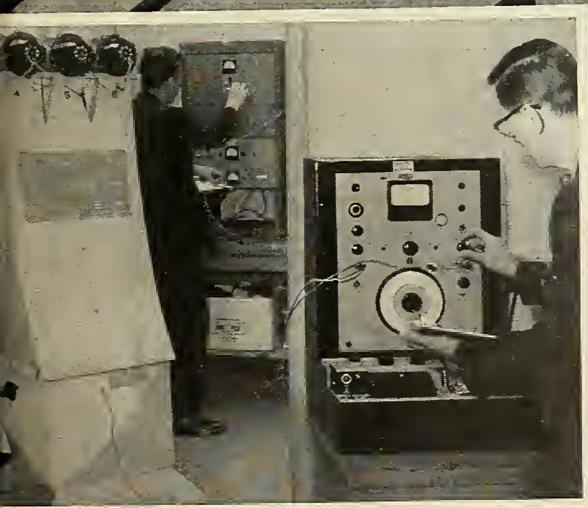
Here the unique Brush Spectrum Recorder performs a complete frequency-spectrum analysis on sounds from 14 to 36,000 cycles per second. Chart records, in one-third octave steps, provide data in most useful form to achieve desired results. **And this instrumentation, operating automatically, saves hours of engineering time.**

Brush-Bruel & Kjaer instruments are available in complete systems for analyzing sound-noise-vibration. Let us help *you* eliminate undesirable noise.

strain measurements speed up field tests

Here Allis Chalmers uses Brush Analyzers and Oscillographs to record variables such as weight and hydraulic pressure variation, drawbar load, axle torque, etc. ***Brush Oscillographs maintain accuracy in such rugged use, provide immediately available chart records to save engineering time.*** Described in booklet "Strain Recording".


DANGER
NO SMOKING



Powerhouse of America's major missile programs

Every day at ROCKETDYNE'S Propulsion Field Laboratory, deep in California's Santa Susana Mountains near Los Angeles, rocket engines developing millions of jet horsepower are tuned and tested for their ultimate job—to power America's long-range missiles.

These high-thrust engines—developing more propulsive power than anything before produced—are moving on schedule from ROCKETDYNE for delivery to the Armed Forces. By fall of this year other high-thrust production engines will flow from another plant now being activated by ROCKETDYNE in Neosho, Missouri.

As today's engines are being delivered, ROCKETDYNE engineers are constantly pushing ahead—evolving dramatic boosts in power outputs and engine performance.

This kind of tomorrow-minded engineering—conducted in a private enterprise system—is a keystone in the defense structure of the free world.

As an engineer, you could find no more challenging and rewarding field than Rocketry. Write: ROCKETDYNE, Personnel Manager, Dept. MAR-72, 6633 Canoga Avenue, Canoga Park, Calif. or Dept. MAR-72, Neosho, Mo.

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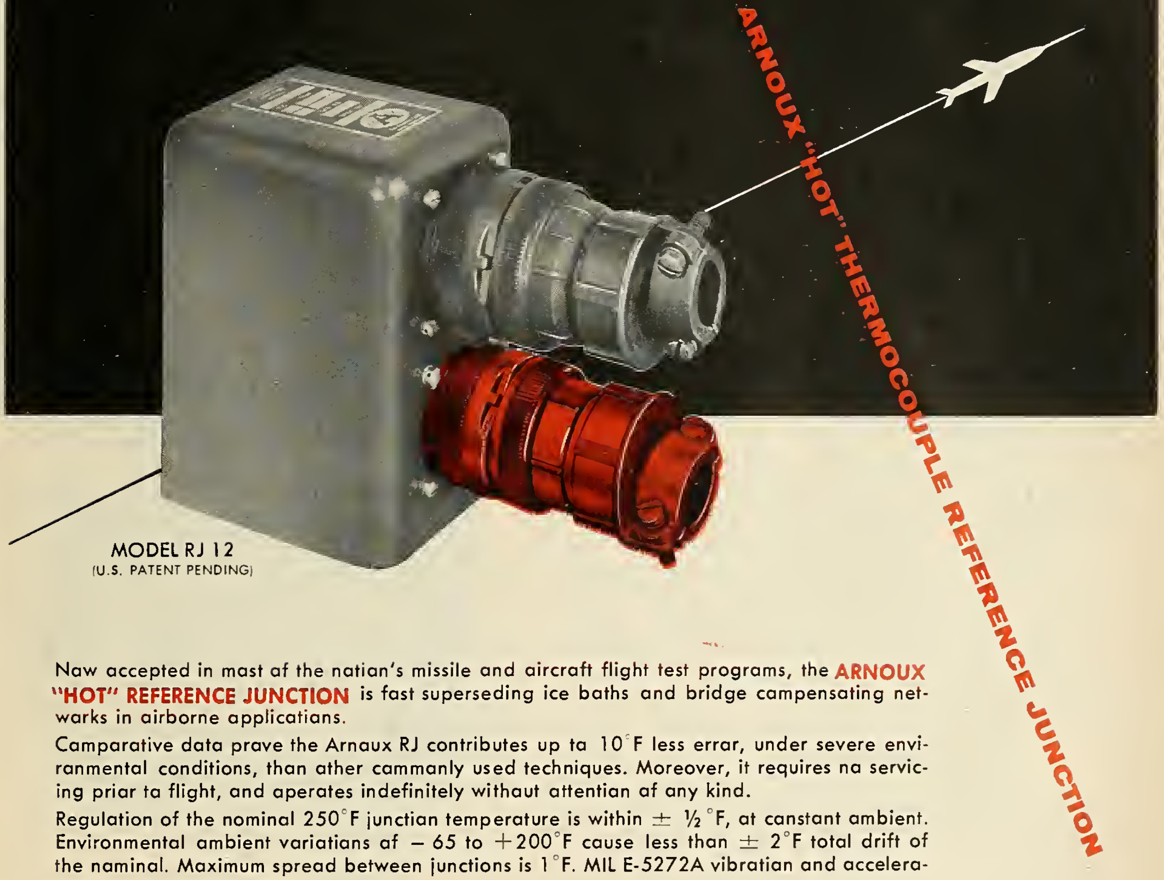

MODEL RJ 12
(U.S. PATENT PENDING)

Now accepted in most of the nation's missile and aircraft flight test programs, the **ARNOUX "HOT" REFERENCE JUNCTION** is fast superseding ice baths and bridge compensating networks in airborne applications.

Comparative data prove the Arnoux RJ contributes up to 10°F less error, under severe environmental conditions, than other commonly used techniques. Moreover, it requires no servicing prior to flight, and operates indefinitely without attention of any kind.

Regulation of the nominal 250°F junction temperature is within ± ½°F, at constant ambient. Environmental ambient variations of − 65 to +200°F cause less than ± 2°F total drift of the nominal. Maximum spread between junctions is 1°F. MIL E-5272A vibration and acceleration cause negligible error.

Operation of the RJ is simple. Thermocouple leads are soldered to the SPECIAL RED AN INPUT CONNECTOR containing pins of thermocouple alloy. Copper output and power leads are soldered to the STANDARD AN OUTPUT CONNECTOR. Special conversion tables for 250°F junction correction are furnished.

Airborne models available in 2, 4, 8 and 12 channels for use with any thermocouples specified. Size: 3" x 3½" x 4¾". Weight: 1¾ lbs. Power: 28V DC, 15 Watts.

Rack mount models also available for ground applications, with capacities of 24, 48 and 72 channels. Power: 115 V AC, 60 cps.

Get the facts . . . write for APPLICATION NOTE RJ1001, a frank analysis and comparison of the three common reference junction techniques.
For more about the Arnoux RJ, ask for Bulletin 400.

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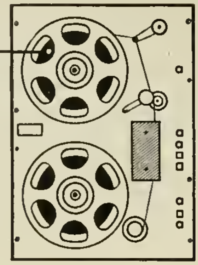
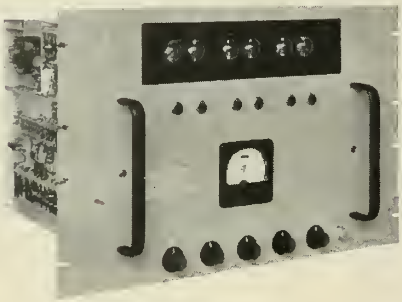
HYCON EASTERN introduces

RAPID ACCESS



IN ANALOG DATA REDUCTION SYSTEMS



Two companion units by Hycon Eastern provide automatic high-speed access to selected data in Ampex Recorders and similar multi-channel magnetic tape instrumentation systems.

For Tape Indexing

DIGITAL TIMING GENERATOR, Model 201, generates numerically coded timing signals which are recorded on the magnetic tape throughout the data recording periods, providing a precise digital index in terms of elapsed time. The Generator also visually displays the exact time in hours, minutes and seconds as illuminated digits. MODEL 206A, A MINIATURIZED VERSION OF MODEL 201, IS SPECIFICALLY DESIGNED FOR AIRBORNE USE.

For Tape Search

MAGNETIC TAPE SEARCH UNIT, Model 202, operates during data reduction periods. On the basis of time indices recorded on the tape by the Digital Timing Generator, this instrument automatically locates and selects for controlled playback the tape data included between a "sequence start time" and a "sequence end time" specified by panel dial settings. The time index is visually displayed as illuminated digits on a small separate panel which may be remotely located for convenience.

DESIGN FEATURES

TIMING INFORMATION occupies only a part of the available bandwidth on a magnetic tape channel . . . remaining bandwidth in timing channel may be used for other purposes; e.g. to record other digital or analog data, or as a voice channel.

TAPE SPEEDS of 60, 30, 15, 7½, 3¾ or 1⅞ inches per second may be used for recording. For playback, any one of these 6 speeds or a high-speed search rate may be used. Other speeds may be incorporated as required.

TIMING TRACK contains a combination of complete time numbers in hours, minutes, and seconds together with interpolation pulses so that time can be measured with a resolution of a few milliseconds.

ADDITIONAL SIGNALS for recording, recovery and display may be assigned to arbitrary control functions in the data system.

FORWARD OR REVERSE directions may be used for tape search at either the high-speed search rate or any one of the 6 normal record play back speeds.

MOUNTS in any RETMA standard 19" relay rack.

Write for Technical Bulletin TSG-O

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Ultra Stable Oscillators
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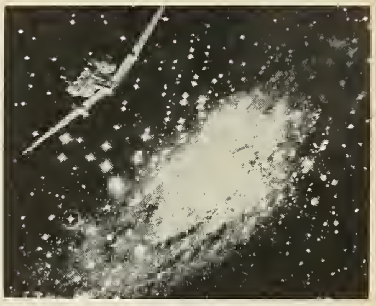

En route to another galaxy! Japanese artists Yasumasa Miyazaki and Toshihiko Sato are famous for their illustrations in the field of astronautics. The cover picture illustrates a combination chemical rocket and nuclear rocket vehicle in outer space. Other outstanding illustrations by these Japanese artists appear on pages 78, 82 and 87. They all have the futuristic look that may be indicative of tomorrow's space vehicles.

columns

departments

photo credits:

Yasumasa Miyazaki and Toshihiko Sato, cover, pp. 78, 82, 87; Martin, pp. 39, 40; Rene St. Paul, pp. 42, 43; Krafft A. Ehricke, pp. 63, 71; SNCAN, p. 43; U.S. Army, pp. 64, 66, 67, 108, 126, 128; U.S. Air Force, pp. 118, 119; Westinghouse, pp. 73, 74; Convair, p. 88; Alfred J. Zaehringer, pp. 94, 184; Seabrook Hull, pp. 94, 103, 104, 184; Chrysler, p. 107; Boeing, p. 122.

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JUNE

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 Mtg., Biltmore Hotel, Los Angeles, Calif., June 17-20.

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

Soviet National Aviation Day, Moscow, June 24.

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.

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

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

SEPTEMBER

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

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

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

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

OCTOBER

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

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

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

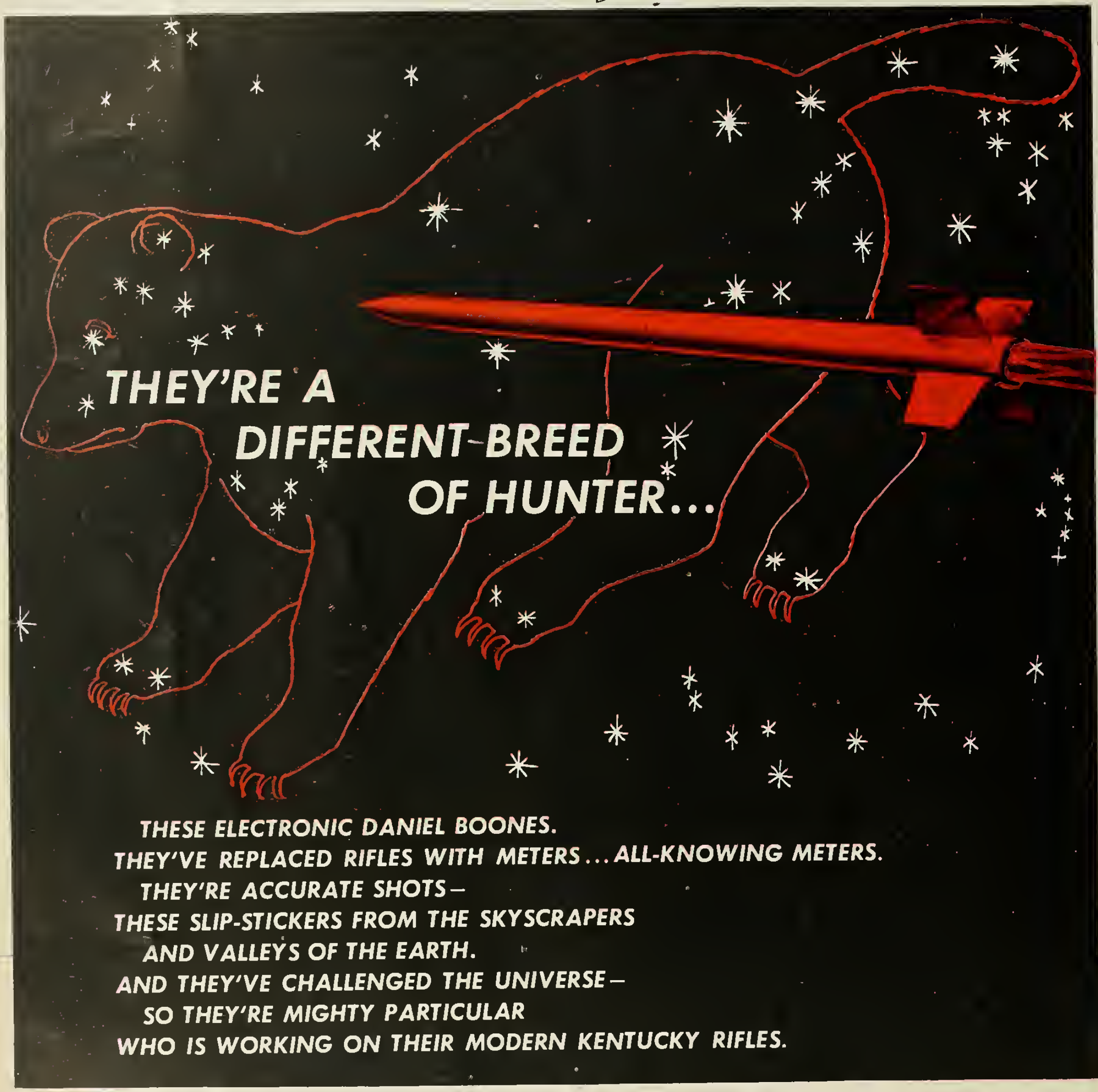
National Fall Convention, Society for Experimental Stress Analysis, El Cortez Hotel, San Diego, Calif., Oct. 9-11.

ASME Conference on New Developments in the Field of Power, Americus Hotel, Allentown, Pa., Oct. 21-23.

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

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

I CILLED A BAR. D. BOON



We at SUN ELECTRIC CORPORATION have had 30 years of accuracy and dependability in building electric, electronic and hydraulic test equipment in fields as exciting as theirs—but in the true nature of the hunter—they were skeptical.

Now in missiles and rocket development, the reliability—the accuracy of SUN Equipment has proved our ability to meet and pass the exacting challenge they put on those who would make their weapons for conquering the universe.

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letters

Would-Be Rocket Engineers Again

To the Editor:

I am concluding my junior year in high school and have been greatly interested in rockets for about 6 years. (My highest dream is to some day be along on the first flight to the moon or some near-by planet.)

I think I am most interested in propulsion and would like to do research on new types of rocket propulsion, or try to perfect today's fuels. I have tried to prepare myself for such work by following high school outlines for most technical or engineering schools. I am very much perplexed on deciding what to major in in college to prepare myself for work in this field.

Aeronautical engineering, physics, engineering science and chemical engineering has all been suggested to me. As a guidance project we are to write to some known expert and ask for advice on our own problem. So, after reading your book I chose you to write to. If you find time to return a letter I would like to know what special field you would suggest I study in college.

As to college I am considering MIT and hope I will be accepted. I have maintained a straight A average in all subjects and have participated in extra curricular activities, such as: baseball, football, basket ball, German Club and others.

I would very much appreciate an answer to the previous questions and if you approve my selections of colleges. Since I could only attend MIT on some sort of a scholarship, I am considering Case Institute of Technology and Carnegie Institute of Technology.

If you know of any others I would appreciate hearing of them.

David Bonn
Deshon Manor
Butler, Penna.

You are one of many thousands of American youngsters with a common problem. If you are 17 years old you can and should join the American Rocket Society as a student member. Write to them for information. The address is American Rocket Society, 500 Fifth Avenue, New York 36, N.Y. Do not hesitate to write to the universities mentioned in your letter, such as MIT and Purdue. Also, why not try Johns Hopkins? We are preparing a special issue on education and training for the missile age, to be published this fall. We hope this will be of value to you. Our personal advice—while you are waiting for the first moontrip—concentrate on mathematics and chemistry.—Ed.

Says He Thought Of It First

To the Editor:

I noted Winzen's comments on the introduction of the Balloon-Launched Rocket in 1947. In a rather science-fictionish article titled "Electronics & Airpower" which ran in the September-October-November, 1944 issues of "Radio-Craft," I made a similar suggestion. Why are not rockets lifted by balloons to 15 or 20 mile heights and then triggered off by aneroid type detonators to send them up another 10 or 20 miles.

This was probably never seen by rocket men, but it looks like it was a pretty good question at that, even though I should have said "100 or 200 miles."

Ted Powell
42 Nassau Rd.
Great Neck, L. I.

Missile Help for High Schools

To the Editor:

Under letters I notice correspondence on high school rocket courses with kudos for the University of Maryland. We have a program under way in which twelve local high schools are participating. I think it's important to interest high schools in rocket work and other scientific work and provide opportunities for them. Maybe m/r can sparkplug such projects.

The item on Page 52, about the Russian drawings of the *Mouse* satellite are of interest to me and I'm glad to know that they are giving me credit . . . Your whole series about underwater missiles is excellent and I can't praise it enough . . .

S. Fred Singer
University of Maryland
College Park, Maryland

A Need for m/r

To the Editor:

I have recently seen your magazine and I would like to let you know that I feel it is very informative and that there is a definite need for it in the missiles and rockets field.

N. E. Miller
Murphy & Miller, Inc.
1326 S. Michigan Ave.
Chicago 5, Ill.

Donner and Blintzon

To the Editor:

We have followed with interest the correspondence in your journal on the subject of the acceleration in free fall of Lintz basalt. We feel obliged to draw to your attention the fact that in the particular case of this phenomenon the Russians may have scored a first. Whereas the paper of Brush, allegedly pioneering the work in this field, appeared in the Proceedings of the American Philosophical Society, Vol. 65 (April 23, 1956), we must report that in the journal Soviet Transactions on Basalt Science, Vol. 17 (April 1, 1924), not only was the constant generation of heat in Blintz basalt reported as exceeding that which is possible from radioactive effects but also the acceleration of Schmaltz basalt was recorded as having been measured at 994.4 cm/sex² (for samples of Schmaltz basalt 99 and 44/100 per cent pure). Furthermore, for samples of Schmaltz basalt 99 and 77/1000 per cent pure the acceleration was reported to be 997.7 cm/sex².

Soviet experiments on these materials were prematurely discontinued (probably due to a grave shortage of Soviet Schmaltz basalt).

It may be pertinent to record, moreover, that the writers have examined the possibility of a quantitized theory which may bear upon inertial and gravitational equivalence in the light of the reported data. We obtain a satisfactory field theory, in agreement with the experiments, provided we postulate a graviton (the Blintzon) and an anti-graviton (the Schmaltzon) for which, in the classical limit, the following results hold: First, there are equal numbers of Blintzons and Schmaltzons in the universe. Second, the equivalence principle of gravitational and inertial mass is valid except for mass in which the parity principle for Blintzon and Schmaltzons is violated. (This seems to be the case for the material used in Brush's experiments.) Third, anti-gravitation is possible only for sufficiently pure Schmaltzy material.

We are presently concerned with the corresponding calculations for Blintz basalt but are not yet prepared to communicate our preliminary results.

R. M. Baer
Dept. of Mathematics
D I. Caplan
Dept. of Physics
Purdue University
Lafayette, Indiana

We appreciate the author's interest in m/r but feel we should point out to them that in their deliberations they completely overlook the catalytic effects of a colloidal suspension of emulsified butyrates in proteinaceous-lactic acid medium which was reported by Kreplach and Bupkiss in the Journal of Comparative Oblivion, Vol. XXX, June 31, 1919 —Ed.

Anomalies on Lintz Basalt

To the Editor:

I have read all the letters dealing with Lintz Basalt with considerable interest and a bit of astonishment.

I cannot help but feel glad that your attitude with respect to the whole "anti-gravity" run is a good one. I think you will be interested in the following and I hope that this will contribute somewhat to a critical look at this question:

Concerning gravity—anomalies on Lintz Basalt.

For a critical consideration of such anomalies claimed to have been observed on Lintz Basalt it is, of course, sufficient to apply the Newtonian concept of gravity.

Isaac Newton in 1687 gave the quantitative relationship for gravitational interactions: $F=GMm/r^2$, where F= Force, $G = 6.68 \times 10^{-8}$ dyne, the universal constant of Gravitation, M= the mass of the earth, r= the earth's radius and m= the mass of the test body. The three factors, G, M and r (the minutest changes of r in experiments with pendulums or falling bodies can be ignored) are constant and can therefore be symbolized by one factor, $g = GM/r^2$. The formula for F now reduces to F=gm, which is the force of the earth on a body on its surface, commonly called weight, or seen from another aspect, a fundamental formula of mechanics. This last formula shows that the acceleration g of a falling body is determined only by these three factors, G, M and r, and is therefore independent of its mass m.

The radius of the earth is known with a remarkably high degree of accuracy. The change of g with varying altitude, respectively the acceleration g_a is given at an altitude a by: $g_a = g(1 - ka)$ where g is the acceleration at sea

Guidance system check out equipment program for the Army Redstone Missile was carried out by DFI. Actual equipment illustrated below

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A very small error in guidance, though, means a very large error in target accuracy. So a precise, highly reliable test system for "guidance check-out" had to be developed.

And it's no accident that Designers for Industry was given the responsibility of producing this vital check-out system. During our 22 years, we've built a reputation for performance on many projects critical to national defense. The unusually tight schedule set by the Army for this program was met by closely coordinated teamwork between Chrysler and *DFI.*

Unusual results were achieved beyond the immediate program requirements. For example, as part of a complete A.C.-D.C. Power Supply, a special control for a standard rotary inverter was needed. This new control gives *regulation of 30 parts per million* at 400 cycles under steady load – and feed or absolute regulation of 0.05 cycles in 400 under varying load and feed.

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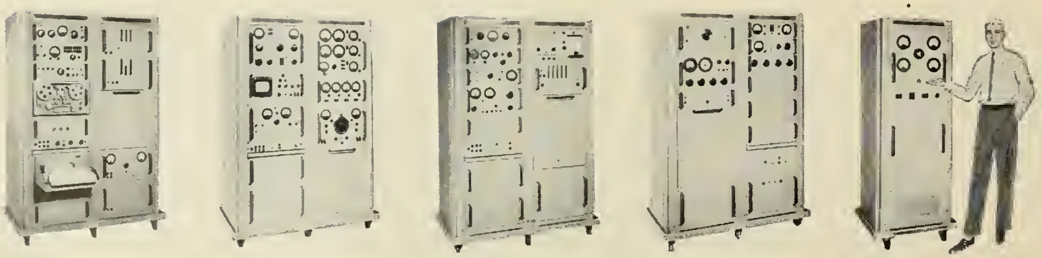

Representative samples of test equipment produced by DFI

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level and k is a factor of proportionality, approximately = 3.10^{-7}, that is, if the weight of 1 kilogram is raised 1 meter, the change in weight is .3 milligrams. For weighing experiments of utmost accuracy it is therefore necessary that the two masses be arranged at exactly the same level. On the other hand, by arranging alternately the two masses at different levels, the factor k can be determined accurately.

G and respectively g are determined with torsion balances (such a torsion balance was used in 1798 by Cavendish for the first determination of G), pendulums, balances and gravimeters. Gravimeters (today mainly used for geophysical explorations, e.g., of oil fields) are in principle spring balances of extremely high sensitivity, the measuring system of which weighs only some grams or fractions of a gram.

Newton showed with pendulum experiments that for a given length of the pendulum, g or the swinging time, was independent of the material of the bob. The accuracy of his experiments was about 1 part in 10. F. W. Bessel, (1), improved the accuracy of these measurements to about 1 part in 10^5 and obtained the same results, that is, no influence of the material on g could be measured. R. V. Eotvos (2) and coworkers (3) improved the accuracy of the torsion balance used by him to such a degree, that G respectively g could be determined with an accuracy of 1 part in 10^9. All his measurements showed that g is not influenced by different kinds of substances, e. g., metals, liquids, organic substances etc. Furthermore he showed that g is not influenced by the radioactivity of the test material. He too showed that the "absorption" of the earth along its axis with respect to gravitation would be less than 1/800 of the total attractional force of the earth. Q. Majorana, (4) obtained the same results.

(5) It was claimed by Ch. F. Brush, based on experiments, that the proportionality or identity between gravitational and inertial mass was not fulfilled; or what is the same, an influence of the material, for example Bismuth crystals of the test body, was present on g. However, it was shown by H. H. Potter & P. Philipps, (6), Wilson (7) and A. Berroth (8) that these claimed discrepancies or results were erroneous. Furthermore. P. R. Heyl (9) showed that the gravitational interaction of cystals: Quartz, Zirconium, Turmalin, Gypsum etc. was independent of the orientation of the different crystal axes. P. Zeeman (10) obtained the same, that is negative results, with spheres made of natural quartz crystal, P. Landolt (11) on the other hand could show that no influence existed of chemical changes on the gravitational interaction. Finally, E. W. Shaw and N. Davy (12) proved experimentally that there is no influence of temperature on the gravational interaction. The discrepancies in some of these experiments were all of a minimum magnitude, i.e. less than about 10^{-8}.

Keeping in mind these experimental facts and referring again to the two formulas, there remains only one very hypothetical possibility for the discrepancies claimed by Ch. F. Brush, and that is a change of G.

P. M. Dirac (13, 14) proposed the hypothesis that G is not a constant but undergoes a variation in magnitude with

letters

respect to time. However, such changes were supposed to occur only during cosmic times. P. M. Dirac discarded his theory in later publications, thinking it too extreme. P. Jordan (15) and many other cosmologists used this concept of a variable "constant" of gravitation, but only for purely theoretical considerations and theories. Therefore this concept is out of the question for short-time measurements of G and g.

Finally, such a gravity anomaly as is claimed to occur on Lintz Basalt would be a contradiction to the observed, measured and so empirically proven identity between gravitational and inertial mass. This identity represents the fundamental concept of the general theory of relativity or the Einsteinian theory of gravitation and expressed in his principle of equivalence. A. Einstein explained this principle in a more condensed and simpler form: gravitational and inertial interactions are determined by the same characteristic of matter, that is mass.

It would be difficult to deduce and describe why this same factor mass should behave in a different manner with respect to gravitational and angular or linear accelerations.

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W. J. Lohninger
Weston Electrical Instruments Corp.
Newark, N. J.

Missile Literature

To the Editor:

I am intensely interested in the field of missiles and rockets.

Would it be possible for you to supply me with a list of books along with publishers and any other literature that is available pertinent to the subject.

Charles Gurney, Jr.
101 Grant Court
Olean, N. Y.

Contact General Astronautics Corp., Oyster Bay, L. I. They specialize in this sort of thing.—Ed.

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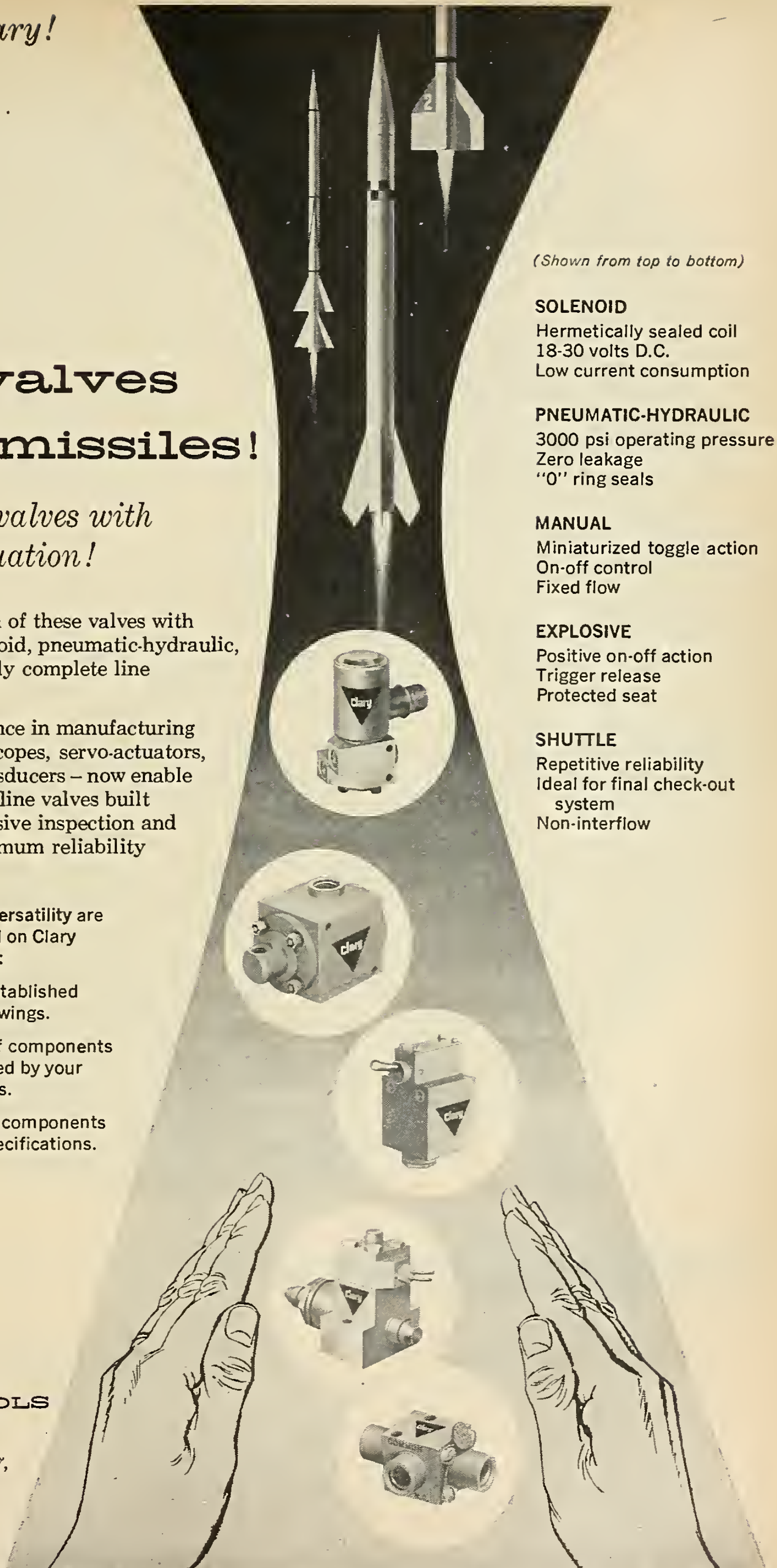

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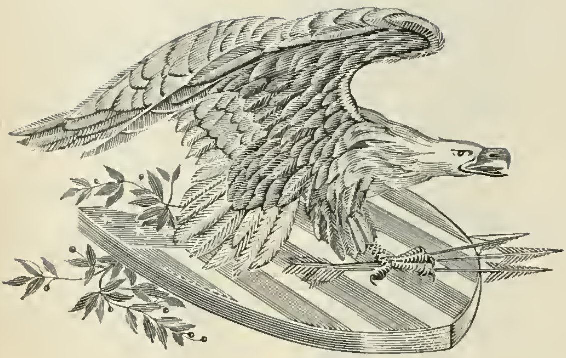

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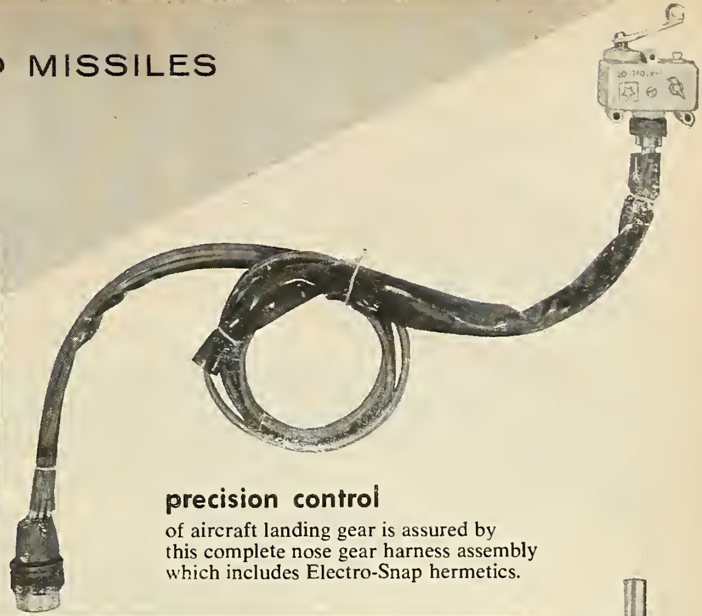

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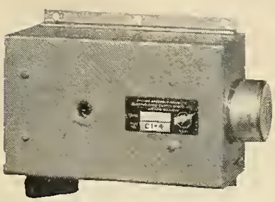

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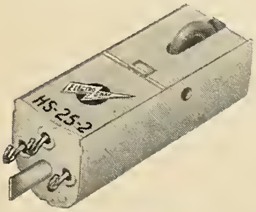

rocket safety switch

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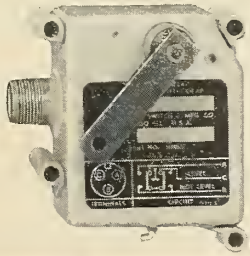

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book reviews

Realities of Space Travel. *Edited by L. J. Carter, ACIS, (Putnam & Co. Ltd., 42 Great Russell St., London, W.C. 1, Price: £1.15.0 ($4.90) plus postage.)*

A fully illustrated 430-page book consisting of twenty-four authoritative articles by sixteen recognized experts on different aspects of space flight including: "The Satellite Vehicle," "Interplanetary Flight," "Physical Factors in Space Flight," "Biological Aspects of Space Flight." Each chapter was originally a paper presented to the British Interplanetary Society.

Among the contributors, Col. P. A. Campbell, USAF doctor, who covers the aeromedical and biological aspects of flight above the atmosphere; L. J. Carter, secretary and journal editor of the BIS, writes about the US Naval Ordnance Test Station at Inyokern and about Woomera; A. V. Cleaver covers rocketry aspects np to a program for achieving interplanetary flight in 33 pages.

L. R. Shepherd, reactor physicist from the UK Harwell Atomic Energy base contributes on the nuclear rocket, cosmic ray hazards and a forward-looking piece on interstellar flight, as well as a clear statement of the basic principles of astronautics; N. J. Bowman of Standard Oil gives his views on food and atmosphere control problems in space vessels.

Professor S. Fred Singer of Maryland University discusses the present practical minimum orbital instrumented satellite. That familiar UK spacewriter Kenneth Gatland in collaboration with A. M. Kunesch and A. E. Dixon, covers the minimum satellite vehicle, while, T. Nonweiler, aerodynamics lecturer at Cranfield College of Aeronautics writes about aerodynamic braking during the descent from orbit.

The book contains useful historical and useful reference curves. It is not for the advanced specialist, but it gives a sound statement of present knowledge in terms that the technician in any trade can understand—the nontechnical can learn almost as much simply by skipping the sums.

The Sun. *By Giorgio Abetti, translated by J. B. Sedgwick, 336 pp. 147 illustrations, 97 figures. $12.00. Macmillan Co., New York.*

Professor Abetti needs no introduction to professional and amateur astronomers. An earlier version of "The Sun" was the recognized text on the subject since its appearance in 1934. A revised and enlarged edition appeared in 1951. This edition was further expanded in 1954 and now makes its first appearance in English as translated by J. B. Sedgwick.

This book evolves from techical data and theories commensurate with interests of the professional astronomer, but is presented in a form intelligible to the layman. Methods of observation of the sun are explained by presenting, with figures and photographic illustrations, the evolution of modern instruments. Spectroscopes, spectrographs, spectroheliographs, spectrohelioscopes, and anxiliary instruments become familiar and meaningful.

The familiar sun spots appear in a new light. Their origin, life cycle, vicissitudes and effects are clarified. Sun spots are generally known for their adverse effect on wireless communication. Apparently they are insignificant in determining the sun's rotation period and its physical behavior.

Perhaps one of the most interesting subjects is the physical constitution of the sun. A chapter of the book is devoted to this subject. In suport of the concept of the sun's physical make-up, the Corona, Chromosphere, Reversing layer, and the Solar Interior theories and interpretations of various phenomena are presented in brief, straightforward fashion supported by numerous figures and illustrations.

The reader will appreciate the extensive studies of the sun. The value of these studies become obvious. The importance of data currently obtained with the aid of rockets will be apparent and the magnitude of knowledge obtainable from satellites is made clear.

Professor Abetti in this book has presented such a comprehensive treatment of this complex subject that not only will it hold the layman's interest, but it will also provoke thought and study by those in technical and scientific fields.

Galactic Nebulae and Interstellar Matter. *By Jean Dufay, translated by A. J. Pomerans, Philosophical Library, New York. $15.00.*

The author, who is director of the Lyon and Haute-Provence Observatories, has succeeded in presenting a most interesting and a thoroughly authoritative book on the study of the diffuse matter in the galaxies. The book provides one of the most complete accounts available of the many diverse phenomena involved in the study of interstellar matter. The book has vocational merit, since it is written for professional astronomers as well as those generally interested in the subject matter.

In part I the types of spectra produced by the atoms and molecules in space are classified and explained. There is also an account of radio emissions from parts of the Milky Way. Part II is devoted to the solid particles of space and the dark nebulae, while Part III explains modern ideas of the physical conditions prevailing in interstellar space and includes a theory of stellar dynamics. In Part IV the behavior of diffuse matter is examined, and the problem of intergalactic absorption is discussed.

In addition to the many illustrations the book is beautifully indexed. It carries a substantial bibliography.

Thinking By Machine. *By Pierre de Latil. Houghton Mifflin, Boston* $5.50

The words automation, electronic brain and cybernetics are now part of our common vocabulary but few people have realized the full implications of the last ten years' progress in the development of self-governing machines. This book describes the principles that make these complex machines possible, as well as the fundamentals of their construction. The book is of great value to electronics and guidance engineers.

This is also a book for those in other fields. Research workers in biology, neurology and other such specialties will appreciate the philosophies and precepts introduced by the author.

Most of all, perhaps, industrial managers will benefit from careful study of the theories presented. Many professional engineers may find this a provocative book. They may not always agree with the author but they will probably agree the book is a fine contribution to the sparse literature on cybernetics.

Man into Space. *By Hermann Oberth, 226 pp. $4.50, Harper & Brothers, New York.*

For those who have made their reservations for the first lunar flight, Professor Oberth gives details on what the well-dressed space man will wear. Also covered in this spacecraft guide are satellite rockets, space stations, his famous space mirror, electric space ships and a vehicle for use in getting around on the moon.

Oberth, the father of space flight, dates his interest in astronautics back to 1922 when he wrote his thesis on the subject. Later he published a German best seller "By Rocket to Interplanetary Space." He started work on a research project involving design of the V-2 in 1938 at the Technical Institute in Vienna and later moved on to the rocket laboratories at Peenemunde under von Braun.

In his book, Oberth describes space ships which will run on electricity derived from the Sun, asteroid observatories and special problems which can be expected on a trip through space.

In addition to a detailed description of a moon car, Oberth also includes instructions on how to drive: "The more experience the driver has had on the Earth, the more difficult he will find it to get used to the novel conditions on the Moon . . . On no account should the car just forge ahead and jump at random . . . a stop will be made first, and then a few vertical jumps to reconnoiter the position."

The chapter on space fashions is complete with diagrams. One robot-looking design includes: Front and side windows, containers for compressed air, oxygen and "fuel for the reaction pistol," glove and claw, gripping magnets, shortwave aerial, rear view mirror, hooks and bolts for hanging up suit, heat dissipator, jack for telephone lead, breastplate hinges.

Oberth comments: "The fascinating film star would have his charm very considerably reduced if he wore one of them under actual space conditions."

The why of this book is explained in Wilhelm Meyer-Cords' introduction: "We are on the eve of events to which more fantastic imaginings have been applied than to the majority of progressive mankind's plans and ideas . . . mothers will have every right to know what their sons can expect in their flights through space and wives to be told what dangers their husbands will encounter on their space journeys."

One interesting proposal described by Oberth is a space mirror 27,000 square miles wide which could result in "whole space fleets wiped out," through concentrating the heat of the sun on them. Peacetime projects on which the mirror could concentrate include lighting up entire towns at night, melting icebergs, influencing climate and weather, including the control of cyclones.

Oberth estimates the cost of a space mirror at $3 billion—"less than the cost of a small war." He suggests, however, that this project be held up until his electric space ship is ready to go into service so that material for the mirror could be brought in from asteroids or the moon as "this would be cheaper."

The professor believes that many of his ideas will be put to use by 2000.

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Titan Now Our Number One Missile

More Advanced Than *Atlas*
Titan Testing Is Underway

By Erik Bergaust

DENVER—High Air Force officials have revealed to m/r that the TITAN Intercontinental Ballistic Missile effort is in a far more advanced stage than was expected less than a year ago, and that the Martin super missile actually will be a "better" weapon than the ATLAS. Furthermore, Defense Secretary Charles E. Wilson recently referred to "another" intercontinental missile as being more promising than the ATLAS. Obviously, he was referring to the TITAN. It has also been revealed that the TITAN will be more advanced designwise, and that the component test program for this second ICBM is well underway. Aerojet's president Dan Kimball has confirmed that his company is well ahead in development of the 300,000 pound thrust first-stage and 60,000 pound thrust second-stage engines.

A visit to Martin's enormous facility here reveals that the company has exceeded all expectations in getting the *Titan* program underway. Four engine test stands are almost completed, airframe manufacturing is in full swing.

Sure, Martin officials can't even talk about their missile, but it has been known for some time that the *Titan* nose cone project is as far advanced as that of the *Atlas*.

The initial USAF *Titan* development contract, totaling $358 million, has reshaped the geographic organization of the Martin Co. The *Titan* program, centered in the new $10 million facility here, is already in its manufacturing stage.

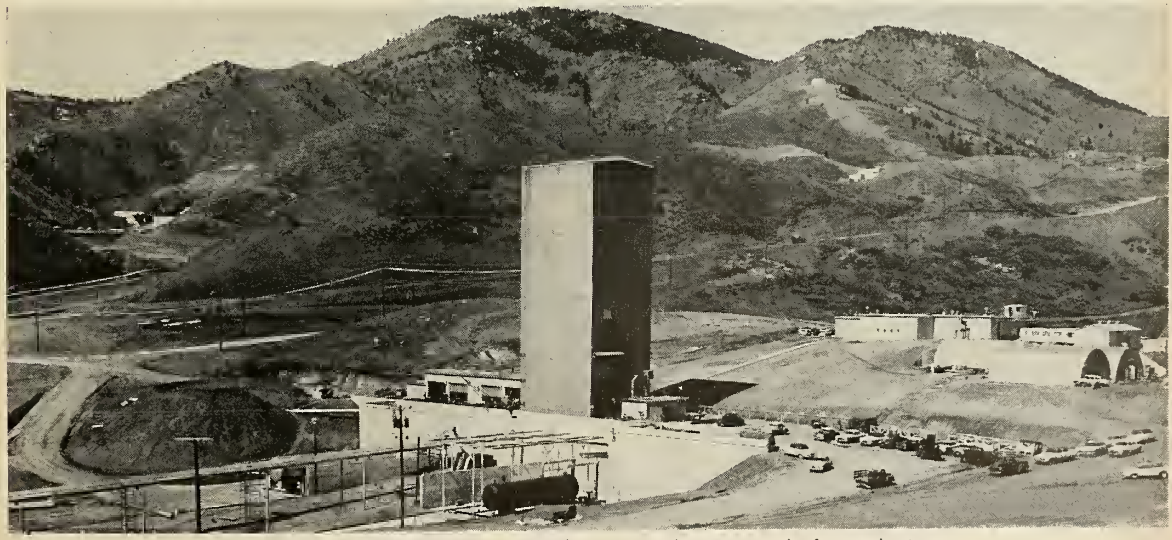
As a result, a $2 million plant expansion is in the mill. Present employment of 2,500 is expected to reach 5,000 next year. Company officials say building of a landing strip is planned to expedite delivery of parts and for transporting military and civilian people to the site.

In *Titan* guidance, American Bosch Arma Corp. of Garden City, N. Y., is spearheading inertial guidance development and Bell Telephone Laboratories/Western Electric Co. at Whippany, N.J. is working on radio guidance.

Titan is a two-stage weapon with the sustainer rocket mounted directly over the booster. General indications are that the length of the missile mounted and ready to fire is approximately 100 feet with the diameter of the booster maybe 10 feet; that of the warhead and final stage, 6-to-8 feet. Fueled weight is undoubtedly well over 100,000 pounds.

The *Titan* program now is broken down into eight departmentalized functions which perform specialized responsibilities in successfully completing the project. Several of these are well underway.

The propulsion section, which has the responsibility for the engine installation, its propellant feed system and its satisfactory marriage to the airframe, is working closely with Aerojet, planning first engine tests at the



Martin's TITAN facility has been mushrooming and is now ready for production.

Soon to be completed, this test stand at th Denver plant of Martin will be used for early static testing of the TITAN.

Denver site.

The airframe section has the responsibility for the design of the structure, the orientation of the various systems within the structure and the general configuration of the missile. This work is in the mill.

tegration of guidance within the entire system. Little is known of guidance progress, but it must be assumed that it is as advanced as the *Atlas* guidance.

The ground support and equipment section, which has the responsibility of supplying all of the neces-

A total of four static test stands are being built—all expected to be operational this year.

The guidance and control section has the responsibility for the analysis, design, development and installation of all of the control equipment which will help the vehicle maintain a stable flight attitude at all times and the in-

sary equipment required to launch the vehicle, is well ahead in its overall planning. In all, the *Titan* program is well advanced, and, needless to say, Air Force officials are pleased with the progress.

This is a 28,000-gallon, stainless steel "thermos bottle" type tank which will be used for liquid oxygen and other fuels. The tank is 11 feet 6 inches in diameter, and 75 feet in length.

Army Successfully Fires *Jupiter* 1,500 Miles

After two failures earlier this year, the Army recently succeeded in firing a *Jupiter* mid-range ballistic missile to the limit of its designed range, or approximately 1,500 miles. The instrumented vehicle attained an altitude of approximately 250 to 300 miles.

The *Jupiter* carried instrumentation in place of the warhead it would normally carry in operational use. It was controlled by a pre-programmed auto-pilot which held its attitude during flight to the programmed course. Later vehicles will be equipped with a full-fledged guidance system which will include computing as well as sensing elements.

Reds Propose Freight Rockets

Russia's official Defense Ministry newspaper *Red Star* has predicted that "in the near future" missiles may be used to transport troops and supplies.

"It should be noted," said the Soviet military organ, "that plans for using ballistic rocket missiles to move troops and materiel are actually not as far from reality as it might seem at first glance. Delivery of ammunition and certain kinds of arms can already be accomplished by some types of suitably-modified military rockets. . . .

"The question arises, what would be the cost of delivering supplies to troops by means of guided missiles? Undoubtedly such a supply system would not be cheap. However, the advantages which this method present justify the cost. Besides high speed and reliability in delivering materiel, use of guided missiles can significantly lower the cost of supplying troops by ordinary methods. These missiles would reduce the amount of rear echelon transport facilities. . . .

W. R. Grace Produces Purified Thorium

W. R. Grace & Co. will build a plant at Erwin, Tenn., to produce purified uranium, thorium, and rare earth alloys and metals.

Thorium is expected to find extensive use in magnesium alloys for jet aircraft and missiles. First production is tentatively planned for late this year.

Propellant Payoff Found in Systems Contracts

FRENCH LICK, Ind.—The missile and rocket industry gulps down huge quantities of chemicals and looks with hungry eyes toward compounds not yet synthesized.

Just what these chemicals are and what quantities are involved is a puzzler for most chemical people. An attempt was made to supply answers at a seminar here on May 13 and 14.

The program was put on by the Commercial Chemical Development Assn. in cooperation with the Assistant Secretary of Defense (Research and Engineering). Some 180 chemical people—product developers, market analysts, plant managers, and door-beating salesmen—assembled to hear the theme: "What the Rocket and Missile Program Means to the Chemical Industry." Panelists gave a run-down on various phases of liquid and solid rocket propellants and new exotic fuels.

J. J. O'Connell, Program Chairman stated that the chemical industry would like to know what chemicals will be needed for the next ten years. Emphasis was placed on propulsion. Although attendees generally were left with the impression that the chemical market for missiles is big, it was agreed the exact status is difficult if not impossible to evaluate.

Big factors in this nebulous situation are military security, trade-secret tendencies, and systems engineering. Industry spy systems have been able to cope with their competitors' trade-secrets but security and more important, systems planning have floored many a qualified chemical firm attempting to sell products in the missile field. The answer: get in on the ground floor when a system is planned.

Systems the Key

To really cash in, then, the chemical industry will have to adopt the systems attitude. This concept was advanced early in the program in a paper given by Stewart A. Johnston of Ramo-Wooldridge Corp. In addition to the usual propellant logistics criteria, two of the biggest propellant criteria are the need for high density and high specific impulse. The optimum, according to R-W, would be to manufacture all propellants right on base. Presumably this idea will be utilized in building LOX plants right on an ICBM base.

An idea of how much new chemicals might be utilized in a new propulsion evaluation program was given by Dr. John F. Gall of Pennsalt Chemicals Corp. Property testing requires but a few pounds of materials but advances to several hundred pounds while still in the laboratory stage. Static engine tests of a few thousand pounds of thrust might require 400 pounds of propellant per second with a total consumption of 2-4 tons. Thus, consumption in a more advanced test phase would soar to several hundred tons per month.

After this, during peace time conditions, the use might sag considerably. Requirements would only be for replacement, training, and minor development programs. And unless, other uses could be found this would represent a bad product growth curve which might seriously deter the chemical firm from starting in the first place. Dr. Gall, in making his pitch for fluorine propellants, stated that present production is equal to 10,000 tons per month of elemental fluorine and that even a large program would not tax the available fluorine capacity.

Managing Molecules

In an unusually detailed analysis, Rocketdyne's Research Chief, John F. Tormey stated that F-O-N-C-H chemical systems would form the basis of liquid propellants for at least ten years and that during this span we might expect specific impulse to be jacked up by about 50% over present systems.

Future oxidant systems will take advantage of more fluorine and will have increased stability and increased boiling points. Mr. Tormey was confident that materials progress would keep up with the hotter combinations. Though lithium, boron, or beryllium might play greater roles in propellants, Tormey was not so optimistic about aluminum or magnesium compounds.

The storage life of the *Nike I* is now five to ten years even though the system is obsolete. Richard B. Canright, of Douglas Aircraft stated that the booster was a multi-perforated double base solid developed by Allegany Ballistics Laboratory. The sustainer uses UDMH JP-4 (dubbed M-3 fuel) and IRFNA. Temperature storage limits are now —50°F to 140°F.

A great deal of interest was generated when E. A. Weilmuenster of Olin Mathieson presented his run-down on Project Zip. Based on early German and British work, OM embarked on its boron program in 1952 for BuAer. Of particular interest were the boron hydrides which gave combustion heats of 28,000-32,000 BTU/lb.

Declining to say just what compounds were now being manufactured, it was stated that there was "lots of interest" in the liquid pentaborane. The high energy fuels are not spontaneously ignited in air, and have flame speeds comparable to JP-4. HEF systems are in the works for several missile and aircraft systems. With development, HEF might be used in the B-58 system. OM also thinks that there are commercial applications for Zip.

The liquid portion of the program was terminated by Robertson Younquist who described engine developer's applications and needs from his Reaction Motors viewpoint.

Solids Growing

With some 1-5% of a production missile's cost, the propellant is but a small item said H. W. Ritchey of Thiokol. However, using the Thiokol-made polysulfides in solid propellants has paid off for the firm since some 50-75% of income is from rockets. Thus small chemical firms such as Thiokol, imbued with the systems concept, can profit from a low-volume, high-cost item.

No Upper Size Limit

Lyman G. Bonner emphasized that solid propellants are the most mature of rocket systems and that Allegany Ballistics Laboratory operated by the Hercules Powder Co. was called on early to supply double-base propellants. World War I techniques were the only ones available at the start of World War II. However, double-base solids can now be cast and performance is edging up toward the limit of about 250 Isp. Bonner said that the upper limit of grain size has not yet been reached.

According to Rohm & Haas Co.'s Redstone Research Div. General Manager, Allen R. Deschere, development of solid propellants differs from other chemical products mainly in the rather dangerous nature of the materials being handled. R&H is content with operating a research lab at Redstone and has no plans for getting into the missile business.

How to Get In

Although the amount of chemicals used in missiles may not be huge, it could be significant for newer materials and for smaller firms. The big payoff is seen to be for those who get in on a systems basis. The road for the chemical industry is clear: get cleared, get out and find out what is needed and start to make it.

Missiles Highlight Paris Air Show

U.S., Britain and France Show the Most
Security Keeps Best from View

By Anthony Vandyk and Jean-Marie Riche

PARIS—U.S., British and French missiles were prominently featured at the International Air Show here. Ranging from the Northrop *Snark* and Martin *Matador* to the smallest experimental rockets, the missiles were the main talking point of visitors. It was clear the European aircraft industry has suddenly become missile-minded.

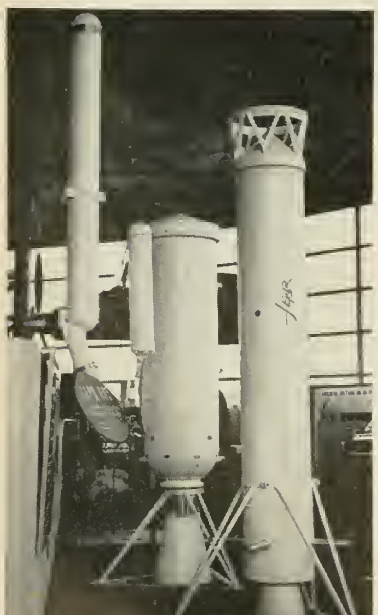
No major manufacturer represented at the show was without some sort of missile exhibit or project. Nonetheless, security prevented any of the latest European missiles from being shown but there were plenty of older models on the British and French stands. Most of them appeared to be subsonic or transonic.

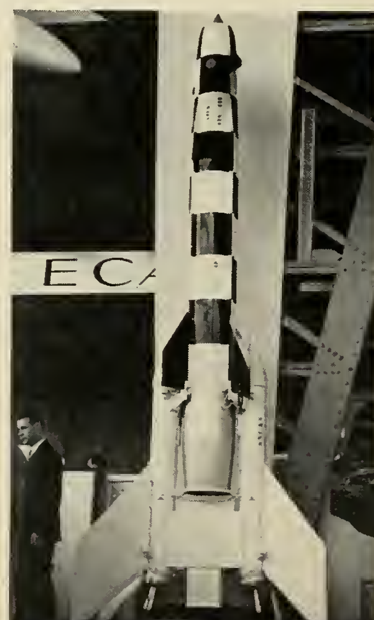
The Bristol *Bobbin* test vehicle made its first public appearance at the show. The Australian *Jindivik* was shown by Fairey Aviation together with its *Fireflash.*

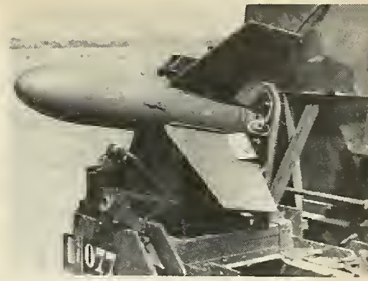
The de Havilland and English Electric/Napier stands held many missile exhibits.

The French, like the British, mainly showed test vehicles. SNCA du

Demonstrating that the French have not exactly been lacking in missile development, this array gives some idea of the different lines of approach being taken by the French aircraft industry. To the left is the Matra 510 air-to-air missile. At the lower left is a selection of solid propellant rocket engines manufactured by S.E.P.R. (Societe d'Etude de las Propulsion Par Reaction). Below center, an experimental two stage test vehicle built by ONERA. Below right is the experimental ST 450 missile (SNCA du Nord) for ramjet testing. A ground-to-air missile has been developed from this vehicle. SNCA du Nord is also working on a ramjet.







This series of pictures shows the French anti-tank missile SS 10, from which the U.S. Army DART was derived. Simplicity and versitility is a feature of the French missile. Both the SS 10 and SS 11 (not shown) are wire guided. Speed of the SS 10 is 328 feet per second; of the SS 11, 655/820 feet per second. Ranges are 1.25 and 1.85 miles respectively. The SS 11 is stabilized in flight by a jet deviator.

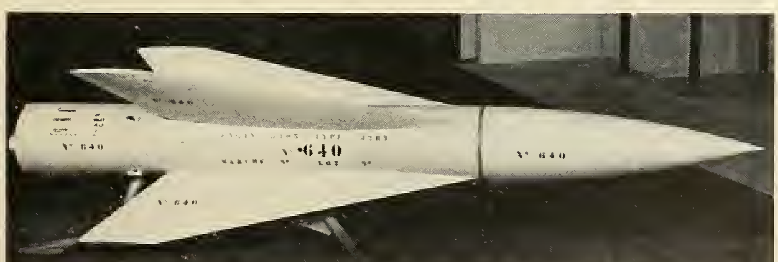
Nord was permitted to display its CT-10 and CT-20 drones and to present full data on them which will be reproduced in a future issue of m/r. Nord's SS10's highly successful SSMs were also displayed. Matra's production AAM was slung under a Dassault *Mirage* interceptor.

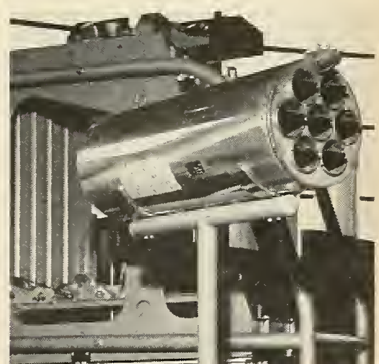
During the show it was disclosed that France's Bronzavia has licensed its missile ram-air turbine to General Electric for U.S. production. SEPR showed a large number of rocket motors including the model 734 which develops 57,700 lbs. of thrust for four seconds. SNCA du Nord showed evidence of important work on ramjets.

A significant presentation was made by SNECMA of its *"Flying Atar"* VTOL—a piloted jet engine with no wings or other control surfaces. The controllability of this device appeared to be excellent.

It was difficult to obtain specific information on what new missiles are being developed by the French industry. It is known, however, that the French government wants a French atomic ICBM to be ready by 1965 at the latest and for effective SAMs to be in service much earlier.

Improved AAMs are already on the way. In fact, all indications are that the French missile industry is making excellent progress.





To the upper left is the Nord 5.103 air-to-air missile now in production for use on super-MYSTERE day fighters and VAUTOUR all-weather fighters. Carrying a warhead of 57 pounds of TNT the missile has a range of 6.2 miles and a speed of 1640 feet per second. It's either a beam rider or radio guided. Lower left is the CT 20 target drone which have been used by French forces and exported to Britain and Sweden. Above is a MATRA rocket launcher.

New Propellants Insensitive To Shock

A new solid propellant, a replacement for black powder and diglycol propellants, was described by Dr. G. von Francois, formerly a special Speer Ministry employee. No. 36E, dubbed yellow powder, consists of 53.5% tetranitro carbazole, 42.5% potassium nitrate as oxidant, 2% carbon, 3% wood flour and 4% polyvinyl acetate as binder. The cool-burning propellant can be used over a temperature range of −58° F to 140° F. Not sensitive to shock, the plasticized mixture burns to give a slightly yellow smoke exhaust.

German solid propellants formerly based on black powder or diglycol dinitrate now appear to be shifting to the high energy composites. Also, the production of synthetic glycerine by one of the Farben groups will now give capacity for production of nitrogylcerine-type double base solids. Another propellant combination is based on tetranitro diphenyl amino sulfone. Several German labs are doing research on new organic solid monopropellants: nitro, nitrate, or nitroso compounds.

French SEPR Builds Two Big Boosters

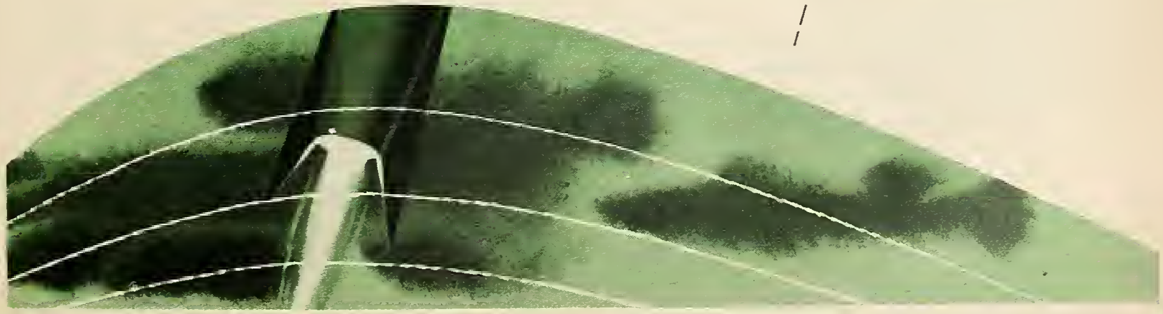
The French SEPR group has successfully scaled up solid propellant rockets and have come up with two new boosters:

	SEPR 73	SEPR 5052
Thrust, lb	55,000	29,700
Burning Time, sec	4	4
Chamber Pressure, psi	1,030	1,030
Propellant Weight, lb	940	620
Total Weight, lb .	1,625	1,030
Total Length, in .	106	105
Diameter, in	25	18

Propellant type is not known.

Longer Satellite Lifetimes Predicted

At the recent American Astronomical Society meeting in Cambridge, Theodore E. Sterne postulated that the *Vanguard* orbit may result in a satellite decay period of 8-10 years based upon latest Air Force Cambridge Research Center atmospheric model. If this turns out to be so, subsequent satellites will be launched at lower altitudes or lower speeds to obtain upper atmosphere density checks within a shorter interval.



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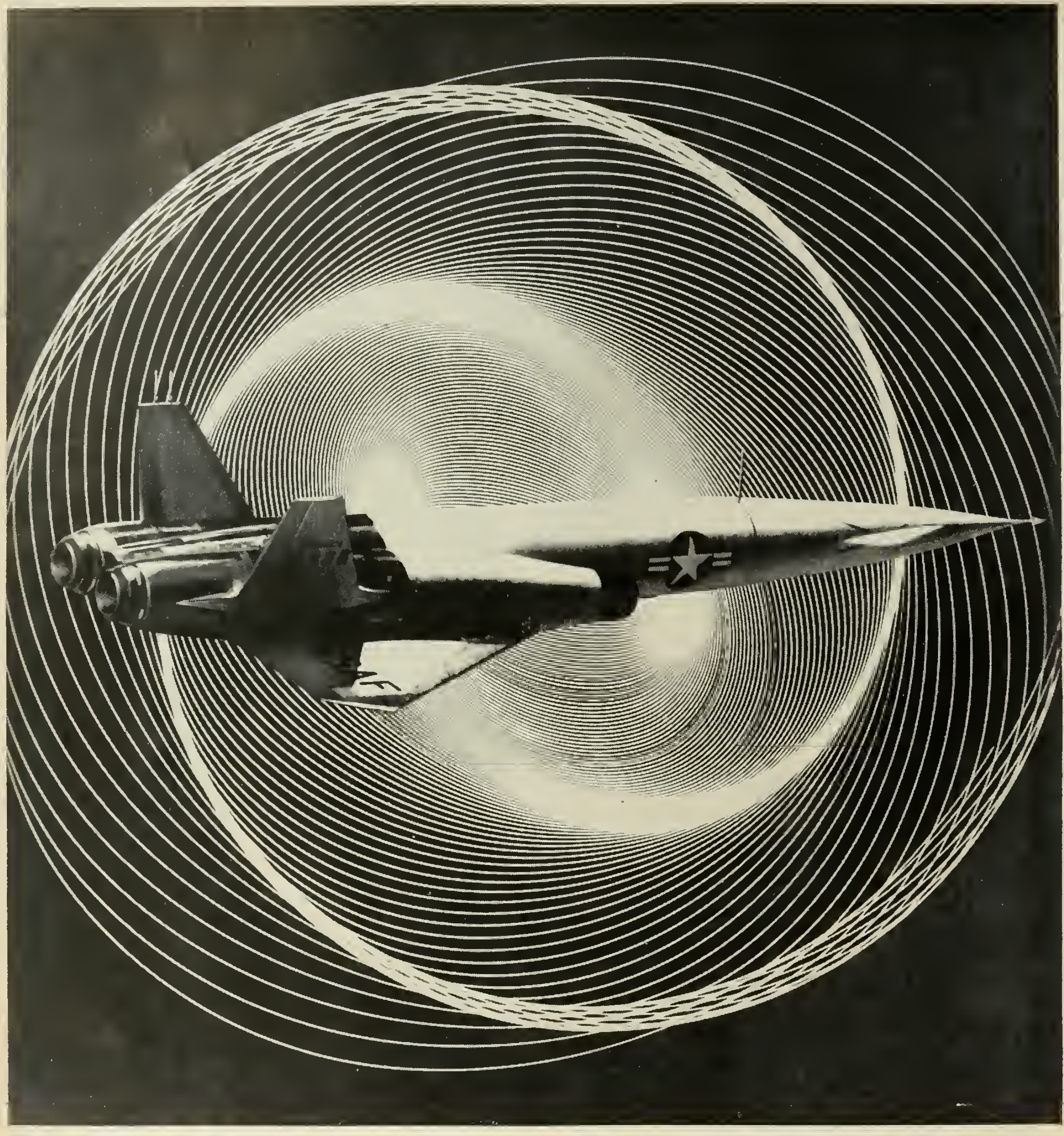

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Missile Program Sharply Criticised by Congress

The House Appropriations Committee subtracted $2,586,775,000 from the military appropriation request for the fiscal year beginning July 1, but insisted the cut will not jeopardize U.S. military striking power.

The lawmakers reported out a bill recommending $33,541,225,000 in new obligational authority for the Defense Department in fiscal 1958, compared with the $36,128,000,000 originally requested by the Administration and the $34,698,523,000 actually voted for the current year.

In support of its cut, the Committee said that the Soviet military threat to the U.S. and its allies appears to have "somewhat abated," but it acknowledged that the Soviet Union is closing the gap in military power.

"In the field of missiles we are in a nip and tuck race with Russia. We are no doubt ahead of the Soviets in the field of guided missiles generally. In the ballistic field, we are probably behind the Soviet Union in progress made in the perfection of the Intermediate Range Ballistic Missile. In the Intercontinental Ballistic Missile area, we are very probably ahead of the Soviets," the Committee said.

The House group had some harsh words in its report for what it called the "apparent lack of timely, effective and decisive action on the part of the Office of the Secretary of Defense in achieving a well-rounded, coordinated guided missile program at minimum cost commensurate with an adequate system." (See Industry Spotlight, p. 169). The Committee strongly urged more prompt and effective evaluation of competing military missile projects, particularly for the non-ballistic missile area.

The congressmen agreed that a certain amount of duplication is necessary in the ballistic missile projects, but added: "It is hoped that within the next few months the ballistic missile program will become clarified and the maximum of lost motion eliminated."

Except in the case of the Air Force, the precise impact of the Committee's action on the missile program was not disclosed. The USAF's $1,414,800,000 request for missile procurement ($676,900,000 for ballistics and $737,900,000 for non-ballistics) was trimmed $70,000,000 "as a reflection of the Committee's dissatisfaction with Air Force efforts in this area," but it was stated that none of the reduction is to be applied to the ballistic projects. Another $5,000,000 was lopped from the Air Force's $105,700,000 request for missile spares to take account of the cut in missile procurement money.

The Committee also gave the airmen a tip on cetrain missiles they might do well to abandon. It said some of the 18 separate missile development and production projects now carried on by the Air Force are of "doubtful value" and it included the Bell *Rascal* air-to-surface missile in this category, noting that the Defense Department feels it is a "marginal" weapon.

A $12,000,000 cut was recommended in the USAF request for $661,000,000 in new research and development funds, but this was not allocated among specific projects. The Committee said this reduction was ordered to emphasize that all possible economies should be effected, particularly in scientific and engineering manpower.

The Army's $583,000,000 procurement request for hardware, including missiles, was reduced by $516,000,000—the amount of the total request the soldiers expect to carry over into fiscal 1959 unobligated. The Committee acknowledged that the reduced amount will give the Army less latitude than it wants, but said the amount should prove adequate if improvements continue in management and planning operations. A cut of $8,000,000 was also ordered in the Army's $400,000,000 R&D request.

The Navy buys missiles in two separate accounts—aircraft and related procurement administered by the Bureau of Aeronautics and ordnance and ammunition, handled by the Bureau of Ordnance. BuAer's request for aircraft, missiles, drones and related items was cut $120,000,000 to $1,812,000,000, but the Committee expressed confidence that the Navy can carry its program with the lesser amount since experience has shown that considerable savings through program changes, contract repricing and the like may be expected.

BuOrd's $256,000,000 request for ammunition and missile money (including *Polaris*) was reduced to $176,000,000, on the strength of BuOrd's past poor performance in hitting its obligation targets, anticipated reimbursements from the military assistance program and the volume of carry-over funds available. The Navy's total R&D request of $505,000,000 was also cut by $10,000,000.

Soviet Research Poorly Organized

Professor Peter L. Kapitsa, the celebrated Soviet physicist, in an article published in the Moscow *Pravda* last month complained of the poor organization of certain important research projects in the Soviet Union today. Giving the construction of an atomic-powered airplane as an example, Doctor Kapitsa pointed out that one Soviet scientific agency usually takes over the entire project, then farms out certain parts of it to various other agencies, whereas a better approach would be for only one team to be responsible, without farming out even the project's smallest parts.

He listed agencies and specialists in atomic energy, thermotechnical problems, and aerodynamics among those now involved in the building of the Soviet atom-powered plane. He hinted in his article that some of these agencies and experts do not work with others in entire harmony. Better team work, through greater centralization, is necessary, declared Dr. Kapitsa.

Launched toward the Future
in WEAPON SYSTEMS MANAGEMENT

Rascal—GAM-63 air-to-surface missile of the USAF—is an operational example of complete weapon systems management by Bell Aircraft. As prime contractor, Bell's responsibilities embraced the design, development, and production of the entire system including airframe, guidance, rocket engine, servo-mechanical devices, launching and ground support equipment as well as flight testing and training.

The personnel responsible for this successful program has recently been regrouped to form a new *Guided Missiles Division.* Its sole function is to provide complete and coordinated management and production for any weapon systems program.

The men who make up this division ar a skilled and diversified team of specialists with a total of some 100,000 man-years of experience in guided missiles. Prior to "Rascal", they were responsible for Tarzan, Shrike and Meteor. Current responsibilities also include important components for the Niké, Hustler, Regulus, Navaho and various I. C. B. M. and I. R. B. M. programs.

These men have past success to attest to their capabilities and foretell future accomplishments. They will be heard from again and again for important achievements in the years ahead.

BELL Aircraft CORP.

Guided Missiles Div.
BUFFALO, N. Y.

Russians Report Super Peroxide

A member of the D. I. Mendelev Institute of Chemical Technology in Moscow, A. P. Purmal, suggests the existence of a super hydrogen peroxide—H_2O_4. Reporting in the *USSR Journal of Physics,* the scientist told of irradiating a fresh hydrogen peroxide solution with a mercury arc light to drive off all oxygen. Oxygen evolved is measured and the solution titrated with potassium permanganate.

Titration results were shown to be lower than calculated. The gas evolved gives the bonded oxygen while titration gives the hydrogen combined with peroxide oxygen. The scientist states that the two methods agree when no other peroxide forms are possible. Purmal, in typical scientific fashion, however, wants other confirming proof.

If super peroxide could be prepared, it would be very useful as a replacement for normal peroxide. Although containing some 97% oxygen (hydrogen peroxide has 94%), it could yield twice as much *available* oxygen. Other desirable properties hypothesized: higher density, ease in catalytic decomposition, high boiling point and low freezing point. The next step, perhaps already in the mill, would be isolation and study.

Controversial Clue Sparks Symposium

Over-instrumentation was one of the most controversial subjects discussed at an informal missile forum held during the Instrument Society of America's 3rd National Flight Test Symposium in Los Angeles, Calif.

All participants agreed, however, there was too great a variation in the nature of tests to establish an arbitrary line between too much and too little.

It was emphasized that all firing tests of complete missiles should be made on an "inter system" basis by placing a boundary or engineering parameter around each system and measuring only such actions as take place between systems. This theory assumes that component accuracy is within specified tolerances and that each component of each system has been thoroughly checked prior to the test of each system.

The use of system boundary techniques would limit the amount of monitor channels to about 140-150 rather than the several hundred required when system components are measured at the tame time system performance is being evaluated. It was felt that component measurement has no place during a test firing other than sufficient instrumentation to "fingerprint" which components *could* have malfunctioned. This technique, it was stated, was one means of providing maximum information with a minimum effort, resulting in fewer dollars spent.

It was stressed, however, that the amount of instrumentation required for test firing varied with the project's size and complexity. Although an aircraft may have hundreds of hours of flight testing prior to acceptance, a missile must render the bulk of its information in a single flight, and missile engineers need all the information they can get on the performance of any system or component involved. Some concern over inadequte instrumentation during test firings was also expressed.

Pointing out that as new equipment and new installations are made, new instrumentation will be required, a representative of one missile test facility noted that their static test instrumentation was increasing at the rate of approximately 20 per cent per year, but the additional instrumentation tended to reduce the number of tests required.

There was general agreement when several of the panel and members of the informal "workshop" declared the responsibility for the amount of instrumentation should be a decision of the instrumentation engineer after an evaluation of the design engineers' requests.

French Astronomer Speaks at Harvard

The well-known French astronomer, Gérard de Voucouleurs, recently told a Cambridge, Mass. audience why he would like to have a close look at the planets. Speaking at a panel discussion at Harvard University, he excluded all the bodies of the solar system but Venus and Mars for reasons of distance or temperature extremes.

Dr. de Voucouleurs would like to determine the mass of Venus by satellite techniques, a quantity inaccurately known today because of the fact that Venus lacks a natural moon. He suggested that radio-ranging could be employed to find not only the depth of the atmosphere but the diameter of the planet. Observations, he said, could be made either by artificial satellites or some sort of probe.

Mars received the lion's share of the French astronomer's attention. Among the studies that could be made.

Dr. de Voucouleurs discussed the following: oblateness and internal structure and discrepancies between present optical and dynamical determinations, fine structure of surface markings, continuous strip mapping surveys, spectroscopic tests of the atmosphere (carried out either between two vehicles or using one with a reflecting mirror), radio observations for determination of Martian relief, variable frequency sounding for detection of ionized atmospheric layers, possible ring-current investigations and magnetometer surveys. He felt that it may be feasible to shoot rockets into the atmosphere from a satellite to determine wind velocities and directions.

Naval Factory Honors Rocketeer

The Naval Powder Factory at Indian Head, will honor the late Dr. Robert H. Goddard on 25 June 1957 by dedicating its new power plant in his name. It will be the Navy's first high pressure (900 lbs.—825°F), centrally controlled, electric and steam generating plant.

The Naval Powder Factory has supplied the Navy's need for cannon powder since 1900 when the manufacture of smokeless powder was begun.

Today, the powder factory is devoted almost exclusively to the scientific investigation of propellant ingredients, grain design, and experimental production, as well as full scale manufacture, testing, inspection and surveillance of propellants for rockets and guided missiles.

Dr. Goddard conducted rocket research at the powder factory between 1920 and 1922. His efforts were directed toward devising a rocket driven, deck-penetrating bomb.

Tiny Meteorite Detector Developed

Instrumentation for measuring meteoric surface erosion or penetration depth has been developed which weighs only three quarters of an ounce. Developed by Professor S. Fred Singer at the University of Maryland, the device utilizes Sr-90 as the radioactive source in a transistorized circuit. The system is adaptable to operation from either the Minitrack 22 volt supply or, with a different circuit, to 2.5 volts. Current drawn is only 0.1 microamperes. Tests are being run in a shock tube to simulate high speed meteoritic dust particle impacts. The experiment appears suitable for both satellite tests and high altitude sounding rockets.

Moscow Claims to be Building an Atomic Plane

They are now building an atomic-powered airplane in Moscow, it has been announced by the Soviet government. The plane will make uninterrupted globe-circling flights at speeds up to 1800 mph. It will also fly non-stop from Moscow to Mirny, the new Soviet base in Antarctica.

"We need regular air communications with Mirny and other Antarctic points," Professor G. Pokrovsky, the chief Soviet authority on atomic planes declared recently.

Despite the fact that the Soviet atom plane is as yet in its first preliminary phase of experimentation, Pokrovsky and his associates have not the slightest doubt that the plane will be a working reality soon. Professor Pokrovsky and his staff admit that there are still unsolved problems but they claim Russian science is confidently on its way to their solution.

Another Moscow physicist-mathematician, Y. Balabanov, elaborates: "The most serious handicap in the utilization of nuclear energy in airplanes is the heavy weight of the protective concrete walls safeguarding passengers from harmful radiation of the reactor. This weight reaches 100 tons.

"Should we succeed in reducing the weight of such walls to 40 tons, such an airplane could lift a cargo of 15 tons and could carry 180 passengers at 1600 kilometers per hour."

Professor Pokrovsky admits that "the problem of relaying heat from the reactor to the motor is also complex." Still, he says, the Soviets can and will make it light and compact. He feels that the entire plane could weigh about 100 tons.

The plane's reactor will have to work at temperatures of more than 1000°C. "What materials are capable of bearing this heat without disintegration or even softening?" asks Pokrovsky. "What materials would successfully resist the furious bombardment by neutrons able to cause complex changes in matter?"

But such materials can be found, the Soviet scientist asserts. On the one hand, science must awaken new and yet newer forces of nature to action.

Atomic power will make the future plane's speeds exceed by far even the top rates of present-day supersonic aircraft. The surface of the plane will become so heated that it will generate tremendous streams of super-hot air around itself. Therefore men must have new, heat-resisting alloys for the plane —different alloys perhaps than those for its reactor. Moscow's scientists are now laboring on this problem too, with every prospect of early success, Dr. Pokrovsky tells us.

Pokrovsky adds that future atomic aircraft will have rotating jet motors which, on the plane's ascent, will assume a vertical position and will thus give the plane vertical takeoff capabilities. "Just like a helicopter."

Balabanov adds:

"Such an atom-driven plane will be able to fly endlessly. With a supply of 1000 kilograms of nuclear fuel, an atomic airplane would have operating power at its disposal equal to about 2 million kilograms of benzine."

This means, continued the Moscow spokesman, that interplanetary flights will in due time, become a possibility. "A rocket to be used for this purpose will have to move in airless space," Balabanov reminds us, "and for its jet-propelled motion a sufficient supply of liquefied gas is necessary."

Rocket Trends

By Erik Bergaust

Missile talk in recent months—for good reasons—has been mostly about intercontinental vehicles. *Navaho* versus *Snark*. *Atlas* versus *Titan*. These missiles will continue to be in the news for years to come because they are important. The long-range missiles have top priority. They should have.

But let us not forget that intercontinental missiles make up only part of the important arsenal that is required for the defense of this country and the rest of the free world. Let us not move along blindfolded, neglecting the other categories. In particular, let us not forget the anti-aircraft and anti-missile missiles. We have heard some terrifying statements about lack of accuracy in *Bomarc* guidance, for example. And what has happened to the *Talos*? Is the *Talos* program bogged down? Last but not least, the latest word on the "incapability" of our *Nike* systems comes from Russia!

Among the publications that our "Russian Editor" scans carefully every month is Sovietskaya Aviatia. This newspaper-type periodical had plenty to say about our *Nike* last month.

It described launching facilities, radar-guidance systems, speed, range and altitude limits of the *Nike* and its installation in conjunction with 90-millimeter antiaircraft artillery.

After reviewing some details, the paper said that the *Nike* missile was very far from modern, because it can hit only single targets.

Sovietskaya Aviatia minimized the value of tests of the *Nike* as reported by the U.S. Army. It said these were conducted against "obsolete piston-engined planes flying at speeds of 200 miles an hour."

"When firing the *Nike* missile under real conditions, where the speed of maneuvering planes keeps changing, the chances of hitting the target become greatly lessened" from the 65 hits out of 100 claimed for the missile, the paper said.

The Russians aren't telling us anything new. Of course, we know the *Nike* is far from perfect. It remains a sad and grim fact, nevertheless, that the Russians are so fully aware of the holes in our air defense system. Certainly it should spur our military leaders to accelerate our advanced anti-aircraft and anti-missile missiles. Obviously, the Russians know that these weapon systems do not exist in this country as yet other than on paper.

There has been some talk about sky-high expenses and non-feasibility in connection with anti-missile missiles. But the majority of our missile experts say an anti-missile missile can be built. Can we afford not to try?

As far as money is concerned, we have noticed that the airmen have programmed $955.7 million for the ICBM/IRBM program for next fiscal year, while "other missiles" will receive $739.9 million worth of attention. How much money will go for *Bomarcs* has not been disclosed. Nor do we have any figures on how much the Army can and will spend on the *Nike Hercules* and *Zeus*. But since the Army's share of the defense budget is microscopic, it appears very little effort is being put into the life-and-death defense weapon, the anti-missile missile.

The drastic slicing of the defense budget is going to hurt all around, of course. In particular, the missile program will suffer considerably. Certainly, there doesn't seem to be any large sum around for an extensive anti-missile R&D program unless Charlie Wilson can dig it up from his special emergency vault. The worst that could happen would be the need for Congressional sanction for such money. Congress probably wouldn't have time to okay this before it adjourns this summer. And this would mean a dangerous set-back time-wise in the anti-missile program.

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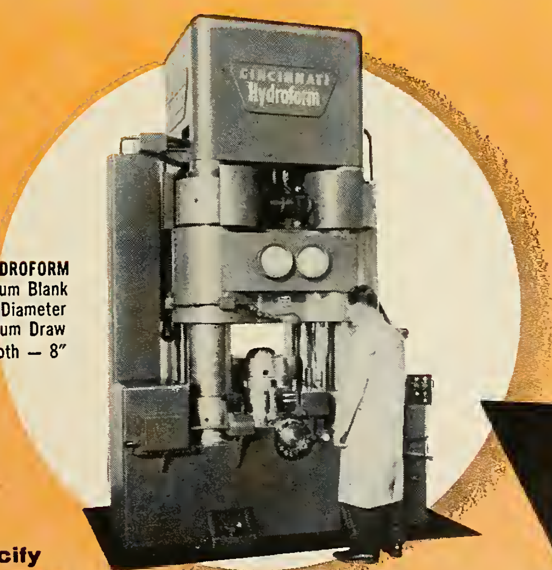

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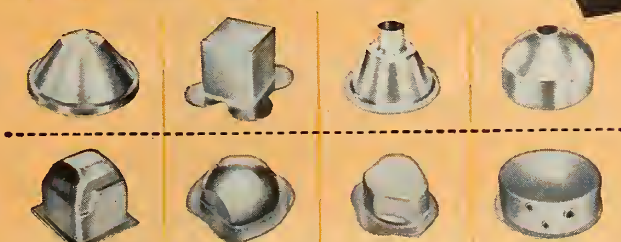

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Washington Spotlight

By Henry T. Simmons

Booming missile activity is a chief factor in the massive over-run in Defense Department expenditures anticipated for the current fiscal year. The Administration predicted a $36 billion spending total for the Pentagon in January; now it looks like the military will go through at least $38 billion before the close of business on June 30. Almost three-quarters of the $2 billion over-run can be traced to the Air Force hardware accounts. The airmen told Congress they expect to exceed their January estimate by $1.4 billion—half the excess coming in the *Atlas*, *Titan* and *Thor* projects. Pentagon has slammed the brakes on overtime payments to contractors in an effort to bring run-away spending under control, but the vital ballistic projects were specifically exempted.

•

Third test flight of the *Navaho* in April was a complete wash-out. The big missile's multiple booster engines fired for perhaps two seconds, then cut off in response to a wild signal from within the missile. Source of the trouble is known. Meantime, North American has successfully tested a 400,000-pound liquid-propellant booster for the production version of the *Navaho* (if there is one); it would replace the three units of 120,000 pounds each now used with the XSM-64. The new engine, incidentally, is the largest liquid rocket motor known to exist today.

•

Lockheed's supersonic X-7 ramjet test vehicle has evolved into the Q-5, a recoverable drone now under development by the Air Force. Like its prototype, the Q-5 utilizes a ribbon chute to slow down after burnout and lands on its spike nose without damage to the rest of the vehicle. USAF has worked out a deal with the Army at nearby White Sands which permits the soldiers to blaze away at the Q-5 with *Nikes* during the test flights. Army has promised to crank an offset error into its fire control system to assure a minimum number of actual hits on the speedy drone development vehicles.

•

Apropos of the deliberate destruction of the USAF *Thor* IRBM during its second test flight, a tale now going around puts the blame on a faulty radar instrument used by the range safety officer. According to the story, the IRBM was sticking to its course, but was detonated by the safety officer on the basis of false information reported by his instruments. Two other monitoring systems reportedly showed that the *Thor* stuck to its flight plan during its 38-second trip.

•

The Navy isn't happy about its contractual arrangement with Convair for procurement of the *Terrier* ship-launched anti-aircraft missile, now priced at $64,000 a copy. Rear Adm. Frederic Withington, Chief of the Bureau of Ordnance, told lawmakers he would like to have a more competitive type of contract for the bird, but said this is not possible because of the high cost of bringing in a second source. Grumbled Withington: "I wish that I could get out of Convair's pocket with the *Terrier* missile, but I cannot . . . I do not like it, and I have to accept it."

•

On the other hand, the Navy appears to be quite happy with its *Sidewinder* air-to-air missile, which was developed by the Naval Ordnance Test Station at China Lake, Calif. Cost of the infra-red bird has dropped almost 50% over a three-year period. It cost $4,591 in 1956, $3,998 this year, and its estimated fiscal 1958 cost is $3,540.

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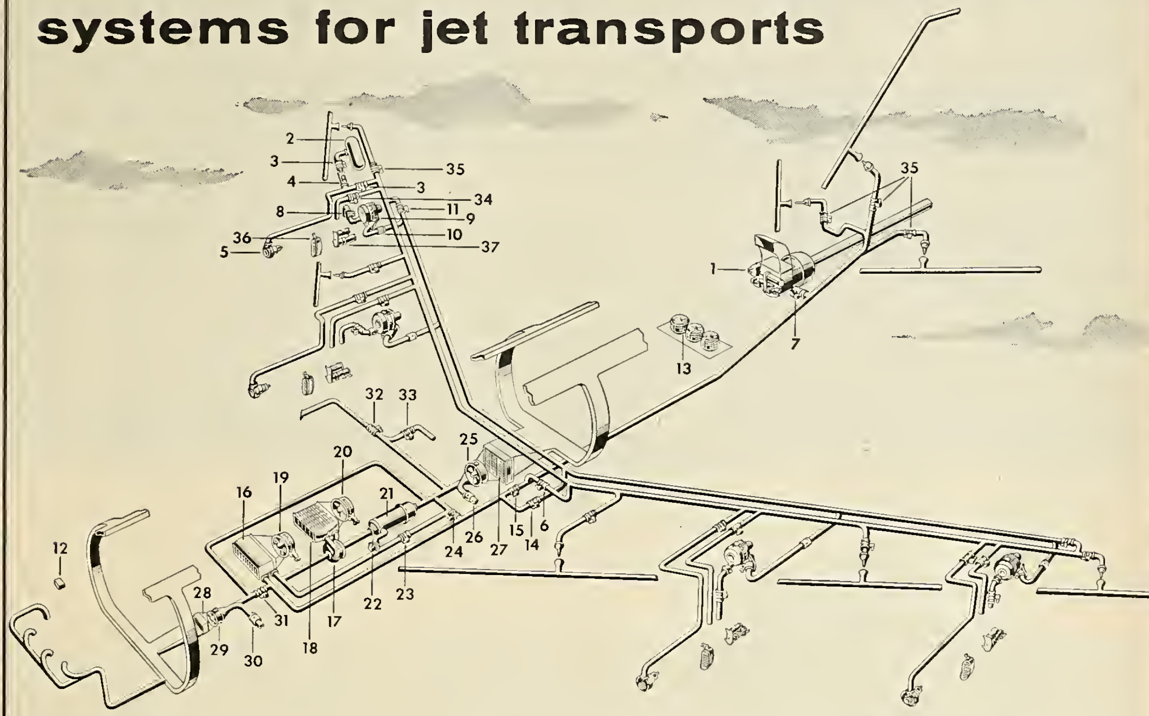

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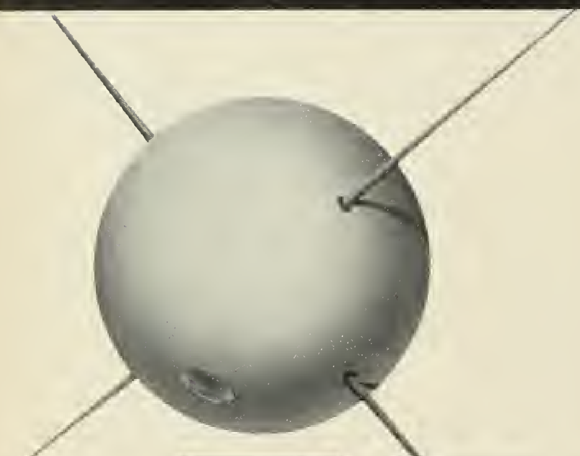

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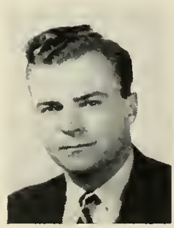

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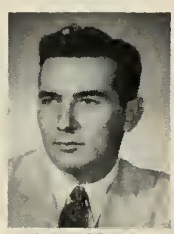

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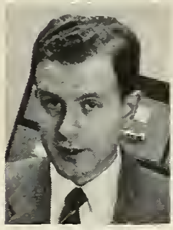

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m/r exclusive:

Seven League Boots

Known Limits on Chemical Propulsion Systems Demand Early Answer to "What Comes Next?"

By Seabrook Hull

WITHIN LESS TIME than it's comfortable to contemplate—perhaps within a decade—man's demands on flight propulsion systems will exceed the capabilities of any known or imagined purely chemical combination, such as the turbojet, ramjet or rocket. This will be true first of military, later of commercial requirements. It is inevitable not only in the case of practical space flight, but also as flight operations are extended into the upper reaches of the earth's atmosphere.

The military urgency is to maintain air superiority over the Soviet Union. In the absence of specific fact there can be no other assumption than that the Russians are exerting a major effort to transform their long-term interest in astronautics into usable hardware. And who first rules the ionosphere gains an immense advantage over his adversary. In turn, the same is true of outer space.

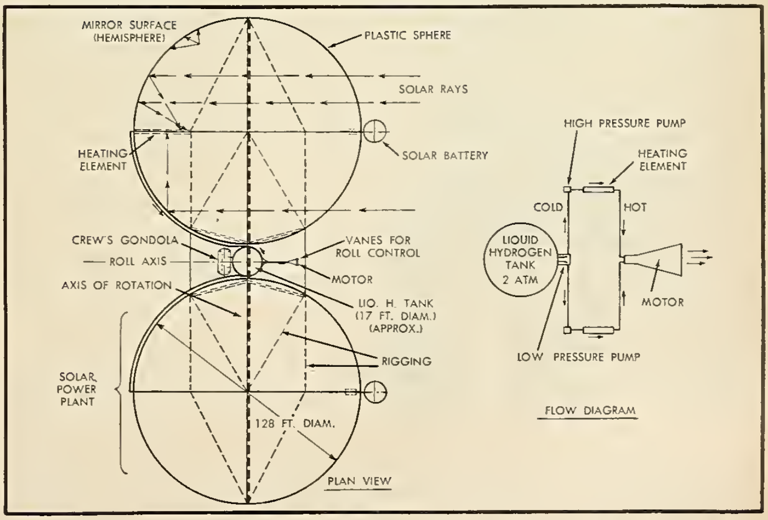
A major consideration in this connection is a propulsion system that has both flexible power and endurance and that is adaptable to the changing conditions of its environment—that can ease readily from the dense lower atmosphere to the ionosphere to free space and back. It should also be as economical as possible in original construction costs, operation and maintenance.

As detailed elsewhere in this issue of m/r, materials will limit combustion chamber temperatures of chemical propulsion systems to about 3000 degrees Kelvin. No matter how efficient a free radical or "zip" fuel reaction may be in heating and accelerating exhaust gases, if it entails higher temperatures, it cannot be used for flights of more than a relatively short duration. They would have to be based on the gradual destruction of the combustion chamber.

Thus, barring development of a practical means of reconstituting the basic structure of matter so that atoms will take a much stronger grip on other atoms, enabling materials to remain solid to higher temperatures, the absolute theoretical limits of chemical propulsion are known. The very best that can be done, for example with a liquid, solid or jelly propellent rocket is a 40% increase in specific impulse.

For flights about the earth this means a specific and relatively low ceiling on velocity. For travel into outer space it means a prohibitive limit to range and maneuverability. For this reason there is as much urgency as academic interest in determining as soon as possible what comes next.

Among the possibilities are four of purely nuclear propulsion; two electrical systems; one photonic and an as yet undetermined number of others including gravity control, though this last still flounders in the most elementary basic research stages. Not all of these are practical in all three environments—atmosphere, ionsphere, and exosphere. Thus, unless some major technological break-through occurs, as in being able to control local gravitic fields, the propulsion system of tomor-



Krafft Ehricke's solar propulsion system is another new power concept. Future will tell . . .

A piece of hardware we can see, this REDSTONE ballistic missile represents the closest advance man has made to the future age of flight. Now being weaponized by the Army, this missile is a liquid fueled rocket.

row will probably be a combination of two or more.

Nuclear propulsion possibilities break down evenly between fission and fusion. One in each case involves the use of nuclear power as a heat source to expand and raise the temperature of a gas, either air drawn in through an inlet or, in the case of space flight, some light gas that is integrally carried on board.

In the case of fission, the ability to design a reactor to supply the necessary heat exists. What doesn't exist, however, are materials capable of standing up to the temperatures that would come with any material improvement over present thrusts. The one singular gain over conventional chemical systems for airborne operations would be in endurance.

In space flight, even this advantage would be lost, for while the fuel supply might conceivably be "limitless," range would be limited by the volume of gas that could be carried.

In theory, a fusion system could be developed along similar lines, but the same materials limitation applies. It is doubtful if, under present concepts, such a nuclear rocket or ramjet will ever reach wide acceptance, whether it be based on fission or fusion. Particularly in the case of manned applications, the problems of shielding are severe. This is also true in ground handling.

The other two possible nuclear approaches entail use of the nuclear reaction not only to heat and accelerate exhaust particles, but also as the source of the particles themselves. While it is theoretically possible to hold and contain a controlled fusion or fission reaction out in space well aft of the vehicle, thus perhaps obviating the materials problem (the fission bomb generates temperatures on the order of 50 million degrees Kelvin; fusion, 100-to-200 million), this has yet to be done successfully in the laboratory. Work is now in process to attempt it, however. It is a possible answer to some future propulsion needs, but the engineering of such a capability into practical vehicle presents appalling obstacles.

Nuclear power, however, does stand out as the white hope in almost any propulsion system of the future, not as a source of heat or as a rocket itself but as a source of electricity for powering other systems.

The most promising of these at the moment is ion propulsion, where charged particles are accelerated either electrically or magnetically through a kind of inflight linear accelerator. Though there are two distinct schools of thought, due largely to some of the problems encountered with extremely high voltages, magnetic acceleration appears to be more practical. The main disadvantages of either electrostatic or magnetic ion systems, however, are that thrusts obtained are relatively small when thinking in terms of escape from the earth's gravitic field, and as in the case of the earlier nuclear systems, the material to be ionized has to be carried for space flight.

But there are certain distinct advantages. For one, being an electrical rather than a heat engine, there is no theoretical limit to the amount the particles could be accelerated except that imposed by relativity, which is the speed of light. The practical limit, of course, is the amount of electric power which is available.

Such a magnetic accelerator would probably look much like a ramjet, and in fact might actually work as a "zip" fueled ramjet in the atmosphere, switching gradually over to magnetic acceleration as it rose into the ionosphere where virtually all the particles are already ionized.

Nobody seems to doubt that such a vehicle would automatically include a nuclear electric power source. Radiation from the reactor would probably also be used to ionize the propellent.

The photon rocket is a theory. It would use light for thrust. The idea is based on Relativity's assumption that energy (light) has mass, thus permits utilization of momentum transfer.

Theoretical calculations done on photon propulsion indicate that it would be most useful probably for space travel over great distances—outside the solar system.

Another kind of propulsion that might find practical application in free space but within the solar system, as in an artificial satellite or some other vehicle that was never concerned with operation within the earth's atmosphere, would utilize solar power. Large mirrors would gather the sun's light and use it to heat hydrogen or some other light gas.

Research into anti-gravity takes various courses ranging from theoretical calculations and subnuclear studies with bevatrons and the like to simple empirical work on the relationship of gravitic and inertial mass. Basically what still seems to be needed is some break in the laboratory or in the calculations that would point the way in which to proceed.

Gravity remains probably the most baffling mystery facing science today. Solution of that mystery, however, would bring a greater revolution in man's approach to his environment promised by nuclear power.★

FUSION FOR FLIGHT

A major goal in researching propulsion systems of tomorrow is development of an idealized nuclear rocket based on controlled fusion. The first step is to find a means of containing such a reaction. It is believed that fusion occurs at the sun's center at 20 million degrees and at a pressure of 400 billion atmospheres. At normal pressures it's estimated that the thermonuclear reaction would be self sustaining at about 100 million degrees.

In this connection it's significant that Britain's Atomic Energy Authority is building equipment at its research establishment at Harwell, Buckinghamshire, to do just this. It will consist of a "huge" glass container, in the center of which the reaction is to be contained by magnetic fields. The AEA claims to have already produced temperatures of two million degrees in small scale equipment without having caused damage to the container.

Cold fusion is another possibility. This involves catylization by the negative mu meson of thermonuclear reaction at reasonable temperatures, but with a full release of energy. This reaction has been observed by Dr. Luis W. Alvarez in a hydrogen bubble chamber at the University of California at Berkeley. Provision of an adequate, controllable source of negative mu mesons presents formidable problems. This work is still at the level of basic theory.

Meanwhile work is continuing in Britain, Russia and the U.S. to contain the hot reaction magnetically. An excellent summation of U.S. efforts in this field was recently given by Chairman of the Atomic Energy Commission, Lewis L. Strauss:

"In seeking the means of heating and confining the ionized gas, the scientists in the Sherwood Program (The Atomic Energy Commission's code word for the controlled thermonuclear program) are working with what some of them termed a 'Magnetic Bottle.'

"Electrically charged particles can be controlled by magnetic lines of force, supplied by suitable coils or by powerful electrical currents passing through the plasma itself.

"The magnetic lines of force cause any ionized particles to be deflected whenever it tries to cross them. The particles, instead of crossing the lines, are compelled to spiral around them. Thus, with the 'Magnetic Bottle' we seek to throw up invisible barriers to prevent the plasma from coming into contact with the walls of the tube.

"The scientists believe it will be possible, in such a system, to contain the plasma at a temperature of more than 100-million degrees, while the walls of the container remain relatively cool, or at least well below the melting point of the material.

"Here we come up against another baffling problem, perhaps the most difficult problem of all. 'How do we set about making the Magnetic Bottle as nearly leakproof as possible?' When the magnetic lines are employed as barriers against escape of the plasma, pressure is built up inside the lines with resulting instability of the plasma. The lines behave much like rubber bands. They're inclined to bend inward and let the plasma flow out around them. Our scientists are hard at work at the present time on this problem of instability.

"The magnetism must be just strong enough to confine the ionized gas at the right density and temperature and to maintain that confinement long enough for a reaction to take place. Since the reaction raises the temperature, the magnetic field must have variable qualities. It must grow stronger when necessary to keep things in balance. We must be able to draw power out of the thermonuclear machine without disturbing its tricky balance.

"In our research on this particular problem, some of our scientists are working with what is known, in the parlance of the laboratory, as the 'pinch effect.' They are trying to regulate the strength of the magnetic field, and obtain a direct interplay between the magnetic energy and the energy of the plasma; in other words, to produce a balance.

"A heavy current, such as a bolt of lightning, can squash a copper drain pipe through which it passes. The 'pinch' is the same phenomenon in a gaseous discharge. This is based on the familiar fact that parallel circuits carrying currents in the same direction attract each other.

"In applying this fact to controlled thermonuclear research, the scientists are seeking through heavy discharges of electricity to 'pinch' the atoms of the plasma together and suspend them in a thin line away from the container.

"Interesting results are being obtained in this particular effort, but the problem is far from being licked; perhaps even years from its solution."

"We have produced very high temperatures for the briefest fraction of time from these 'pinched' discharges. But the time during which these can be maintained, at present, is reckoned only in microseconds. As yet, the 'pinch' is not fully stable.

"And, of course, to be valuable for the purposes of producing power, the atoms to be fused together must be held in a tight bundle long enough and at a temperature high enough for an appreciable number of them to fuse. Furthermore, the energy output must far exceed the amount of energy that is required to produce the reaction.

"As I stated at the beginning of my remarks—I should like to emphasize again—we are making progress, but the problems are formidable."

Three nations have made public announcements that they are working towards controlled nuclear fusion. They are the U.S., Britain and the Soviet Union. The latest position report on the British program is noted above. The Russians, as usual say little. However, it's known that their thinking in this connection, at least, is very advanced.

U.S. progress can best be described as at the stage where scientists are seeking to get to a stage comparable to the first fission reactor which was built by Enrico Fermi's group in 1941. As of April 1, according to AEC's Chairman, "There has been nothing yet that could be described as a major breakthrough."

Efforts to achieve controlled fusion, however, are getting a $10-million boost from private industry. The Texas Atomic Energy Research Foundation last month signed a contract with General Atomic Division of the General Dynamics Corporation for a four-year research program in the field of controlled thermonuclear reactions. The Texas foundation is supported by private electric power companies operating in the Southwestern United States.

Though their objective is controlled fusion for the production of electric power, any such reaction that worked safely and economically would be a major step forward in the search for a fusion rocket. Research under this project will be carried on at General Atomic's new multi-million dollar John Jay Hopkins Laboratory for Pure and Applied Science at San Diego.

Atomic Power Packages For Missile Launching Sites

As MILITARY strategy and tactics enter the era of operational missiles like *Snark, Navaho, Bomarc, Thor, Jupiter, Atlas* and *Titan,* problems switch from exciting to essential.

It's one thing to build a missile and test fire it from point A to point B. It's quite another to develop reliable, mobile support equipment for servicing and firing missiles from any point in the world as required by a military situation.

The primary task is development of a source power to keep an operational missile base functioning. There are crews' quarters to be supplied with heat and light; radar and other electronic gear to be powered; gantries and launching gear to be powered; oxygen to be separated from the air, purified and liquified; fuel and oxidant to be pumped, etc.

Ideally this power unit should be air transportable—perhaps ultimately air dropable—and it should contribute a minimum to logistical supply problems. It should be an atomic power plant.

Recently the first test prototype of just such a power plant began operating at the Army Engineers' Research and Development Laboratory at Fort Belvoir, Va. Heavily encumbered with extra-special safety shielding and precautionary measures because of its proximity to the nation's capital, the Army Package Power Reactor, APPR-1, is anything but packageable and anything but air transportable. However, its basic components, stripped of the probably-unnecessary additional "catastroph shielding," form the basis of just such a mobile unit.

At the present time a joint Army-AEC program has been established with the objective of developing a family of nuclear powerplants to meet the requirements of Army, Navy and Air Force. The large plants will be capable of use in areas where logistical support is difficult, costly, or vulnerable to interruption by enemy action.

Smaller plants are to be developed as mobile or semi-mobile compact powerplants for support of military operations in theaters of operations and for emergency power requirements.

The great military advantage of nuclear power is the elimination of all but a small fraction of the logistic effort which otherwise would be required to transport and store bulky conventional fuel.

The Army Package Power Reactor, APPR-1, is designed to operate at full power for a year and a half on a single charge of nuclear fuel, which

General view of the Army Package Power Reactor, with the vapor container at left. This heavy concrete dome is a major part of the extra precautionary measures taken because of the plant's proximity to the nation's capital.

is smaller than a barrel and weighs only a few hundred pounds. Over the same period a comparable conventional plant would consume some 60,000 barrels of fuel oil, equivalent to the capacity of a medium-size tanker.

Our Arctic base system is a good example of a power requirement where use of nuclear power offers a great advantage. Ship supply is seasonal, limited to the short ice-free period of less than 60 days each year. Unfavorable weather may completely throw out of adjustment the re-supply schedule for any one year to say nothing of what enemy attack would do.

In more temperate climates there are also bases which in ordinary times are subject to delay in re-supply due to their remoteness. In time of war their existence at the end of long, vulnerable supply lines is precarious.

The use of nuclear power would reduce total supply tonnage required to support many of these bases to less than half of that required when using conventional powerplants.

In addition to the present requirements, a situation of war would multiply power requirements for military operations and disaster relief. The use of nuclear power to satisfy these demands would simplify the difficult logistic problem which they create.

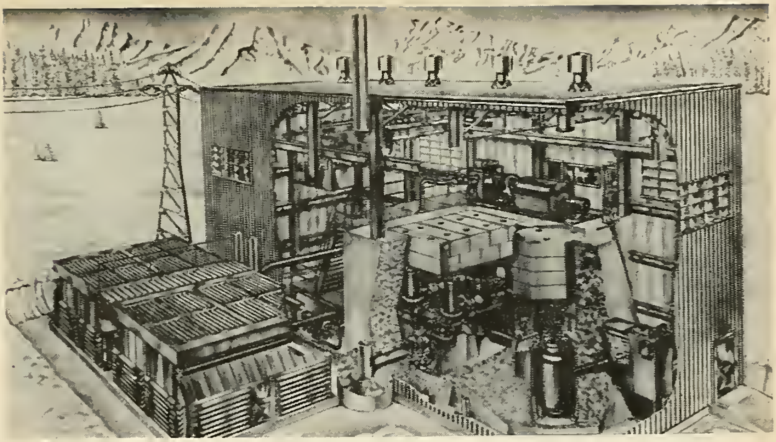
The military need for a family of such nuclear powerplants was established as the result of a series of investigations begun during 1952 by the Corps of Engineers.

As a result of these studies, the Army recommended the construction of a prototype nuclear powerplant in the U.S. In late 1953 the Defense Department approved the Army's plans and requested the Atomic Energy Commission to undertake the necessary development program. Shortly thereafter a joint organization was established to coordinate AEC and DOD activities in the Army Nuclear Power Program.

The Corps of Engineers representing the Army, has been given the responsibility for development of the non-nuclear portion of the plant on behalf of the Department of Defense. The Army Reactors Branch within the AEC fulfills the Commission's responsibilities for development of the reactor and associated equipment.

Three general categories of military nuclear powerplants are already being developed under this program. The first category covers fixed plants to furnish electric power and heat at remote and relatively inaccessible military installations where the cost of conventional fuel is high.

In the second category, development has been started on mobile nuclear powerplants for support of military operations and for emergency power systems. The objective is to develop plants which can be mounted on trailers. railway cars or barges, with essentially no requirements for replacement fuel or water for the duration of military operations. Two major projects are now under way.



This artist's conception shows how simplified such an atomic power plant might become once it has been stripped of such things as class-rooms and all but the most essential shielding.

The third category covers special-purpose nuclear reactor systems. Feasibility studies are being conducted on nuclear propulsion of land vehicles. The Transportation Corps is directing particular attention to a nuclear-propelled "sno train" suitable for overland supply of arctic bases.

A special-purpose reactor is about to be constructed to furnish ionizing radiation for use by the Quartermaster Corps in the irradiation and preservation of food.

Army Package Power Reactor is the first prototype of a field, military, nuclear power plant to be built as a result of this program. It has been constructed to accomplish three broad objectives:

Solve technical construction and operation problems associated with a reliable nuclear power plant.

Provide firm cost information, operating parameters and engineering test data necessary to adapt the system to a remote location.

Provide a training facility for troops and specialists who might eventually be required to operate and service remote plants.

Early in 1954 the Commission invited proposals from thirty-three major industrial firms for complete design, construction, and test operation of a prototype nuclear power plant, the APPR-1. Eighteen proposals were received in response to this invitation, and in December of 1954 the contract was awarded to ALCO Products Incorporated. The contract provided for guaranteed operation, to be established by a 700 hour performance test and a six-month operating test during which the plant would be producing usable power. The provision for a fixed price was the first such agreement in the awarding of reactor contracts.

After a survey of various locations within the U.S., and with the approval of the Atomic Energy Commission's Advisory Committee on Reactor Safeguards, the Engineer Research and Development Laboratories area at Fort Belvoir, Va., was selected as the plant's site. Since it will be in a heavily populated area, elaborate precautions have been taken in the design to insure maximum safety of operation. In addition, the reactor core will be located within a container designed to retain all radioactivity even in the event of a major incident.

The plant's design as conceived by the Oak Ridge National Laboratory and as detailed by ALCO, is based upon a pressurized water reactor operating at a power level of 10 megawatts. Pressurized water circulated through the reactor, is heated and passes to a heat exchanger where it transfers its heat to a secondary loop of water.

This heat converts the secondary water to steam which is then used to drive the turbine. The net electrical output of the plant will be utilized to supplement the Fort Belvoir power distribution system.

Construction of the plant was begun on October 5, 1955. The 700 hour performance test is scheduled to be completed before July 10, 1957. Trained men from all three military services will assist ALCO in starting and operating the plant in anticipation of the day when the plant will be turned over to the military. Experienced cadres for future nuclear power plants will be taken from this group of military operators.★

International Control of Outer Space

What Will Outer-Space Missiles and Advanced Earth Satellites Mean to World Security?

By Dr. Donald W. Cox

IN THE LONG HAUL our safety as a nation may depend upon our achieving space superiority . . . Several decades from now the important battles may not be sea battles or air battles, but space battles . . . We should be spending a certain fraction of our resources to insure that we do not lag in obtaining space supremacy."

Major General Bernard A. Schriever, Commander of the Western Development Division of the Air Research and Development Command, USAF, made this statement before the first government-industry sponsored "Space Symposium," held in San Diego last February.

The significance of this challenge by an Air Force official, who, probably more than any other man alive, is closer to the realities of the coming space flight age, is worth pondering. With the announcement of the first successful IRBM launching and hints that the first earth satellite might not be too far off, it is not too early to consider possible future legal problems involving ownership and use of the last unexplored frontier—space.

A noted international lawyer, Wilfred Jenks of Great Britain, recently summed up the need for promulgating a body of space law that will be mutually accepted by all nations.

He wrote: "It is not premature for international lawyers to give some preliminary consideration to the problems which will confront them as a matter of urgency if the current efforts of scientists and engineers, specializing in astronautics and electronics, should suddenly achieve a dramatic success . . . There are circumstances in which the possibility of developing the law on sound principles depends primarily on initiative being taken in the matter before de-facto situations have crystallized too far. The exploration and exploitation of space may proceed as slowly as the course of polar exploration or the conquest of Everest; they may however, develop as rapidly as the utilization of atomic energy, or of rocket propulsion. It is wise to be prepared for any eventuality."

With technology beating a steady tom-tom on the door of outer space, a search for a rational and acceptable space control theory is essential to help insure civilization's survival.

Theories of Space Control

In the past few years, several renowned international lawyers have taken an interest in space law in its embryonic state. Their theses have appeared in such journals as: MISSILES & ROCKETS, *Jet Propulsion, The Journal of Air Law and Commerce, The Nation's Business* and *The International and Comparative Law Quarterly.*

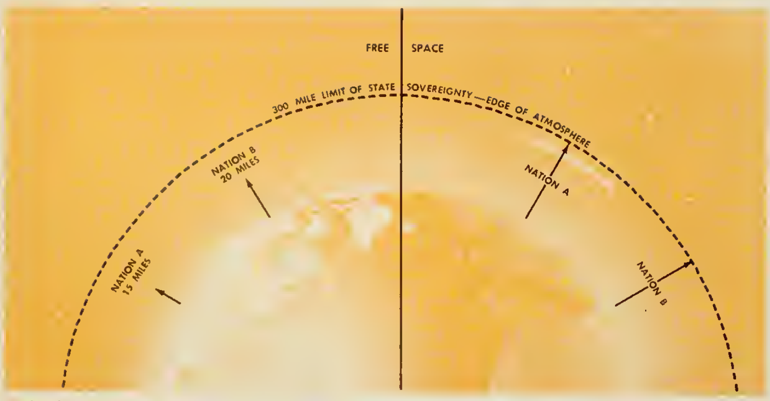
Excerpts and briefs of four of the leading theories will be analyzed here:

Oscar Schachter, an English international lawyer and a Director of the UN General Legal Division has fathered the Airspace Theory, which is adhered to by many U.S. experts.

Schachter's theory holds that national sovereignty upwards is limited to navigable airspace which will reach a maximum of 40 miles in the future.

This doctrine sets some legal precedents. This is evident in the multilateral air treaty agreed to by 49 nations at the Chicago Convention of 1944. Although this treaty is adhered to by most of the civilized world in granting exclusive sovereignty to airspace over national territories, it does not define the term "airspace." Because of this, there is no general agreement of height limit to sovereign control by the leading nations.

This theory is unrealistic since nations today do as they please except where treaties or their own best interests dictate otherwise. Space law like international law, therefore, will probably develop according to the relative



Shachter's "Airspace" theory—State sovereignty is limited to the height at which aircraft and balloons can operate.

Jenk's "Free Space" theory—State sovereignty is limited to activities within the limits of the earth's atmosphere only.

power of various nations instead of through any master plan. Failure to perceive the power realities is the major flaw in the workability of this theory.

Jenks' Free Space Theory

Mr. C. Wilfred Jenks, L.L.D., an Associate of the Institute of International Law at Cambridge, England, has written "International Law and Activities in Space," (1956), in which he propounds a *Freespace Theory*. In a 6-step program, he theorizes that:

(1) The appropriation of outer space by any one nation is impossible because of its nature. State sovereignty is limited to activities within the atmosphere with control similar to that "exercised in territorial waters or over a wider maritime frontier belt."

(2) Jurisdiction over space activities should be vested in the U.N.

(3) Failing this, jurisdiction should be determined by analogies to maritime and aviation law.

(4) Rules will be necessary to protect national authorities in space.

(5) The sovereignty of the moon should be vested in the U.N.

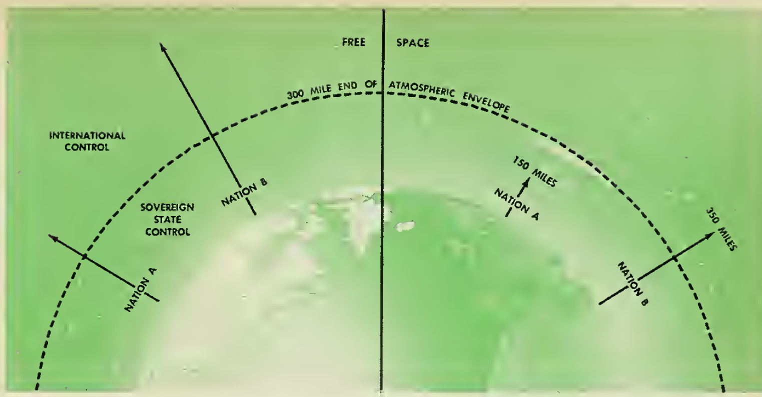
(6) The natural resources of the moon should be vested in the U.N.

Although Jenks' theory appears to be more realistic than Schachter's from a power competition standpoint, it, too, would establish an illogical power control limit at the edge of the atmosphere. Will those nations which perfect a device to penetrate outer space submit to such a limitation?

Some moralistic nations might acquiesce to such a hypothetical limit, but not immoral ones.

Haley's International Unanimity Theory

Andrew Haley, General Counsel for the American Rocket Society and one of the two most prominent international space lawyers, has written several articles on space law. In one of his more comprehensive tomes, he propounds a theory which we will call the International Unanimity Theory.



Haley's theory—Extra-atmosphere "might" be subject to sovereign control; with international control for peaceful purposes.

Cooper's control theory—Sovereignty extends as far as a nation is able to govern those events occurring over its territory.

Haley theorizes that areas above the atmosphere (roughly 300 miles and up) *might* be subject to sovereign control by one or more nations. But the now historic fact that no nation objected to the plan to send earth satellite vehicles over their sovereign territories during the IGY, leads Haley to conclude that the sovereignty of space has been, ipso-facto, given to the U.N.

This mutual understanding will undoubtedly continue as long as outer space is to be used for peaceful, exploratory purposes, or as long as no one nation has the ability to intercept a satellite or space missile. Haley feels that the "scientists in the IGY Program have benefited mankind as a whole in a field where the lawyers might well have failed."

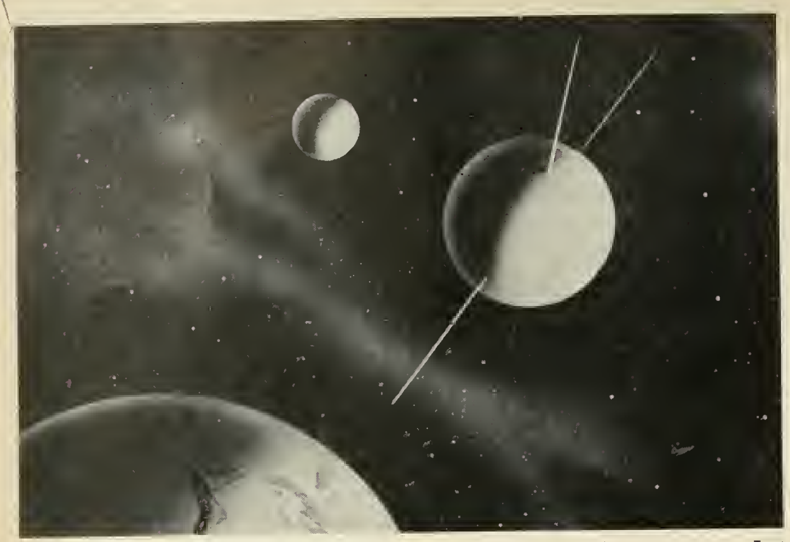
He says that the present body of international law, based on maritime jurisdiction and restricted aviation law is entirely "hostile" to the realities of space flight and is therefore inadequate. This inadequacy applies to both civil space flight rules and rules of space war. This is why a new system of space law, under the U.N., is needed.

Haley's plan calls for a mutual agreement on space communications. He rules out the possibility of any nation, with outer space capability, breaking a U.N. agreement and offers no plan if such an event should occur, putting his faith in the peace making machinery of the U.N.

Cooper's "Control" Theory

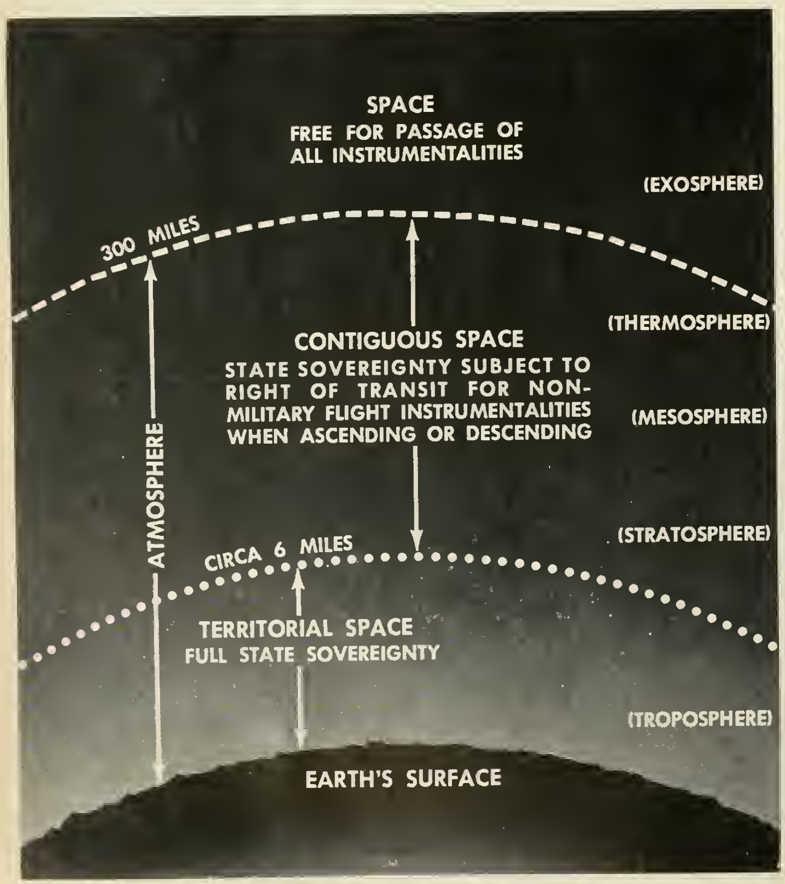
John Cobb Cooper, the Dean of American International Air Lawyers,

Advent of the ICBM and the hypersonic rocket glider calls for planning now to solve future legal problems involving ownership and use of space. Regulations are needed to insure peaceful exploration of our last frontier. One theory calls for a uniform code covering such activities as: instrument-carrying missiles and satellites, space radio communication, navigation, space stations and passenger transport.



An artist's view of the artificial earth satellite and the moon as seen from outer space. Fact that it is to be sent aloft during the IGY program should spark public interest in space law.

formerly Chief Counsel for Pan American World Airways and currently a member of the Institute of Advanced Studies at Princeton, has propounded a Power Theory of Space Control, which is unlimited in its scope. It is based on the assumption that a nation's ability to govern activities over its territory varies only with the nation's ability to penetrate up into space.



Cooper's "Tri-space-level" theory, as adapted from the Journal of Air Law and Commerce.

According to this theory, one nation may not be able to launch a vehicle which can escape the confines of the earth's atmosphere—while another one may be able to reach out well beyond the space frontier.

Realizing the efficacy of potential future space rivalry, Cooper proposed that an amendment to the 1944 Chicago Convention be adopted to restrict space power enthusiasts.

He feels that full state sovereignty could be maintained in the territorial space between the ground and a 10 mile high altitude in the troposphere. However, he felt state sovereignty should rule between the 10 and 300-mile levels, in what he termed "contiguous space," subject to the right of transit for flight instrumentalities when ascending or descending.

Space itself, he feels should be kept free for the passage of all intrumentalities, military or civilian, with any nation having the right to launch space flying vehicles as high and far as they wish.

Such an eventuality was predicted by General Schriever at the first Space Symposium last February, when he supported the concept of using ICBMs as a lever for the U.S. exploration of Space. He emphasized the direct military importance of space to the U.S. and added that the nation's prestige as a world leader "might well dictate that we undertake lunar expeditions and even interplanetary flight when the appropriate technological advances have been made and the time is ripe."

However, according to Haley, Cooper's rule of space control "presents the disquieting prospect that a state with extraordinary scientific resources could extend an empire into deep space. It is a counterpart of the might makes right principle which pervades maritime law and kept England mistress of the seas for centuries. This rule . . . imposes a limit over national sovereignty." This would give Cooper's theory an empirical limit.

The trouble with Cooper's control theory is that sovereignty is limited only by relative state power.

Nations that possess the capability to blast any satellite or missile from the skies overhead, regardless of their purpose, could do so at will, while other nations would be helpless to do anything about various types of spacecraft passing over their territory or to intervene in support of a friendly space exploring nation.

The concept of space ownership as envisaged by these four theorists does not call for a universally agreed space code.

However, certain common assumptions seem to be held by all the theorists studied, regardless of their differences on application of individual theses of space law and rules.

However there is general agreement that there is an inherent conflict between the doctrine of freedom of the seas and that of state sovereignty over territorial airspace. Rules for the former seem to be more applicable to outer space vehicles than the latter.

The inability of present rigid "air curtains" over fixed territorial boundaries, to adapt themselves to the constant changes of spatial relationships of a space vehicle, due to the rotation of the earth. is the logical determinant which negates the present state sovereignty air law.

All four theories propose some limit on national air sovereignty, which should be enough to seal the coffin on this present doctrine and to prevent its application to space flight.

Because missiles and space stations would be constantly changing positions, new, progressive legal regulations are needed to insure the peaceful exploration and exploitation of space.

Jenks proposes eight such regulations which still need to be written and agreed upon by all the nations, in a progressive series of steps. International uniformity will be necessary in most of these rules to guarantee civilized activities in space and to keep space instrumentalities under proper control. The legal regulations which he prescribes would encompass the following:

(1) Instrument-carrying missiles and satellites; (2) A Navigation code in space; (3) A space radio-communication code; (4) Certification of space navigators and other space persons; (5) Rules governing construction of space stations, bases, etc.; (6) A space rescue code; (7) Rules governing the carrying of passengers and goods; (8) Rules determining the law applicable to legal transactions occurring in space.

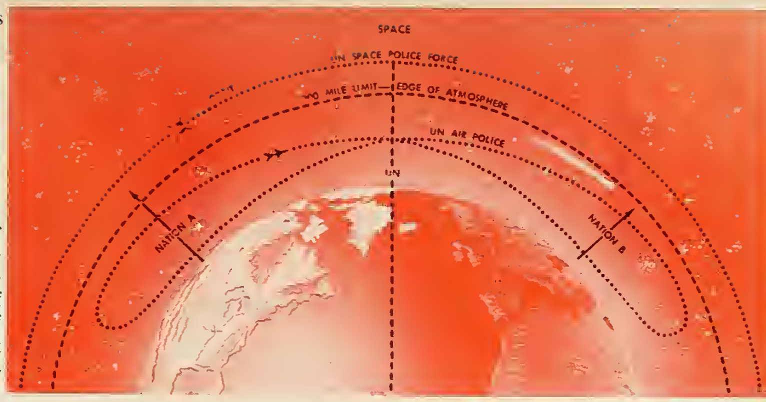
In preparing an ultimate space law code, we can learn much from the "freedom of the seas" maritime law established by Grotius.

Need for a New Theory

There is an important omission in all four theories of space control: recognition of the need for a UN space police agency to control and patrol the interplanetary regions.

The precedent for the feasibility of such an international space police force has been the relative success of the recently organized first international police force which has been operating on the ground only in the disputed areas between Egypt and Israel. To make sure that any power-mad nation or nations does not usurp their free space prerogatives, a police force will have to come into being. The vehicles could be supplied by the major earth national powers, but the crews could be composed of space police-navigators recruited from secondary or neutral UN powers (much like the present Suez Police Force). Space control stations on earth could also be supervised and monitored by UN designated teams, even though constructed and owned by sovereign nations.

Note: The views expressed in this article are the author's and do not necessarily reflect those of The Martin Co.



An "International Space Force" theory would have both United Nations air police and a UN space police force.

Without a permanent UN space police organization, in advance of any space dispute, Haley's *International Unanimity Theory* is in danger of being compromised.

Haley hits at the necessity of guaranteeing the joint world ownership of space in the following statement:

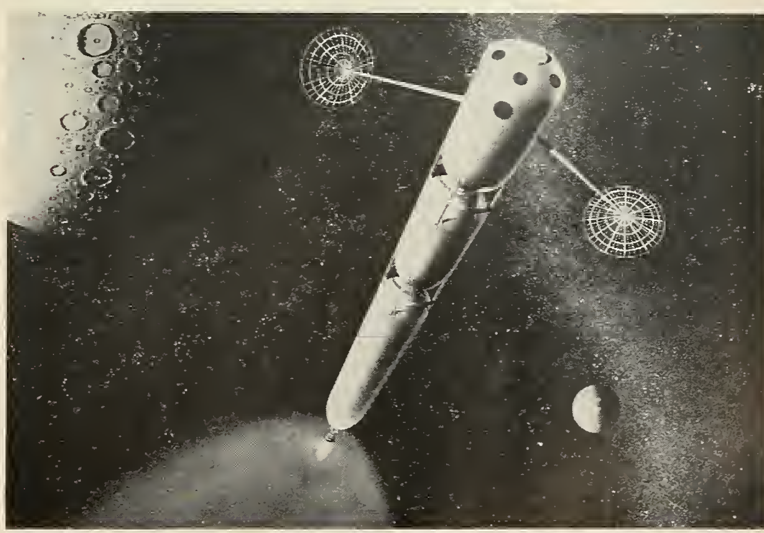
. . . "These principles must necessarily have only interim application, for there must be a basic principle that the regions beyond the aeropause may be called by no nation; mankind may make only such utilization of space as will be for the benefit of all mankind and to the detriment of no other intelligent creature."

The expansion of the first UN police force's duties in the Suez dispute points up the faith which the Free World has in such an organization.

The extension of the UN's control to the upper air and outer space regions with its own air and space force is a need which merits immediate consideration for initial planning purposes.

An international air-space police force could be established in a series of steps, with the conventional UN air police force patrolling the air over the Poles, oceans and uncivilized desert and jungle regions.

Such experience would provide the force with valuable insight into the greater problems with which they will have to cope when their duties are extended to the upper atmosphere and eventually to outer space.★



When space becomes a highway, who will control the traffic.

SHIPS for SPACE

Some systems considerations on high performance power plants

By Dr. Peter A. Castruccio

Westinghouse Electric Corporation
Air Arm Division

FIRST ESSENTIAL for practical space-flight is an economical propulsion plant. Present-day power plants are almost adequate for exploratory expeditions, but they do not fulfill the requirements for military usage of spacecraft. Military vehicles should possess mobility: to maneuver essentially at will, to deploy in formations as required by their mission, and generally should adapt to a wide variety of kinematic and dynamic conditions as may be dictated by the maneuverings of an intelligent adversary.

Among the missions which military spacecraft will be required to perform are: reconnaissance of enemy territory, bombing missions, rescue operations, refueling in flight, and battles with other ships, stemming from the adversary's desire to thwart these missions.

These requirements necessitate that military ships have a sufficient "acceleration reserve" above and beyond the bare minimum necessary for takeoff and subsequent landing. These craft must be able to endure prolonged periods of sustained, even though not intense, acceleration.

The basic, and only propulsion system so far considered practical for space flight is the reaction principle, based on the law of conservation of momentum. According to this law, if a body of mass M + m ejects a fragment of itself of mass m with a speed v, the body M will receive a "recoil" speed equal to $\frac{mv}{M}$.

This is true for a "one-shot" ejection. If the ejection becomes continuous, as in a rocket motor, the law of recoil states that:

$$a\ M = q\ v \qquad (1)$$

where a is the acceleration imparted upon the mass M, v is the jet velocity, and q is the mass ejected per second (flow). It should be noted that (1) is only true instantaneously: as time progresses, the mass M will constantly diminish by the amount of the ejected mass, so that the acceleration will increase as time goes on (if q and v are maintained constant).

From Equation (1) we derive this expression for the acceleration:

$$a = \frac{qv}{M} \qquad (2)$$

This means that a ship of mass M can theoretically achieve any desired acceleration by using a sufficiently high qv product.

A space vehicle with high acceleration reserve should be designed to use as little reaction mass as possible in order to make the reaction mass last for as long as possible.

A reduction of reaction mass can be obtained by an increase in the jet velocity v, maintaining the product qv constant. Equation (2) shows that as far as acceleration capabilities are concerned, we can trade indifferently reaction mass for speed of ejection.

The Power P required from the ship's power plant to eject a flow of

TABLE 1

Spaceship Loaded Weight = 100 Tons
Mass Ratio = 1.09
Reaction Mass = Mono-ion H^2

Acceleration	Power Output HP	Accelerating Voltage	Flow	Time to Burn-out	Burnout Velocity Miles/Sec.	Time Required to Cover 50 Million Miles—Start From Rest, End at Rest
1g	2 Billion	100 KV	11.5 Oz/Sec	8.6 Hours	194	5.8 Days
0.1g	200 Million	100 KV	1.15 Oz/Sec	86 Hours	194	7.8 Days
0.01g	20 Million	100 KV	0.12 Oz/Sec	36 Days	194	21 Days
1g	70 Million	100 Volts	22 Lbs/Sec	1000 Sec	6	200 Days
0.1g	7 Million	100 Volts	2.2 Lbs/Sec	10,000 Sec	6	200 Days
0.01g	700,000	100 Volts	3.5 Oz/Sec	1.16 Days	6	129 Days
0.001	70,000	100 Volts	0.35 Oz/Sec	11.6 Days	6	66 Days
0.0001	7,000	100 Volts	0.035 Oz/Sec	116 Days	6	244 Days

The practical realization of a high performance rocket ship hinges upon three basic developments:

1. A means to achieve high jet velocities.
2. Development of power plants of high specific power.
3. Development of energy sources of high specific energy.

A practical means to achieve high jet velocities is the acceleration of charged electrical particles.

A body of mass m and charge e, in passing through an electric field of V volts acquires a speed:

$$v = 2\ \frac{e\ V}{m}$$

mass q per second at speed v is ½ q v^2. By substituting (2) in this latter equation, it is easy to show that the required power is:

$$P = \frac{1}{2} M a v$$

This means that, for a given ship mass and acceleration, the power required from the ship's power plant increases directly with jet velocity (and inversely with the flow of reaction mass): thus a reduction in reaction mass can be achieved only at the expense of increased power.

Let us also assume for simplicity, that the reaction mass required for the trip is small compared with the ship's own mass, so that the simplified equations given above can be used; consider now two ships, starting from the same point, and of identical masses. If both ships travel with the same acceleration, one with a low jet velocity, the other with a higher jet velocity, both ships will cover the same distance in the same time, in other words, both will perform the same amount of external work. The ship with higher jet velocity will use a greater amount of energy than the other. Precisely, the energy used is proportional to the jet velocity.

This points out a basic law of the rocket motor: more power and more energy is required to perform the same amount of external work if the reaction mass must be economized.

A measure of basic rocket efficiency can be had by consideration of the following simple case. Consider a ship in a gravity-less field, starting from relative rest, and required to travel from Point A to Point B, a distance d apart.

Assume the trip is performed by constantly accelerating with acceleration a for half the distance d, then decelerating at the same rate until B is reached with the ship at rest. (This is almost optimum from the standpoint of power reduction.)

Under these conditions, the external power required to perform the trip is:

$$P_e = Ma^2$$

The power required to propel the ship via the rocket mechanism (the actual power the rocket must expend) equals:

$$P_r = Ma^2 \times \frac{M}{2q}$$

The ship's power must be greater than the external power by a factor $\frac{M}{2q}$

The quantity $\frac{2q}{M}$ can be considered as a measure of the basic "power efficiency" of the rocket propulsive system. The efficiency is obviously lower, the lower the reaction mass ejected. We reach the following general conclusions:

— Reaction mass can be economized by increasing the jet velocity.

— Any reduction in reaction mass must be paid for by an equivalent increase in energy expenditure.

— Any reduction in reaction mass must be achieved by a corresponding increase in power capability of the power plant.

It follows that a ship capable of sustained accelerations with economy of reaction mass must possess an energy source with high energy per unit weight, and a power plant capable of high power output per unit weight. Nuclear reactors satisfy the energy storage requirements; however the power plant is another matter.

As an example of the quantities involved, consider a ship of 100 tons weight (about the size of a DC-8), to be propelled at an acceleration of lg, with a total reaction mass of 10 tons. At a flow of 1 kilogram (2.2 lbs.) per second, the power output required will be 700 million HP. Such a ship will possess almost three (3) hours acceleration capability.

Starting from rest in gravity-less space, this ship could attain a speed of 35 miles per second, and still have sufficient reserve mass to decelerate again to rest. The total energy required to exhaust the reaction mass is equivalent to 25 lbs. of U238 at full efficiency.

By contrast, the external power required to do the same job is only about 13,000 HP.

These figures point out the huge inefficiencies of the rocket mechanism, and the tremendous discrepancies between energy requirements—which are low in terms of nuclear sources—and power requirements, which are great.

The power requirements can be reduced by either increasing the flow (the power reduces directly as the flow is increased) or by decreasing the acceleration (the power reduces as the square of the acceleration). Thus, if our ship be limited to a 0.01g acceleration, with the same flow, the power output is reduced to 70,000 HP, and the energy is reduced by a factor of 10,000. The terminal velocity reached by the ship will be only 0.7 miles per second. Table I, above, gives various relationships pertaining to the assumed ship model.

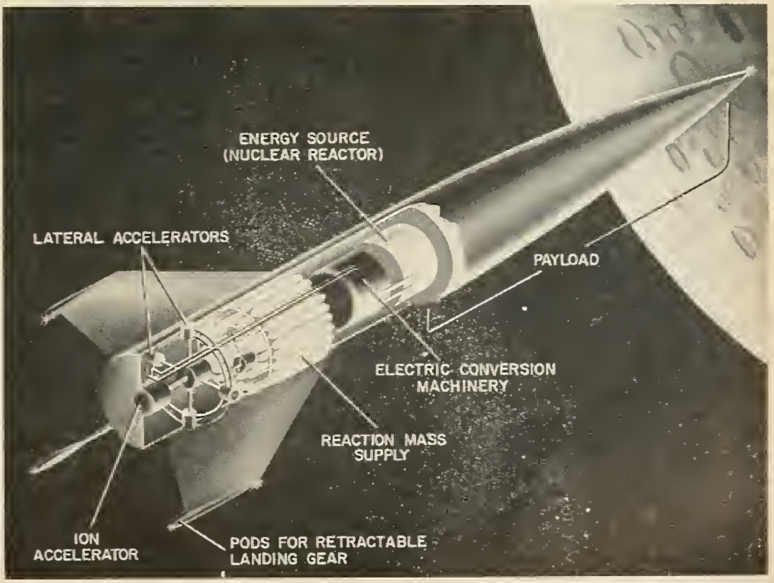
The speed is seen to depend on the charge-to-mass ratio e/m. Thus lighter particles will be speeded up more than heavy particles.

Electrons can be accelerated at higher speeds than any other particle. Electrons, however, do not constitute desirable reaction material because their total mass is but a small fraction of the mass of even the lightest substance.

In a given amount of electron-emitting metal, for instance, less than $\frac{1}{100{,}000}$ th of the metal's mass is composed of electrons.

Even if it were possible to strip a given amount of material of all its electrons, the mass of electrons thus gained would be insignificant with respect to the total mass of the material. At such low masses, extremely high jet velocities would be required and thus the power requirements would be enormous.

The converse process to electron generation is ion generation. Ions possess practically the entire mass of the reaction material, and can still be



Proposed layout for an ion-propelled space vehicle.

An ion propelled space ship accelerating at 1 g would have a power output of some seven million horse-power. A mythical cable car to the moon accelerated from an outside source would take 13,000 horsepower.

accelerated to high velocities by reasonably strong fields.

In theory, the basic concept of the ionic rocket motor is simple: the reaction material is passed through an ionizing device: the ions so formed are accelerated through an electrostatic or electromagnetic accelerator, and are ejected in space beyond the rocket.

The criteria for design of an ionic power plant depend on the intended use for the ship carrying the plant.

Generally, the known data will be: the mass of the ship, the mass of the reaction material, and the power output available from the power plant.

If the ship is required to reach the highest possible top speed with the available reaction mass without regard for the time involved, the motor should be designed to yield the highest possible jet speed. This stems directly from the "rocket equation":

$$V_f = V \times \ln \frac{M + Mr}{M}$$

where V is the final velocity attained by the rocket, Mr is the reaction mass, M the ship's "empty weight."

In this case it will be desirable at least in theory, to use ions of high $\frac{e}{m}$ ratio, namely light ions, such as hydrogen.

The characteristics of this mode of operation are: low acceleration, low values of jet flow, low power requirements:

As an example, assume a ship of the following characteristics:

Total Weight: 100 Tons
Reaction Mass Weight: 10 Tons
Power Plant Output: 10,000 HP

Assume H_2 is chosen as the reaction substance: a linear accelerator operating at 100 KV is used. The jet velocity will be 3,000 Km/sec. The acceleration turns out to be 0.000005g's.

At burnout, the ship will reach a velocity of 285 Km/sec.: it will employ a little over 180 years to reach this speed. During this time the ship will cover better than 500 billion miles (in gravity-less space). The flow will be 1.66 milligrams per second. The total need will be equivalent to 200 pounds of U238 at 100% efficiency.

In this case, the time lapse involved is undoubtedly excessive. A better criterion is the requirement to cover a given distance (in gravity-less space) in a given time for the minimum amount of power output, at a given expenditure of reaction mass. A distance d can be covered by accelerating to a given velocity, then coasting without power for a period of time, and finally decelerating back to rest: or it can be covered by constantly accelerating for half the distance, and subsequently decelerating for the other half. It turns out that, for a ship of low mass ratio, the first alternative is slightly better, if the flight parameters are properly chosen: the second method is, however, almost near optimum.

In our spaceship example, if a distance of 50 million miles must be covered in 30 days (at the specified mass ratio of 1.09), the power requirement is around 3 million HP. If the same distance need be covered in five (5) months, the power can be reduced at 24,000 HP.

At higher mass ratios, a proportional reduction in the power requirements can be secured.

We conclude that, at least in theory, an ion rocket which must reach high speeds, or which must deliver low acceleration for prolonged periods of time should have these characteristics: Reaction substance as light as possible, or with high $\frac{e}{m}$ ratio, high jet velocities and high specific power output.

If the ship's specifications call for high accelerations, sustained for relatively short times, (such as may be required to leave the Earth's gravitational field, or for certain military vehicles), then the jet velocity should be reduced, and the flow correspondingly increased, or enormous power outputs are required. For any reasonable power, the flow must be increased to such an extent that completely impractical operations result.

In our previous example of a 100-ton ship, equipped with a 10,000 HP power plant, an acceleration of 2g's calls for a jet velocity of only 4 meters/second. The corresponding flow is 500 tons/second: only 20 milliseconds are available for acceleration. (By comparison, this amount of power, applied externally, could lift the ship at a constant speed of 25 feet per second, another demonstration of the basic power inefficiency of the rocket propulsion mechanism.) Thus, the ionic rocket is definitely not a high-g device.

The ionic rocket can yield very high specific impulse; it offers in principle high performance operation at low mass ratios.

Full utilization of these advantages requires very high power outputs, and thus necessitates machinery of very high specific power, of the order of ten to fifty horsepower per pound, at high efficiencies. If such high powers are not available, we must resign ourselves to low accelerations and longer times of flight, still retaining the advantage of low mass ratios.

It is worthy of note that at high powers, efficiency is necessary to keep the heat generation down. In one of the previous examples, a power output of 3 million HP at 50% efficiency would generate sufficient heat to melt all the metal in the spaceship in less than a minute, and even at efficiencies of 95%, a good heat dissipating mechanism would be needed to insure reasonable temperatures.

Machinery such as this is completely beyond our state-of-the-art today. Thus the high-g, lightweight, high performance spaceship is still very much in the future: its realization may well require a radically new concept.★

SPACE AND SOCIETY

The relationship between astronautics and society, with emphasis on economics, has been dramatically underscored by plans for launching the IGY satellites.

Scientific achievements have, in the words of Wernher von Braun, now placed us on the threshold of the "golden technological age." He has even referred to the previous periods in civilization's advance as "bondage." Regardless of philosophy, the new scientific advances offer large fields of speculation for the economist.

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

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

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

The technological revolution knows no national boundaries. Its smokestacks, roads, railroads, power lines and industrial cities can be found on both sides of the Iron Curtain, in America and Europe, the cradle of modern industry, as well as in historically agricultural Russia and China.

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

Although the impact of astronautics on society and our economy has been felt, if economic barometers can be projected to any degree, the advances which have been made to date have been merely small, hesitant movements in preparation for the steps which will inevitably come later.

If energy controlled by man is the first factor in his steady advance, communications is the second. Mass communication has been a dream of every progressive leader in history.

Space satellites will teach us how to achieve mass communication. The increasing demand for energy will, of course, not be truly resolved until atomic energy complements other power. To be properly effective, energy must be plentiful and within the reach of the population served. This goal will be realized shortly. The satellites will speed this up. This is particularly true in radio and television.

The radio-television industry can foresee a universal series of networks. In the United States the feasibility of this has been demonstrated. European TV is equally obvious, based on the continental performance during the winter Olympics last year. Universal telephonic facilities can be projected just as easily as TV and radio. Dial an associate in Tokyo . . .

The family farm is no longer a sound economic entity. Technological advances and the scientific advances in the utilization of chemicals have doomed the barefoot farm boy with his mongrel pup and his fishing pole. Agricultural corporations with agronomists, auditors, mechanics, packers, merchandisers and salesmen make up the personnel on today's farm. Hence the economists use the term food and fiber industry.

Take the food and fiber industry for example. Proper weather charting by space satellites will bring on a new era, enable further development of the industry, creating the opportunity for greater research across the board.

To the economist, the extended development of mass communications portends great, new markets for goods and services. The efforts to achieve a measure of productivity in keeping with the demands will tax the ingenuity of the industrial engineers. But there can be no doubt of the ability of these men to cope with the problem. Automation will play an important role, as it does even now.

The need for the increased productivity will also show up the need for additional financing. It always does. Thus, the monetary structure must be considered. During periods of controlled inflation, the prosperous periods of expansion and development, investors are eager to support new developments and risk capital is fairly easy to come by. The nation is in just such a period, and indications are it will continue in this phase for a long time.

There can be no doubt that the studies produced during the IGY will, in all phases of the social structure, have a direct effect on the economic structure. Corporations seeking diversification, and expansion will find new lines to enter. Banking establishments, too, will want to support some of these productive enterprises. As a result the basic diversification of industry will probably be accelerated.

If all of these ideas can see any measure of fulfillment, then the economist will revise his thinking on a national scale and bring it up to a truly international scale.

For man will have to concern himself with the gross universal product. The fact that the IGY satellites now are estimated to cost $57 million, much more expensive than originally planned, is insignificant. This is the most promising investment man has undertaken.

In the words of von Braun:

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

"It is the ultimate objective of our great Technological Revolution to free Man from the slavery of heavy physical labor, to elevate Mankind from its historical bondage to a race of masters, in whose service toils an army of mechanical and electrical slaves.

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

Air Force Studies Ion Power

By Henry T. Simmons

INGENIOUS NEW IDEAS in the field of ion propulsion are spurring lively government and industrial interest in the charged particle as a posible key to the next big rocket power breakthrough.

Probably the most active government agency in the ion propulsion picture right now is the Air Force Office of Scientific Research, which carries out highly advanced study projects for the Air Research and Development Command. At least three AFOSR contractors are presently working on various phases of ion propulsion:

Giannini Research Corp., Costa Mesa, Calif., ion plasma jets; Avco Manufacturing Co., Research Division, Everett, Mass., means of magnetic acceleration of gases; North American Aviation, Inc., Los Angeles, a feasibility study of ion propulsion.

In addition, several companies are investigating ion possibilities with their own funds. These include The Martin Co., Baltimore, and the newly-formed Astronautics Division of General Dynamics Corp., located in San Diego.

It is doubtful whether the dollar value of present ion propulsion research exceeds $1 million a year, but it is clear that keen interest already shown in the field presages a general expansion of such activity.

This growing interest is based on a general conviction among scientists and engineers that liquid propellant rocket combustion engines can be increased in specific impulse by only about 50% over present levels, or to a figure of about 375 pounds of thrust per pound of propellant per second. Ion propulsion specific impulse figures in the tens of thousands.

Ion propulsion has some major drawbacks, to be sure. One is the fact that any ion drive requires enormous amounts of electrical power to vaporize, ionize and accelerate the particles to high velocities. An even more important disadvantage is the very small amount of thrust developed by ion systems in relation to the mass propelled. It is so low, in fact, that no ion propulsion system so far suggested can possibly lift a vehicle from the Earth without aid from combustion rockets.

A fascinating discussion of the problems and potentialities of ion propulsion was presented to the recent spring meeting of the American Rocket Society in Washington by Martin I. Willinski, an engineer employed by the Preliminary Design Section of North American's Rocketdyne Division at Canoga Park, Calif. Willinski, together with Mrs. Elsie Orr and other North American technical personnel worked up the idea of "Project Snooper" in their spare time.

Snooper is an unmanned, ion-propelled contraption which could reach the Moon, Mars or other planets, circle them at close range, and transmit its findings back to Earth by means of television and radio. The vehicle would have a total weight of 3,300 pounds, including an allocation of 1,150 pounds for an unshielded atomic reactor, heat exchanger, turbo-generator and electrical system, 280 pounds for a heat radiator, 220 pounds for propellant, 150 pounds for structure, and 1,500 pounds for payload, including guidance.

Snooper's propulsion system would consist of two ion motors which would accelerate charged particles of cesium vapor at a velocity of 657,000 fps, compared with conventional chemical combustion exhaust velocities of about 6,000 feet per second. But the system would be limited to a total thrust of about one-third of a pound, or about .0001 gravity. This would provide Snooper with an acceleration of about .04 inch per second.

Source of Snooper's power would be a fast or intermediate nuclear reactor which could operate for a year or more before the slow accumulation of poisonous isotopes choked off the reaction. The reactor would have a total thermal output of about 1,000 kilowatts, sufficient to produce about 147 kw of electrical power. Sodium would be used as a reactor coolant, giving up its heat to mercury through a heat exchanger. The mercury would drive the turbogenerator and then flow through a second condenser-heat exchanger where it would give up its heat to a sodium loop which would circulate through the huge bat-wing radiators necessary to reject unwanted heat from the cycle. These radiators would be folded around the vehicle during the boosted portion of the flight, and unfold when the ion system would commence operation.

Cesium was chosen as the propellant for a variety of reasons, although the other alkali metals—lithium, sodium, potassium and rubidium—were also considered. Cesium has the highest ionization potential of all the alkalis, the lowest melting, boiling and vaporization points of the alkali family, and the highest density.

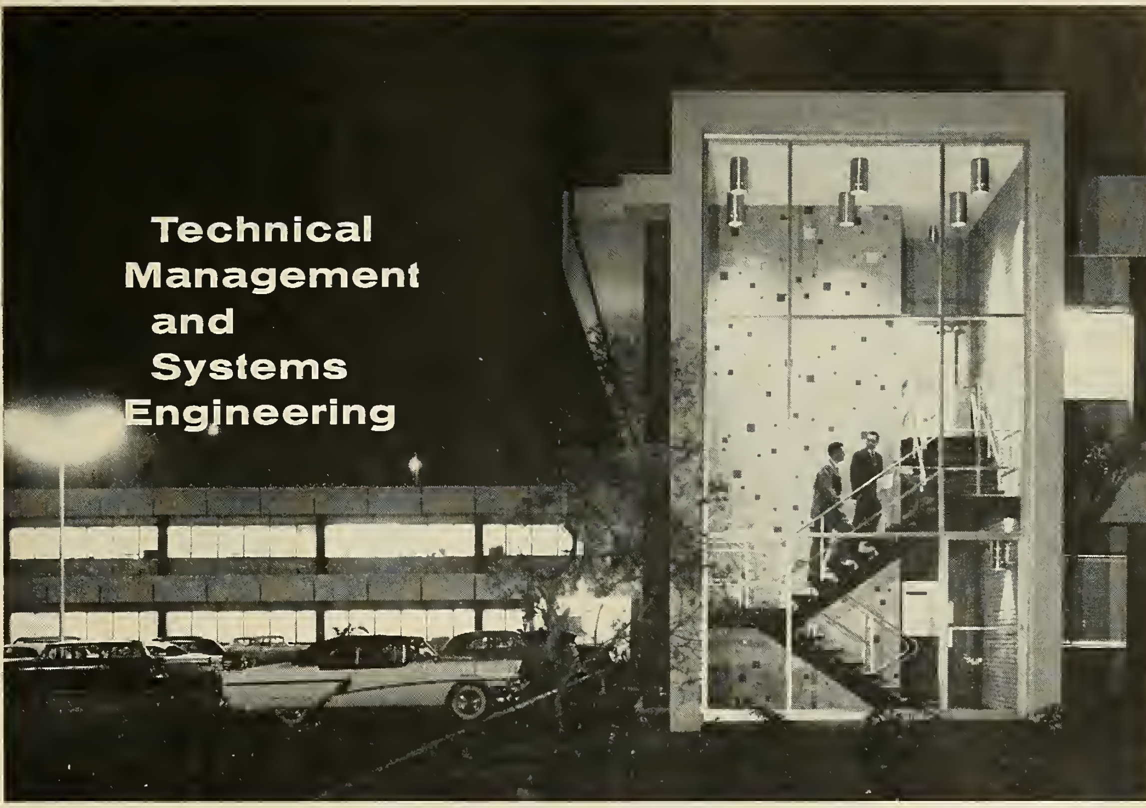
In the Willinski-Orr vehicle, the cesium would be contained in a tank heated by an electric blanket to about 100°F. to hold it in a molten state. An automatically controlled metal expellant bag within the tank would pressurize the vessel and force the cesium into an atomizer which would vaporize the metal at a temperature of approximately 1,500°F.

The vapor would then flow through a sintered steel distributor and then impinge upon incandescent tungsten surfaces formed into a series of ionizing grids. After a stay of only a few microseconds on the grid, essentially all the cesium atoms would lose an electron and become ions.

At this point, the ions would be accelerated across a three-centimeter gap to a velocity of 657,000 fps by a direct current potential of 27,500 volts. The cathode grid would consist of a honeycomb cross-section to assure a uniform electrostatic field in a radial direction. The authors note that this motor is based on a system proposed by Dr. Ernst Stuhlinger, research scientist for the Army Ballistic Missile Agency, Huntsville, Ala. They also make use of a Stuhlinger technique for simultaneous ejection of the electrons along with the ions by means of an emitting system located downstream of the cathode grid. The electrons thus mix with the ions at a point which does not interfere with the efficiency of the reaction and no excessive negative potential is allowed to accumulate in the vehicle.

The Willinski-Orr proposal is not related to North American's contract to study ion propulsion for AFOSR. So far as is known, there is no working model of an ion propulsion system now in existence. But the enormous potential of ion propulsion means that such hardware will be placed under contract before much more time elapses.

As to the task of getting such a vehicle into an orbit around the Earth, Maj. Gen. Bernard Schriever, chief of ARDC's ballistic missile program, has all but promised that the ICBM will be available for scientific research after its development as a weapon. He said in February that 90% of the unmanned space exploration projects now visualized "could be undertaken with propulsive, guidance and structural techniques presently under development in the Air Force ballistic missile program." ★



In systems engineering work, it is necessary to bring together a team that includes scientists and engineers of a wide range of technical specialties. In major weapons-systems projects, such teams will include hundreds of scientists and engineers.

But the assembly of a large group of scientists and engineers, no matter how capable they may be individually, does not of itself ensure good systems-engineering performance. The caliber of the project management has a major effect upon its technical accomplishment. It is not easy to coordinate the activities of large numbers of scientists and engineers so as not to stifle their creativeness on the one hand, nor to permit the various development sub-efforts to head toward mutually incompatible objectives on the other.

Of primary importance for good systems management is the philosophy underlying the selection of the supervisory personnel. The head of a technical activity should, first of all, be a competent scientist or engineer. A common mistake — nearly always fatal in systems work — is to fill such positions by non-technical men who have been trained only in management techniques. In the highly complex activities of major systems work, what is required is *technical management*, and of the two words, the word *technical* must never be overlooked.

In the selection of scientists and engineers for technical management, it is essential that the men chosen be broad in their training and approach. Each principal department head, for example, must have a good basic understanding of the technical facts of life of the other departments. When these people get together they need to speak a common language and understand each other's fields, so that proper decisions can be made on the many interrelated problems that come up. The higher the organizational responsibility of a technical manager, the more important this factor becomes.

The Ramo-Wooldridge Corporation is engaged almost entirely in systems work. Because of this, the company has assigned to scientists and engineers more dominant roles in the management and control of the business than is customary or necessary in most industrial organizations.

Scientists and engineers who are experienced in systems engineering work, or who have specialized in certain technical fields but have a broad interest in the interactions between their own specialties and other fields, are invited to explore openings at The Ramo-Wooldridge Corporation in:

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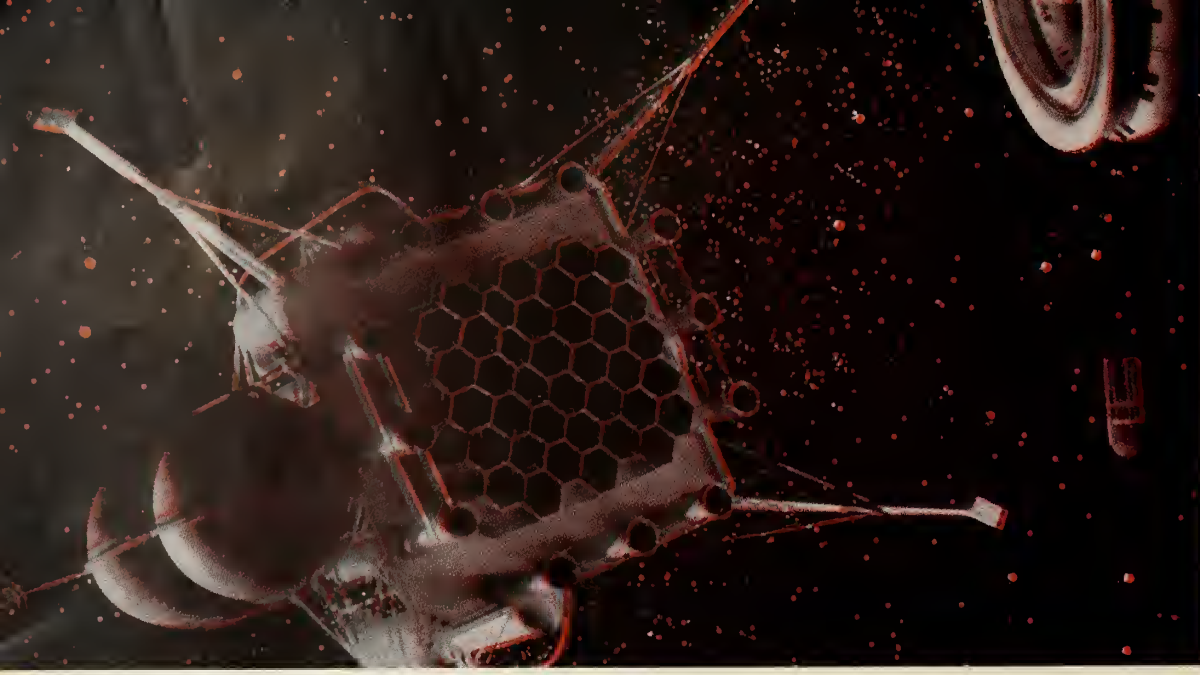

Use of space stations or space platforms for reconnaissance purposes and possibly for military use has been proposed by many experts.

Open Sky Plan in the Atomic Age

by Dr. Edgar A. Parsons
Member, Planning Staff
Federal Civil Defense Administration

WITHIN A DECADE the major military powers will be able to activate open-sky inspection plans through use of satellite vehicles. These will contain military reconnaissance gear, camera scanning equipment, television and telemetering instrumentation.

Use of reconnaissance satellites will be an inevitable outgrowth of the IGY satellite effort. Now is the time to consider the forthcoming sky sweep from all angles.

Meanwhile the big-two are attempting to reach agreement on mutual arms inspection. Major recent events include:

—The Soviet Union's statement that it will accept a limited "open skies" inspection plan, including creation of ground inspection posts.

—The U.S. counter-offer of a three-way surveillance over Alaska, Northern Canada and Northern Siberia.

If the statesmen are groping for solutions, the scientists and engineers are already demonstrating their own solutions for the manufacture and delivery of appalling payloads in a matter of minutes to distant targets. Achievements here include:

—The United Kingdom exploded its first H-bomb May 16th.

—A new $100-million base which will serve as our first operational launching site for ICBM, and the training of launching crews has been opened at Camp Cooke, Calif.

—The tempo of firings at Patrick Air Force Base has increased.

In view of these developments, what can man do in the interim period until operation sky-sweep becomes a reality? What kind of inspection is possible meanwhile?

General Nathan Twining, USAF Chief of Staff, has summarized the danger to the U.S. of nuclear disarmament. In a statement cited by a Senate Committee on Reduction and Control of Armaments, he stated: "To give up our nuclear weapons, unless arms were truly banned, would mean victory for the Communists."

Inspection poses a tremendous problem: It is not technically feasible to detect hidden nuclear stockpiles or to accurately account for past production of nuclear weapons. Atomic bombs can be made peculiarly insensitive to instrumentation. One could be almost on top of such a bomb and not know it.

The difficulty of accounting for past production of nuclear weapons is attributed in part to three factors: (1) the relatively inaccurate character of the assay for uranium isotopic content, (2) the tremendous extent of the atomic energy plants, (3) undetectable but legitimate losses within the process.

Dr. Manson Benedict, Chief of Operation Analysis of the Atomic Energy Commission, has speculated that "from one to five bombs per year could be produced from non-accountable material if one sought to divert material improperly."

Unreliable accounting of fissionable materials, together with relative ease of this interchangeability for either peaceful or military uses, are basic difficulties which must be overcome. In an unprecedented step to help overcome these difficulties, the U.S. Government, through the Disarmament Commission of the United Nations, recently invited

"the scientists and officials of any nation in the world, if they believe they have a method which can completely account for past and present production of fissionable materials and to insure against improper diversion of nuclear weapons, to come forward and advance for consideration such method."

Aerial Reconnaissance

With present equipment, one plane can photograph a 490-mile wide strip across the entire United States—a distance of 2700 miles—*in less than four hours*.

There is a great difference, however, between taking photographs and interpreting the results. While aerial reconnaissance is most effective in detecting large objects, it has definite limitations: the camera eye can be fooled, there is difficulty detecting small objects, and a camera cannot look through opaque surfaces.

Today's ICBM launching and testing sites are huge and complicated agglomerations of extremely bulky equipment. As soon as intercontinental ballistic missiles become available in operational numbers, launching sites will probably be "miniaturized" and dispersed throughout the country. This would make detection extremely difficult and destruction by long-range bombardment almost impossible.

It is assumed the sites will gradually be decreased to about the size of the launching pad. For some missiles, this might be only 10′ x 10′. The missile itself, as well as its launching pad, might well be below the surface of the ground, and maintained in a state of readiness by personnel housed in underground chambers. Sliding or folding doors with great resistance to blast, over-pressure, and radioactivity, would protect the missile from bombardment, as well as from chance detection by the camera.

Although the art of subterfuge and camouflage is clearly superior to the science of aerial photography detection, if the photogrammetrist knows precisely where to look, and is provided a series of detailed photographs, large scale activity would be detectable.

Need for Speed

It was reported last fall that an Army test vehicle traveled 3,300 miles. The missile allegedly soared to an altitude of 650 miles and terminated its flight in the South Atlantic. Continued high level of progress is evident in the press statement last March by Maj. Gen. John B. Medaris, Commander of the Army Ballistic Missile Agency, that development of the Army's Jupiter is "on schedule or ahead of schedule in every respect" and will be "brought to a successful conclusion on time."

The essence of the problem is to control the military application of atomic weapons by control over the means of mass delivery.

The longer the period of time that elapses before international agreements are consummated, the greater the opportunity for deceit and subterfuge.

If the technologists and engineers produce operational missiles before the diplomats agree on an inspection procedure, no nation can be sure that the other nations will reveal the true extent of their respective arsenals. Without such certainty, of course, disarmament is not feasible, and the world must continue to live with the fear of surprise attack.

Much can be done to make the most of whatever time remains without waiting for international agreement.

We should:

(1)—*start now to train the ground inspectors and aerial technicians required to implement a reliable inspection system.*

The administrative problems can be solved now, and personnel can be trained to implement our inspection agreement without delay.

(2)—*institute a ground and aerial inspection system now with an ally.*

This would facilitate the training of ground and air inspectors and re-emphasize to the world the seriousness with which the United States regards its mutual inspection proposals. Such an interchange would reveal the capabilities and limitations of ground and air inspection, and thus provide opportunity for refinement of techniques.

(3)—*negotiate for expansion of the existing military attache system.*

The U.S. and the USSR have for many years exchanged attaches, who are now customarily invited to witness certain military demonstrations. This attache exchange arrangement might serve as a nucleus for future ground inspection teams.

Initially, it would not be necessary to give these attaches permission to visit all the buildings of a particular installation. Through working level agreements, reinforced with concurrent high-level negotiations, it may be possible to facilitate mutual information exchange as an interim measure.

(4)—*institute an inspection system with a part of the USSR or a Soviet-satellite now.*

This recommendation would also facilitate the training of required inspection personnel. It would demonstrate, at first hand, the possibilities and limitations of the open skies proposal. This would provide first hand experience, without irrevocably committing the two parties.

(5)—*establish a working procedure with recipients of fissionable material to insure proper accountability and minimum danger of diversion to military use.*

Various technological arrangements will be required to insure that fissionable material will not be diverted for military purposes. To some extent agreements will provide the basis for a continued U.S. inspection and supervision over these fissionable materials; and these same arrangements might provide a basis for continued U.S.-USSR negotiations.

(6)—*pass the legislation required to establish open skies inspection now.*

Special amendment of the Atomic Energy Act was required to furnish atomic weapon information to our partners in NATO. According to Atomic Energy Commissioner Strauss, the Atomic Energy Act would have to be amended to permit foreign inspectors to examine atomic energy installations, facilities and stockpiles. If this evaluation is correct, the U.S. could not legally agree to a bona fide inspection system without new legislation. It is feasible, of course, to provide a legal basis for such inspection through the treaty device but even here ratification would require approval of the Senate. Experience does not warrant optimism for the speedy passage of such a treaty.

A comprehensive international inspection system might well be regarded as diluting the war making power of the Congress. An inspection system might also impinge upon the President's Constitutional powers as Commander in Chief. The precise Constitutional implications, of course, will not be clear until inspection agreements have been drafted. Nevertheless, the American public should be alerted now to the Constitutional implications.

Prospects for a speedy legal solution are dim indeed if inspection and disarmament procedures require amendment of the Constitution. The Second Amendment to our Constitution suggests some of the legal obstructions, which may not be insurmountable, but will undoubtedly be time consuming: "A well regulated Militia, being necessary to the security of a free State, the right of the people to keep and bear Arms, shall not be infringed." The possibility of this obstacle cropping up should be faced now and overcome.★

Note: The opinions in this article are those of the author and do not reflect an official evaluation of any agency or government.

Rocket Engineering

By Alfred J. Zaehringer

NEW FUEL: DIMETHYL SULFIDE. West Coast researchers have found the compound valuable in controlling the combustion of monopropellant ethylene oxide. Crown Zellerbach Corp., Camas, Washington, now offers the low cost fuel. of 99% purity, in tank car lots.

ETHYL CORPORATION has patented a new process (US 2,787,626) for producing aluminum triethyl (AT). AT ignites spontaneously in air and is being tested by government and industry as an igniter and fuel for ram jets and turbojets. US Industrial Chemicals has recently made this material available in pilot plant quantities.

USE OF LITHIUM and its compounds as a missile fuel is still small. Total lithium production in 1956 was about 50 million lbs. Estimates put nondefense lithium at over 11 million lbs. The difference is now going to AEC in their nuclear program and in government stockpiles. However, Purdue University chemists now see a promising future for lithium hydrides in conjunction with boron hydrides in the preparation of exotic boron fuels.

COMPOSITE LIQUID PROPELLANTS—premixed solutions of fuel and oxidizer—are now being tested in rocket runs here in the U.S. Biggest problem seems to be stability and shelf life. Getting performances of 250-300 sec is now "routine" for many of the new high-energy liquid combinations but they start to fall apart in stability over the 225 sec mark.

INDICATIONS OF PHILLIPS PETROLEUM potential in the solid propellant field can be gleaned from these annual production figures from their Chemical Division: 235 million lbs. of carbon black, 715,891 tons fertilizer, and 56,121 long tons of synthetic rubber. The Rocket Division uses unknown quantities of all these materials for producing ammonium nitrate-type solids.

MORE ON FREE RADICALS: University of California scientists have mapped the infrared spectrum of typical atoms. The potential rocket fuels have already been studied in the ultraviolet and visible regions by others.

SEVERAL MATERIALS are compatible with gaseous fluorine at atmospheric pressure but, says NACA, only Teflon and aluminum oxide can stand up at pressures of 1,500 psig.

FURALINE III is the furfuryl alcohol base fuel used with 98% nitric acid for the SEPR 481 rocket engine. The three-chambered 481 is used on the SO.9000 *Trident* I aircraft. Total nominal thrust is abont 9,900 lbs. Maximum sea level thrust is 10,500 lbs. and nearly 11,500 at an altitude of 40,000 ft. The *Trident* II is to be equipped with an improved model, the SEPR 631.

MORE NITRIC ACID ON THE WAY: Allied Chemical & Dye Corp. is adding a new nitric acid unit to its Newell, Pa. facility which will double present capacity.

SCALING DOWN a solid propellant rocket motor presents some unusual difficulties. In miniature motors of a few ounces of thrust, standard design techniques are not wholly adequate because of excessive heat losses to the relatively more massive chamber walls. NACA's Langley facility did manage to design a small rocket to deliver 3 ounces of thrust for 2 seconds. Propellant weight was slightly over 1 gram, total loaded weight was 18.5 grams. It is interesting to note that the Cordite SU/K propellant produced an I_{sp} of 145 sec at a chamber pressure of 353 psia.

Ion Propulsion and Why . . .

A Comparison of Space Ship Propulsion Systems

by Ernst Stuhlinger

Army Ballistic Missile Agency
Huntsville, Alabama

A SPACE VEHICLE, like any vehicle in any system of reference, can be accelerated in a given direction only by accelerating some mass in the opposite direction by a force which acts between vehicle and mass. The resulting movements of the vehicle and the reaction mass are governed by the law of conservation of momentum.

The main requirement of a propulsion system can be described thus: the product m.v should be as large as possible, where m is the total propellant mass, and v the exhaust velocity. An additional requirement applying to a space ship is that the ratio of the total initial mass of the vehicle to the payload mass should be as small as possible to make the trip economical.

The total mass includes the structural mass, the propellant mass, the mass of the thrust chamber, the payload mass, and, where applicable, the mass of the power plant.

A number of different propulsion systems have been suggested for space vehicles. Four of them will be considered here.

In the first system, the propellants are accelerated by heat energy from chemical reactions.

In the second, the propellants are accelerated by heat energy from a separate power source like a nuclear reactor, an electric arc, or the sun.

In the third, the propellants are ionized and accelerated by electric fields.

In the fourth, photons are emitted. They create thrust by virtue of the momentum which they impart to the vehicle when they are emitted from a radiation source.

Chemical Systems

Chemical rocket engines are the best known since they have been used successfully in many earth-bound rockets. They have the great advantage of combining the propellant mass and the power for its expulsion in the fuel-oxidizer system. No separate power source is necessary. Their disadvantage is that the exhaust velocity v, a function of the combustion temperature, is limited to relatively low values. The total propellant mass m must therefore be high. The combustion temperature is determined by the energy of combustion, by dissociation effects, and by the temperature resistivity of structural materials. Modern rocket engines have exhaust velocities of 2500 to 3000 meters per second. It does not appear likely at present that chemical rocket engines with much greater exhaust velocities will be developed in the near future for space-going vehicles.

Several studies have been published dealing with chemical propulsion systems for space vehicles. The most detailed of these, "The Mars Project" by W. von Braun,[1] provides the characteristic data of a chemical propulsion system capable of taking a space ship to Mars and back.

This system uses hydrazine and nitric acid as propellants with an exhaust velocity of about 2800 meters per second. The highest acceleration attained during the trip is of the order of one G.

The ratio of take-off weight to final weight after consumption of all fuel, is about 25 to 1. Burning time is 16 minutes. Travel time from earth to Mars would be 260 days.

Gas-Heating Systems

The next category is characterized by three different designs. The characteristic data of the first one, a propulsion system using a uranium reactor which heats liquid ammonia, can be derived from reactor design and operation data that were published recently.[2]

The second is a solar energy ship proposed by K. Ehricke.[3] The third is based on the high-intensity electric arc, a gas-heating method which may find application in wind tunnel systems.

In all three proposals, the energy source is separate from the propellant mass. This separation introduces a weight penalty as compared to the

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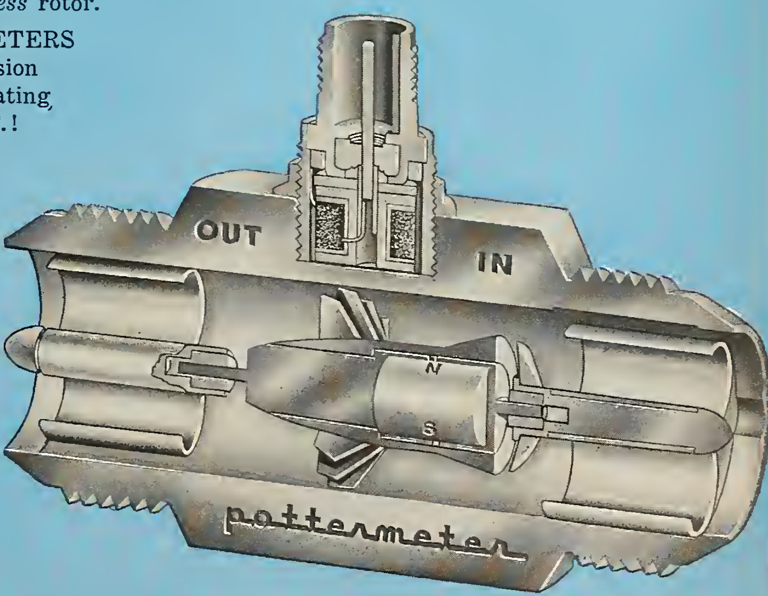

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chemical propulsion system which can only be compensated by higher exhaust.

The nuclear reactor system, in which ammonia is pumped through graphite tubes inside the reactor, provides an exhaust velocity of about 4000 meters per second. This value is limited by the heat resistivity of existing structural materials.

Using pure hydrogen, exhaust velocities of the order of 6000 meters per second can be expected. It seems that the reactor-heating method becomes superior to chemical systems only when space ships are considered whose take-off weights are greater than a few hundred tons.

The solar-powered ship designed by K. Ehricke uses two large reflectors which are formed by inflated balloons of Mylar polyester; one half of each balloon is coated with aluminum. In the focal area of each reflector there is a boiler in which liquid hydrogen is vaporized and heated to a temperature of 850°C. Blowing out through a nozzle, the hydrogen jet develops a thrust of about 160 pounds. Its exhaust velocity is of the order of 4500 meters per second. The acceleration of the ship is about 1/100 of one G.

Since the energy-producing system in this case is very light, the solar-powered hydrogen ship may well be superior, weight-wise, to a chemically propelled ship on shorter interplanetary trips. Its life would be limited, though, by the action of meteors which puncture the balloons. Even though the deflation would be very slow, one could not expect an operating lifetime of more than a few weeks.

The technique of heating a gas, or rather a plasma consisting of atoms, molecules, and ions, by a high-intensity electric arc, has been developed mainly by Finkelnburg, Maecker, and Peters[4], and by Giannini.[5] Exhaust velocities of about 6000 meters per second have been obtained.

The electric power needed to operate the high-intensity arc could be generated with a nuclear reactor driving a turbo-generator. Considering the fact that exhaust velocities of the same order can be obtained by direct heating of hydrogen in an atomic reactor, it seems doubtful whether the complicated mechanism of turbo-generator and electric arc would pay off.

Direct generation of electric power by means of radioactive isotopes has been considered by H. Kaeppeler.[6] Although this method of providing electric power would be very straightforward, it is likely that the production and handling of such large amounts of radioactive isotopes as needed would present insurmountable difficulties.

The heat generated within the radioactive substance and the structural elements of the battery would amount to at least 20 or 30 per cent of the electrical power output. Dissipation of this heat would be a severe problem.

Electric Systems

Electric propulsion systems for space vehicles were proposed as early as 1923 by H. Oberth.[7] A more detailed design and performance study of an electrically propelled space ship has been worked out recently.[8] The payload chosen for that design is 150 tons.

The primary power source is a uranium reactor which generates heat for steam production. Electric power is produced by a turbo-generator with radiation cooler. The propellant material is rubidium or cesium; these metals ionize easily and with an efficiency of almost 100 per cent, if they are vaporized and brought in contact with hot platinum surfaces. The ensuing ions and electrons are then subjected to electrical fields which accelerate them to high exhaust velocities.

The power contained in the jet increases with the square of the exhaust velocity; the total mass of the power plant, including cooler, increases at nearly the same rate. The thrust, however, increases only with the first power of the exhaust velocity. This fact is the reason why the exhaust velocity of the ions should not be too high.

A detailed investigation of a representative design resulted in an optimum ion exhaust velocity of about 80,000 to 100,000 meters per second, corresponding to an accelerating voltage of about 5000 volts. A higher or lower accelerating voltage would mean larger total mass of the ship for the same payload.

The ion thrust chambers as required for an electric propulsion system can be operated only when the space charge effects connected with charged particle beams are successfully eliminated. Neutralization of the space charge as soon as the ions have left the thrust chambers can be achieved by mixing the ions with the electrons from the electron thrust chambers.

Actually, the thrust contributed by the electrons is very small because of their small mass. However, they must be expelled from the ship anyway to keep the ship electrically neutral.

A representative space ship with an electric propulsion system, capable of carrying a payload of 150 tons to Mars and back, would have a total take-off mass of 730 tons, a propellant mass of 365 tons, an accelerating voltage of 5000 volts, a total electric power production of 23,000 kilowatts, a thrust of 50 kilograms, and an acceleration of a little less than 10^{-4} of one G.

The propulsion system would work during the entire trip, partly accelerating, and partly decelerating the vehicle. Total travel time from earth to Mars would be about 400 days.

Photonic System

The common feature of the three previous kinds of propulsion systems is that they could be built with techniques as we know them today. This is not true for the fourth kind of propulsion system, the photonic rocket.

A photonic propulsion system emits an unidirectional beam of photons. Their momentum is E/c, the quantum energy divided by the light velocity. The theory of photonic propulsion systems is based on the assumption that the photons can be created by direct and controlled conversion of matter into radiation energy according to the fundamental Einstein equation $E = m c^2$, a conversion which can be observed in nuclear processes, for example in the annihilation of an electron and a positron to form a pair of gamma quanta, but which is not yet known to exist on a technical scale.

Provided that the entire mass of the propellant could be converted into energy according to Einstein's equation, the energy content of matter is 10^{10} times greater than the chemical energy content of conventional propellants, referred to the same mass.

For a proper functioning of the photonic propulsion system, the further assumption must be made that photons of all the wavelengths generated in the conversion process can be reflected and collimated to form an almost parallel bundle. The collimating mirror must have a reflecting power of the order of 0.99999999.

If the photons are generated within a container, its walls must have a transmissivity of the same order. With lower reflectivities and transmissivities, the mirrors and walls would absorb such great amounts of radiative energy that they would vaporize immediately.

Although these requirements are still completely out of the range of present technical feasibility, it is most interesting to study the principal features of a photonic propulsion system. A number of very thorough studies on the mechanics of photonic propulsion have been published by E. Saenger.[9]

Assuming that the direct and controlled conversion of matter into radiative energy is feasible on a technical scale and that the ensuing photons can be collimated without noticeable absorption by lenses or mirrors, the relativistic formulae for mass consumption, thrust, velocity, mass ratios, and flight times of photonic space ships can be developed. It must be admitted that the photonic propulsion system opens horizons to space travel which are entirely out of reach for "classical" designs of space ships. Since the exhaust velocity of the photons is equal to 300,000 kilometers per second, an appreciable thrust could be obtained even with an extremely low mass consumption. After a sufficiently long time of operation, the ship would approach light velocity.

The relativistic dilatation of its own time, as experienced by the space travelers, would then become noticeable. Even trips to remote galaxies could then be made within a few years as counted by the crew of the ship. The following table shows the time interval Δt, the acceleration b, and the total elapsed time t as measured from the earth and on the ship.[10]

Table I. Relativistic transformation formulae.

	Earth system	Ship system
Time interval	$\Delta t = \Delta t_0/\sqrt{1-v^2/c^2}$	Δt_0
Acceleration	$b = b_0(1-v^2/c^2)^{3/2}$	b_0
Elapsed time	$t = c/2b_0(e\, b_0/c\, t_0 - e - b_0/c\, t_0)$	t_0

These formulae show that the relativistic effects are the same for positive and negative velocities, and for positive and negative accelerations. In particular, if a crew of space travellers left the earth on an accelerating ship and returned after some time on a decelerating ship, the crew members would find that during their absence everything on earth has aged more than they have themselves.

The difference between the time elapsed for the earth and the time elapsed for the crew is determined by the formula in the last line of the above table. Some pertinent figures of space trips made with photonic propulsion systems are listed in Table II.

While the propellant mass needed for a voyage as far as the planets would be negligible, the necessary mass ratio of a photonic ship capable of a round trip through the universe would require, for an empty mass of about 600 tons, a propellant mass equal to that of our whole earth.

Even though a photonic space ship cannot be achieved with technologies which may be at our command within the forseeable future photonic propulsion studies are most interesting as speculations because they give an idea of where the limits are set in principle by the basic laws of physics as we know them today.

It seems very obvious, though, that the two main problems of the photonic propulsion principle, the conversion of matter into radiative energy and the extremely high reflectivity of surfaces, will not be solved by engineering effort alone. Both problems are of a very fundamental nature. If they are solvable at all, their solution should be expected only as an achievement of basic scientific research.

Table III shows a few characteristic figures relevant to the four groups of propulsion systems considered in this paper. It is very likely that the first trip to another planet will be made with a chemically propelled ship, simply because its techniques are well developed.

Electrically propelled ships would be more economical from a weight standpoint, but they require a longer development time. Preference should always be given to that type of propulsion system which gives the greatest assurance for the crew's safe return.★

TABLE II

Characteristic Data of Photon Space Ship *

Trip	Mass Ratio	Ship Time	Earth Time	Distance
Half around earth	1.00007	47 min	47 min	2×10^4 km
Moon	1.0003	3.5 h	3.5 h	4×10^5
Planets	1.006	2 d	2 d	10^8
d Centauri	20	3.6 y	6 y	4×10^{13}
Center of galaxy	10^4	20 y	6×10^4y	2.8×10^{17}
Andromeda nebula	10^{11}	26 y	2.5×10^6y	7×10^{18}
Round trip thru the universe	10^{19}	42 y	4×10^9y	3.2×10^{22}

* A constant acceleration of 1 g to the midway point, and a subsequent deceleration of the same magnitude, was assumed for these trips.
Mass ratio is the ratio of take-off mass to burn-out mass.

TABLE III

Comparison of Propulsion Systems

Propulsion System	Exhaust Velocity (m/sec)	Acceler. (G)	Power/Thrust (kw/kg)	Technical Feasibility
Chemical	3×10^3	1...8	15	Technology Proven
Nuclear or solar power plus light gas	$4..6 \times 10^3$	1...8	20..30	Technology Known in Principle
Nuclear power plus ions	1×10^5	10^{-4}	500	Technology Known in Principle
Photonic	3×10^8	1...2	3×10^6	Technology Unknown

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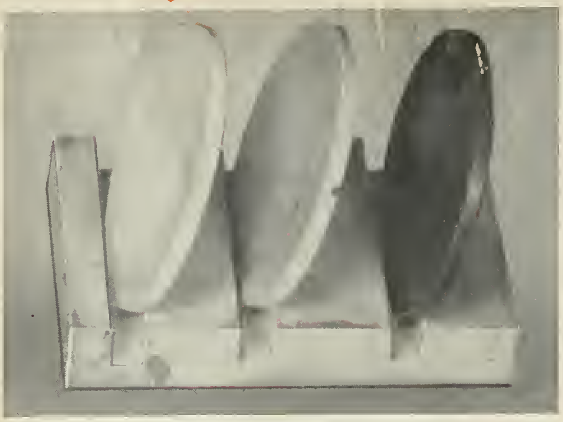

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SUPRAMICA* 560 ceramoplastic insulation (Left) is to be compared with SUPRAMICA* 555 ceramoplastic (Center) and MYCALEX 410* glass-bonded mica — the best available materials with comparable properties.

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SPECIFIC GRAVITY	2.8 (Comparable to Aluminum or Mineral-Filled Polyester)
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CONTINUOUS	500°C
SHORT-TIME	800°C
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The Ion Rocket

The Most Attractive Power Plant for Space Flight?

Dr. John E. Naugle
Convair Division
General Dynamics Corporation

THE ION ROCKET is a low thrust system which must be placed in a satellite orbit by a high thrust chemical or nuclear powered rocket. Once there, if the ion rocket has sufficient thrust it will slowly accelerate and escape from the earth's gravitational field. With the advent of the ICBM program and high-current ion ejectors the ion rocket moves from the realm of the imagination to a candidacy for advanced research and development.

A propulsion system with ultimate exhaust velocities in the neighborhood of 3×10^{10} cm/sec. is attractive but when this is combined with a system which allows these high exhaust velocities and the rate of mass flow both to be controlled, the possibility of interplanetary space travel moves from the realm of science fiction toward reality. The ion rocket works on an entirely different principle than a chemical rocket. Many people familiar with the operation and problems of the chemical rocket are not aware of the principles of the ion propulsion system. The purpose of this article is to present a highly simplified version of an ion rocket to illustrate the basic principles of the system.

An ion rocket operates by ejecting ions at high velocities. To accelerate the ions to these high velocities the propulsion system must exert a force on them and by Newton's third law an equal and opposite force will be exerted on the propulsion system, thereby accelerating the rocket ship.

The basic difference between an ion propulsion system and a chemical propulsion system lies in the difference between an ion and an ordinary molecule. An ion is a particle which carries a net charge. An atom or molecule is normally neutral. However, under certain conditions an electron can be added or removed. This charged molecule is an ion.

Neutral molecules are accelerated and acquire high velocities through collision with other neutral molecules whereas an ion can be accelerated in an electric field. In a gas composed of ordinary molecules the directions of motion of the molecules are completely random. A cloud of ions in the presence of an electric field will all move in the direction of the field.

An ion of net charge Q, mass m and in an electric field of magnetic E will have an acceleration a, given by:

$$a = \frac{EQ}{m} \qquad (1)$$

The acceleration of dust particles or any aggregate of molecules of mass m, and net charge Q will be given by equation (1), thus from a propulsion standpoint they should also be classified as ions and considered as possible propellants.

It is customary to refer to a beam of ions as a current of given amperage. If f ions of charge Q pass a certain point in one second the current I, in amperes will be:

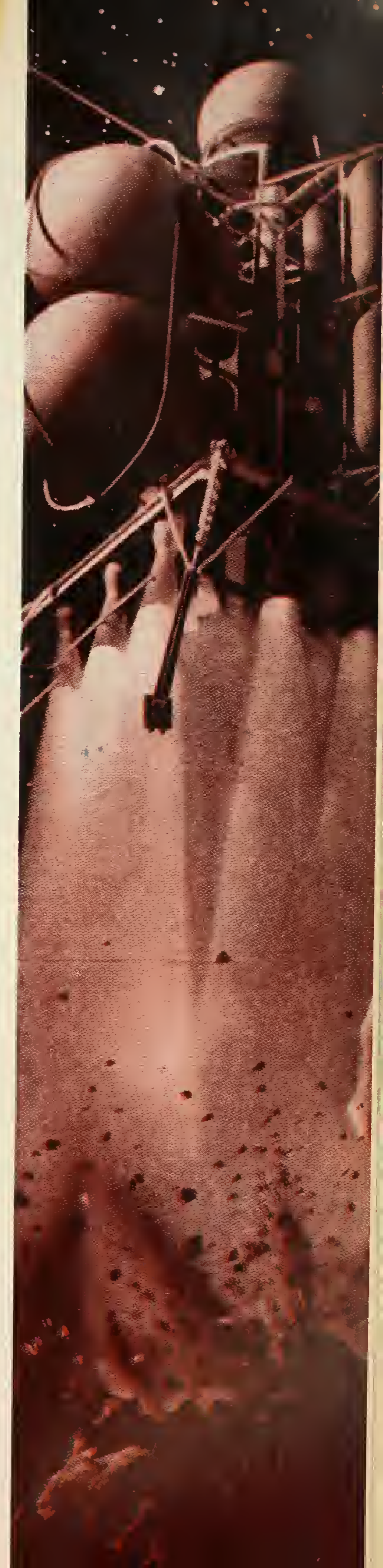
$$I = fQ \qquad (2)$$

if Q is measured in coulombs.

The diagram illustrates the functions which must be performed to achieve propulsion in an ion rocket. The propellant is carried as neutral molecules. These are ejected into the ion source and ionized. Ions can be formed by radio frequency discharges, arc discharges and by other ions traveling at high velocities.

Electrons are removed from neutral molecules leaving them positively charged. The electrons may attach to another neutral molecule forming a negative heavy ion or remain as free electrons-light negative ions. An electric field can then be used to move the ions out of the source.

The positively charged ions move in the direction of the field and the negatively charged ions move in the opposite direction. After leaving the source, the ions pass into region B where their trajectories are curved to bring their direction of motion out the end of the rocket. This can be done



either by an electric or magnetic field in region B.

In region C strong electric fields are used to accelerate the ions to their exhaust velocities. This is a highly simplified concept but it serves to illustrate the basic principles. It is necessary to eject ions of both signs and in equal numbers, otherwise the rocket would acquire a net charge and attract and slow down ions it is trying to eject.

The thrust F, on the rocket is given by the relation:

$$F = fmu \qquad (3)$$

where f is the number of ions of mass m, and velocity u, ejected per second. If an ion of mass m, and charge Q is accelerated through a potential V, the kinetic energy which it acquires is given by:

$$\tfrac{1}{2} mu^2 = QV \qquad (4)$$

Using equations (2), (3) and (4), it is possible to express the thrust in terms of the important parameters as:

$$F = I\sqrt{\frac{2mV}{Q}} \qquad (5)$$

Disregarding losses, the total power P put into the beam would be VI, the thrust per unit power would be:

$$\frac{F}{P} = \frac{I\sqrt{\frac{2mV}{Q}}}{VI} = \sqrt{\frac{2m}{VQ}} \qquad (6)$$

The thrust per unit mass is:

$$F' = \frac{I}{m}\sqrt{\frac{2mV}{Q}} = \sqrt{\frac{2V}{mQ}} \cdot I \qquad (7)$$

According to equation (6) a high thrust-to-power ratio is obtained with a propellant of high atomic weight and a low accelerating potential. A high thrust to mass ratio is obtained with a propellant of low atomic weight and high acceleration potential.

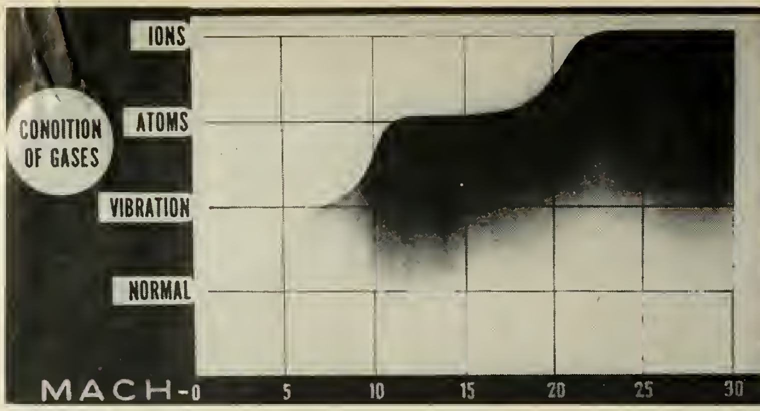
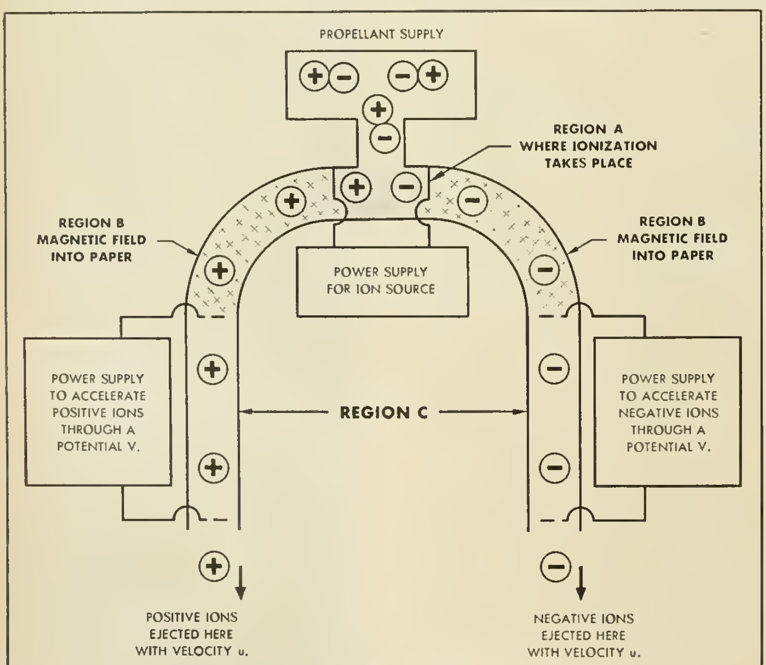


Chart showing dissociation of earth's atmosphere with increased speed. Ions from about Mach 20 and up could be used in electrical ion "ramjet."

In any actual design the weight of the power supply will have to be taken into account. This power supply may be electrical energy stored in batteries, a nuclear powered generator or a device to convert solar energy into electrical energy.

One of the very attractive features of the ion rocket is that both I and V can be easily controlled. This means that both the exhaust velocity and rate of propellant utilization can be varied.

The final design would incorporate the proper propellant and a programmed flight regime to make the rocket travel the maximum distance, in the shortest length of time with a minimum initial weight.



Schematic diagram showing the basic layout of ion propulsion system.

The major obstacle to be overcome to make the ion rocket feasible is the development of a high current ion source and a light and efficient power supply. The ionization process requires about 4 to 10 watts of power per ampere of ions.

The actual process as used in the high current ion ejectors is still very inefficient. It actually required about 10 to 100 kilowatts of power to produce an ampere of ions. This power, however is independent of the exhaust velocity of the ion.

If the ions are accelerated through a sufficiently high voltage the power lost in ionization can be made small compared to the power in the beam or to the kinetic energy transferred to the rocket by this process.

The present "state of the art" for ion sources is best illustrated by the "High-Current Ion Injector" described by W. S. Lamb and E. J. Lofgren in Rev. Sci. Instr. 27, 907 (1956). This machine produces a 0.75 ampere beam of 100 kilovolt deutrons.

The total power into the machine is about 170 kilowatts, the power in the beam is about 75 kilowatts or about 44% of the electrical energy is converted into kinetic energy of the ions. The total thrust from this beam however, would be only about 5000 dynes or about 10^{-2} pounds. The exhaust velocity is 4.4 x 10^8 cm/sec.

In summary: the ion rocket is attractive because of the high and controllable exhaust velocities, the efficient conversion of electrical energy into kinetic energy and the overall control over the propulsion system. A major effort is required to produce ion sources of thousands of amperes, which ionize and accelerate the major fraction of the propellant carried aloft. A companion effort is required to produce an efficient light weight power supply.

engineering briefs

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There is also a vacuum and perlite insulated 500-gal. liquid nitrogen or liquid oxygen storage tank, plus essential piping, instrumentation, manifolding, safety valves, pressure regulation controls, vacuum protection, bleed valves and polution dampers.

The system can provide helium flows as high as 80 lbs./min. at pressures up to 6,000 psig and at temperatures ranging from —300°F to 165°F. Liquid nitrogen or oxygen, as required by special tests and for use in operating heat exchangers, can be supplied at flow rates up to 100 gal./min. at pressures as high as 100 psig.

All helium used for testing is recycled. It passes from test stations into the two large low-pressure storage tanks, from which it is drawn to be recompressed, dried, filtered and stored in the high-pressure storage tanks.

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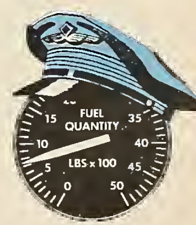

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Outline of 1000 Temperature-Pressure Problems

Any rocket engine looks simple in silhouette—but its 150 or more parts present new and complex problems of operating temperatures and pressures. This is the reason why The M. W. Kellogg Company, leading designer and fabricator of industrial high temperature, high pressure vessels and steam power piping, was assigned a major role in the development and production of over ten different guided missiles to date, including the Terrier.

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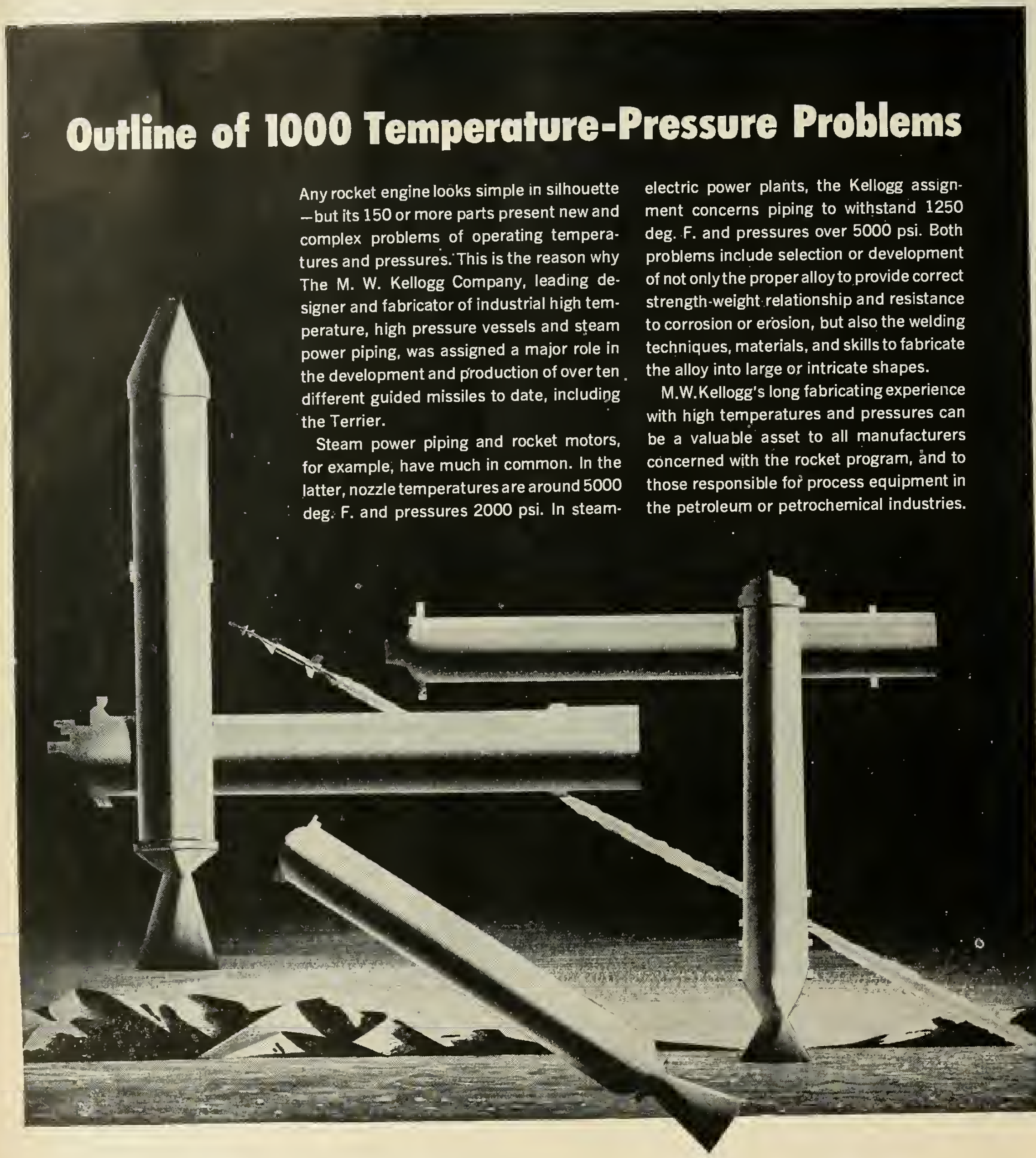
M.W.Kellogg's long fabricating experience with high temperatures and pressures can be a valuable asset to all manufacturers concerned with the rocket program, and to those responsible for process equipment in the petroleum or petrochemical industries.



DEFENSE PRODUCTS DIVISION

THE M. W. KELLOGG COMPANY

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M KELLOGG W

Fuels for the Atomic Rocket

by Alfred J. Zaehringer

TODAY'S VIEW of the atomic rocket—a pile to heat a working fluid—is beset by such bugaboos as heat transfer, high temperatures, and corrosion. These problems can be solved by technological breakthroughs or by a painstaking, empirical approach. It is certain however that developments now taking place in the atomic reactor field will form one of the ribs of any future atomic rocket.

Free world reserves of uranium oxide concentrate are estimated equivalent to ½ million tons (some 500-1,000 million tons of ore). This conservative estimate was recently made by the firm of Arthur D. Little, Inc. If one includes presently uneconomical uranium-containing shales and phosphates, the uranium reserve figure would increase. Based on 1958 military production rates, these known reserves will hold out for 25-50 years.

The U.S. now produces 3 million tons of ore each year and will increase it to 5-6 million tons by 1958. Most of this is slated for military purposes. It is estimated that our capacity for uranium will be ten years ahead of any civilian power requirement.

Propulsion

In the U.S., about 70% of our reactor work is devoted to propulsion, mainly aircraft and ships. By 1965 all new naval vessels will be nuclear-powered while the entire U.S. Navy will be nuclear by 1980. Commercial nuclear-powered aircraft will be started by this date according to Arthur D. Little, Inc.

Atomic Fuel

Replacement for chemical fuels is the atomic fuel element. The elements are mechanical structures made of a fissionable material (such as U-235). Atomic fuels are solid or liquid. Most reactors today use solid fuels. Because liquid fuels are more corrosive, much of the present reactor fuel research is with solids.

For the atomic rocket to beat the performance of a chemical rocket, atomic motors will have to operate at temperatures much higher than present 900-1,000 F power reactors. Right now, research is concerned with raising temperatures to 2,000-3,000 F in order to raise efficiencies. It is interesting to note that North American Aviation, Inc. hopes to raise reactor temperatures to over 3,500 F.

The uranium or thorium fuel elements (metallic or metal compounds)

Atomic Fuel Research

Firm	Activity
Argonne National Laboratories Lemont, Ill.	R&D on fuel elements.
Armour Research Foundation Chicago, Ill.	Manufactures elements for Argonne; molybdenum fibers in thorium oxide impacts. R&D work on fuel elements.
Babcock & Wilson New York, N. Y.	Thorium and uranium oxide ceramics.
Batelle Memorial Institute Columbus, O.	Fuel element R&D. Uranium alloys of columbium, molybdenum, zirconium and uranium oxide(di).
Davison Chemical Div., W. R. Grace & Co., Baltimore, Md.	Development of thorium oxide (stands 5000 C).
General Electric Co. San Jose, Calif.	Manufactures UO_2 fuel pellets; ceramic research.
Horizons, Inc., Cleveland, O.	Ceramic fuel element research.
Mallinckrodt Chemical Works St. Louis, Mo.	Uranium metals & alloys. Uranium dioxide clad in zirconium (Zircalloy). R&D on uranium & metal oxides. Aim: uranium dioxide for power piles in 1000-3000 C range.
Minnesota Mining & Mfg. Co. St. Paul, Minn.	Work on Si-SiC elements.
National Lead Co., Fernald, O.	Uranium feed materials refining. Aim: Enriched fuels for power reactors.
North American Aviation, Inc. Los Angeles, Calif.	Research on thorium-uranium and U alloys. Of promise are uranium dioxide and uranium carbide alloys. Aim: Core temperatures of 2000 C.
Olin Mathieson Chemical Corp. New York, N. Y.	Recently set-up nuclear fuel division. Aim: faster production and cheaper fuel elements.
Nuclear Metals Co. Cambridge, Mass.	Working on uranium and beryllium oxides. Aim: intermediate uranium compounds.
Sylvania-Corning Nuclear Corp. Bayside, N. Y.	UO_2 ceramic fuel elements using U-235 or U-238.
Westinghouse Electric Corp. Pittsburgh, Pa.	Metal-clad uranium dioxide ceramics for reactors.

General Electric nuclear propulsion proposals as shown at recent Philadelphia atomic power exhibition. GE is one of the pioneers in this field.

are clad with a wide variety of metals for corrosion protection. Metals include: aluminum, beryllium, chromium, columbium (niobium), copper, nickel, nickel-chromium, magnesium, molybdenum, silicon, stainless steel, titanium, or zirconium.

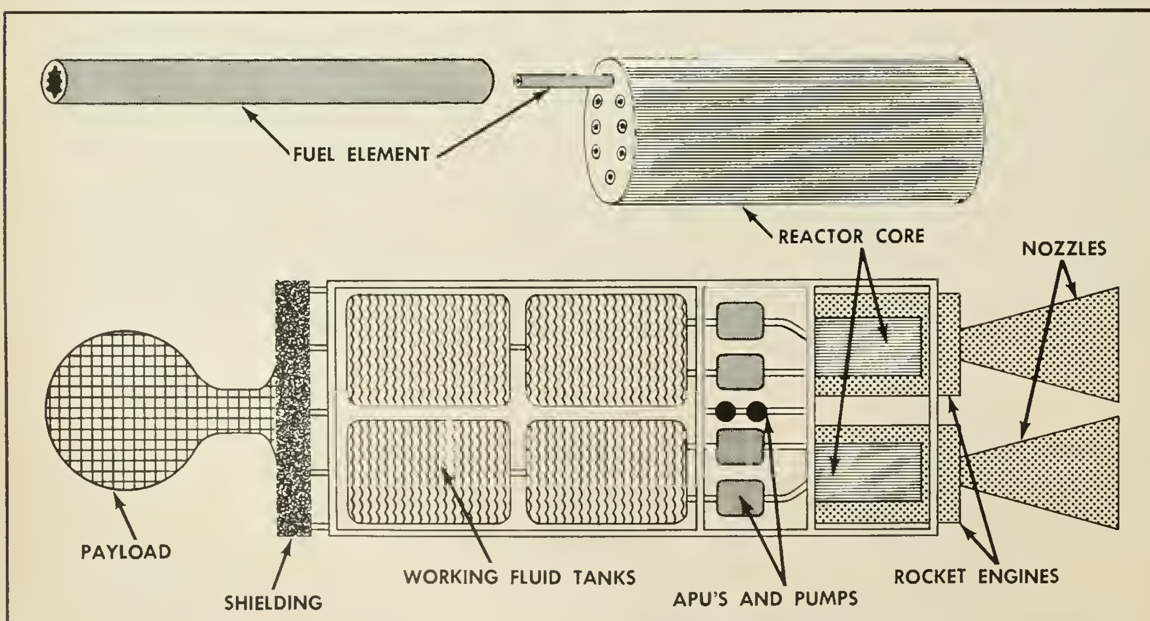
Mixtures of metals, ceramics, and even cermets are also being considered (see table). In considering semi- and non-metal materials, however, thermal shock is important.

Fuel elements of the solid nuclear material may be in pellet, rod, or plate form and are of various hollow configurations. These configurations have to allow the proper heat transfer and also support a chain reaction. The geometry also has to allow for control of the reactor and for easy removal. The fuel has to be "canned" to prevent excessive loss of fission materials.

Present reactors have elements about 4-6 inches in diameter and 4-6 feet long. Several elements are assembled into a reactor core. Not only must the element and core have to stand the high temperatures and corrosion but radiation now lets only 1 per cent of nuclear fuel to be consumed before the element has to be yanked out and replaced. The reasons for this are structural damage by neutrons, and fuel poisoning.

Although the reactor problems associated with the atomic rocket now look like mountains, it is encouraging to note that developments now taking place in the power reactor field are gradually wearing down the mountain.

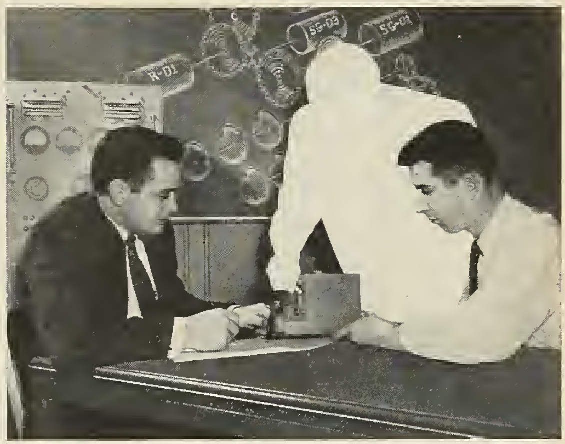
This growing technology that will aid the atomic rocket include: heat transfer, better high temperature materials and fuel elements, antidotes for fuel poisons, and better radiation-resisting materials. Thus, development of the atomic rocket can now take a free-ride on the rising materials and know-how curve of power reactors.★



The atomic rocket that may never be built. Although this principle is feasible—we might concentrate on electro-nuclear propulsion systems.

Where do you belong in IBM Military Products?

Systems Design Engineer: Before his recent promotion, this man formulated advanced concepts of configuration, capabilities, and operational features, and coordinated the design of radar, computer and inertial equipments for optimum integration as a system. Engineers interested in military systems, computers or servo applications will find opportunities in error analysis, ballistics, reliability, and electro-mechanical, servo and equipment interconnection design. *Could you handle his responsibilities?*



Test Equipment Engineer: Also promoted recently, this man formerly developed test sets of advanced design, requiring precision electronic measuring circuits and mechanisms meeting military specifications. He started with specification requirements and carried designs through model testing by electronic and mechanical engineers. This activity includes application of servo-mechanisms, packaging of precision components, and liaison with sub-contractors in many fields. *Could you handle his responsibilities?*

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- Technical Publications
- Test Equipment
- Transistors

At the new plant and laboratory in Owego, N. Y., IBM designs and manufactures advanced airborne analog and digital computers for Air Force bombing-navigational equipment. At the new Kingston, N. Y., facilities, IBM builds the world's largest electronic computers for Project SAGE, part of our nation's giant defense net.

The electronic computer field offers one of the best ground-floor career opportunities today. Economic experts rank the electronic computer in importance with automation and nucleonics in growth potential. Sales at IBM, the recognized leader in the field, have doubled, on the average, every five years since 1930. Engineering laboratory personnel quintupled in the past five years. Future expansion plans offer even better opportunities. As a member of IBM Military Products, you enjoy the stability and security of the IBM Corporation, plus the opportunity to progress in any other IBM division. Promotions open up frequently from continuous growth. The "small group" approach assures recognition of individual merit. Salaries are excellent and company benefits set standards for industry.

For the facts about an engineering career with IBM Military Products Division, please write to:

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Nuclear Powered Rockets

and the Problems of Heat Release

by **Rudolf H. Reichel**
Bell Aircraft Corp.

UP TO THE PRESENT our rocket propulsion systems have been entirely dependent on chemical propellants, either in a liquid or solid state. Because of their heat content which results in a specific impulse in the order of 200 to 400 lb-sec/lb, high mass ratios have to be realized in order to fulfill a given mission. This means multi-stage rockets are necessary in many cases. To escape from the earth's gravitational field, or even to bring any payload in a satellite orbit, at least two or three-stage vehicles are required.

No basic change can be expected in the capability of chemical propellants even for liquid hydrogen or fluorine as components. Because the resulting high mass ratios severely restrict space flight, man is looking for higher energy propulsion systems.

A unique power source leading to basically new propulsion concepts has become available with the discovery of nuclear energy. Proposals have been made for example, to use free radicals to produce the reaction $2H \rightarrow H_2$, to heat up an inert working fluid, to produce photons or ions, or to use the nuclear energy of fission or fusion.

It is beyond the scope of this article to discuss which of these propulsion principles are or seem to be realistic. However, it is of great interest and importance to describe the critical factors which govern the application of these "super fuels."

First because of the tremendous heat content of nuclear fuels, e.g. U-235 or Pu-239 yield about 3×10^{10} BTU/lb, it is interesting to study the feasibility of any nuclear-powered rocket propulsion system. If it were not for the numerous technological and shielding problems, doubtlessly very favorable mass ratios would result.

However, this promising situation also has a major drawback. According to the momentum principle, the amount of energy which must be released in the combustion chamber or in the re-

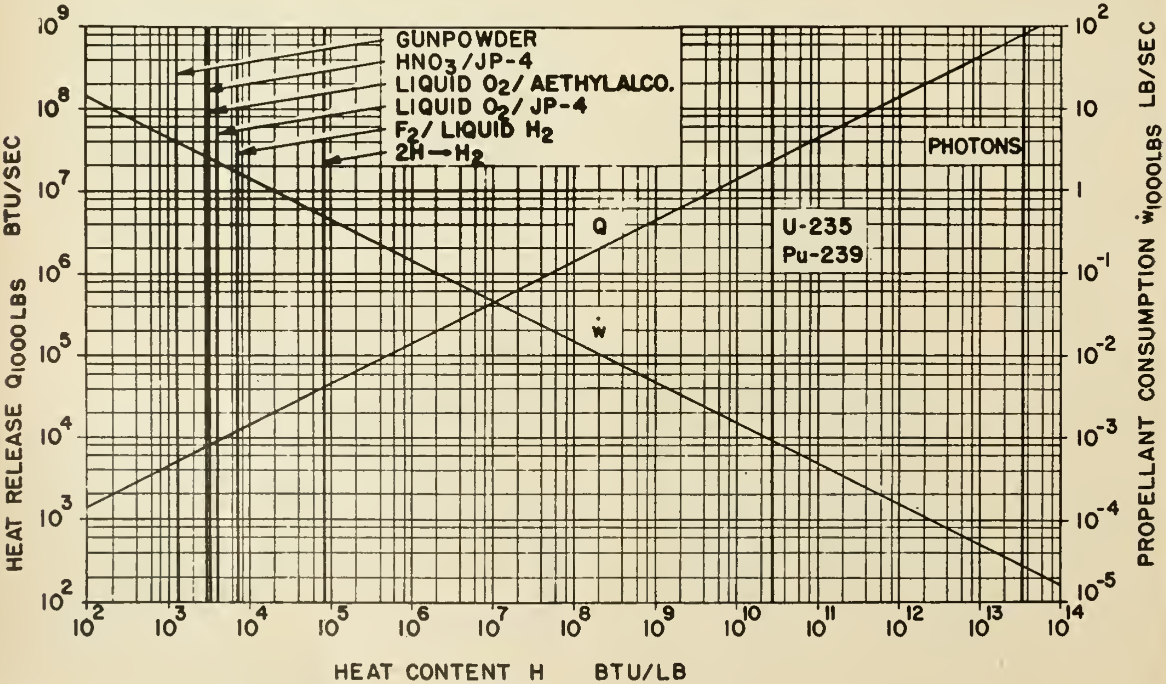


Figure 1 is a full log graph showing heat release Q and propellant consumption w for 1000-lb thrust versus heat content H for different propellants. Heat content of photons assumes the complete conversion of one pound of mass according to $E=mc^2$.

action section of the powerplant in order to generate thrust follows the simple functions of $(H/\eta_1)^{1/2}$ or c/η_i. H represents the heat content of the propellant, c exhaust velocity; η_1 internal efficiency of the reaction process.

In Fig. 1 this relationship is presented by plotting the energy Q released for generation of 1000 lbs. of thrust versus the heat content H of some typical "propellants" when the internal efficiency is assumed to be 100 per cent. Moreover, the propellant consumption $\dot{\omega}$ shows that with increasing heat content it has a tendency to decrease as per the relation $(H\eta_1)^{-1/2}$.

For purposes of comparison a constant internal efficiency η_i is assumed. Heat must be released according to the ratio $(H_{11}/H_1)^{1/2}$ or c_{11}/c_1, where the subscripts I and II refer to the propellant contents with II higher than I.

In a hypothetical rocket generating its thrust by fission of U-235, more than 2000 times the energy must be released than is required for an equal thrust motor using common chemical propellants, for comparable η_i. Even for a thermonuclear rocket using the reaction $2H \rightarrow H_2$, about five times the energy would be required compared with common chemical propellants.

In the application of the photonic rocket principle, which is still entirely hypothetical, a tremendous quantity of energy has to be released per unit thrust. About 100,000 times that of chemical propellants is necessary. The area of the photon reflector becomes very large and may become unrealistic in order to keep the surface temperature in a reasonable range.

The application of nuclear power for rocket propulsion obviously would provide tremendous energy quantities. From a pure performance point of view this would indicate great progress. However, the basic law of heat release shows that the quantity per unit thrust increases with increasing enthalpy.

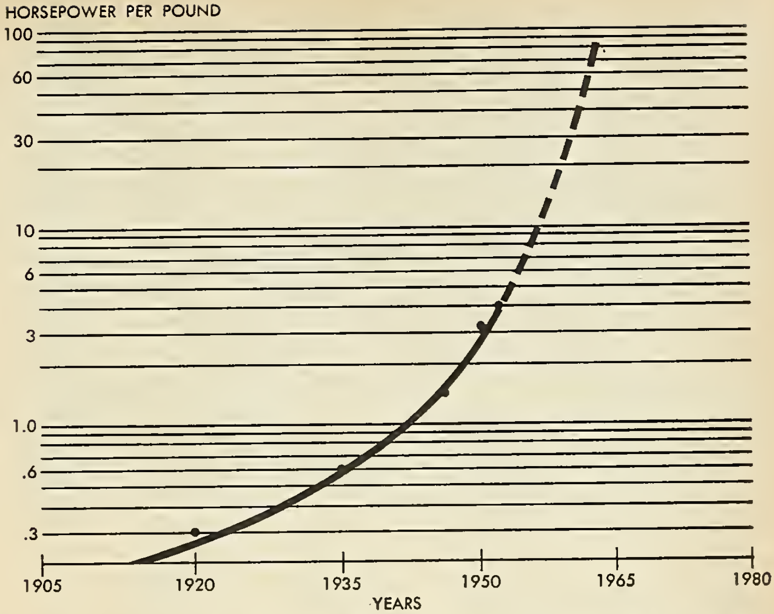
This leads to problems which we currently do not know how to handle. It seems that entirely new techniques of heat transfer are needed in order to deal with energy release problems.

In this connection, the structural properties of materials at high temperatures form a critical factor. It would seem that any solution must probably entail the use of magnetic or electrical techniques now under study.

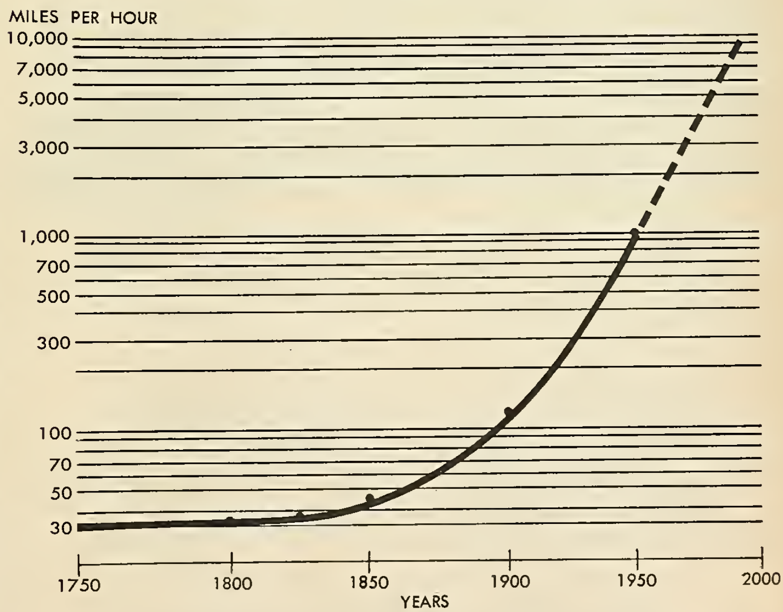
In addition, since at the temperatures involved virtually all particles of matter could be highly ionized, considerable additional knowledge of heat flow rates, flow characteristics and shock wave phenomena in ionized gases is needed.

Because of the high heat release when high performance propellants are applied, proposals have been made to avoid some of the problems by taking advantage of special applications, such as use beyond gravity.

In this case only a very small acceleration of the vehicle would be required. Therefore excessive reaction temperatures can be avoided and realistic reaction areas are adequate. In order to fulfill the above requirement, the ascent of the rocket from the earth must be achieved by the use of conventional propulsion. ★



These two half-log graphs provide a dramatic evidence of not only man's quest for greater and greater speed but of his success in achieving it as well. The top graph shows thrust-horsepower per pound of engine weight plotted against time. That below shows the advance of speed records against time. The remarkable point about both of these is that they curve upwards on a log plot. A straight line on a half-log plot is considered to be the normal learning curve. The accelerating rate of rise is evidence of the addition of creative thought to the normal learning process. The successful application of nuclear power to propulsion, directly or indirectly, will sharpen the curve more.



Martin Tests Titanium For Hydrogen Content

Martin now regularly tests samples of its titanium for hydrogen content with a Vacuum Fusion Gas Analysis Apparatus developed by the National Research Corp. The apparatus could also be used to determine the amount of various basic elements in other metals.

During the various stages in the refinement of metals, small quantities of oxygen, hydrogen, carbon, and nitrogen are retained or picked up by the metal. Minute amounts of these impurities may produce marked effects upon the final properties of the metal. Good strength combinations are possible with these interstitial alloying elements—oxygen, hydrogen, carbon and nitrogen. However, other properties such as impact and notch-toughness suffer disproportionately.

GE Develops New Leak Detector

A newly-improved electronic leak detector "so sensitive it can detect one part of helium in two million parts of air" has been announced by General Electric's Instrument Department.

Based on an original development for the wartime Atomic Energy Program, the re-designed mass spectrometer leak detector features extreme sensitivity and fast response.

Ten times more sensitive than its predecessor, the new M-2 leak detector finds and locates leaks in vacuum or pressure systems. It is used by electronic industries, nuclear developments, and research laboratories for quality control and production checks.

AF Breaks Ground For ICBM Training Base

Ground has been broken for the first of several technical facilities to be constructed at the Air Force $100 million ballistic missile training base at Cooke Air Force Base, Calif.

Installation is slated to have several thousand military and civilian personnel by December 1958.

Aeronutronic Expands

Aeronutronic Systems, Inc., a Ford Motor Co. subsidiary, has added a 10,000-sq. ft. experimental shop to its Glendale, Calif., plant.

Crucible Steel Reports $1.5 Million Expansion

Crucible Steel Co. of America has announced a $1,500,000 expansion program for Vacuum Metals Corp., division of the company's Sanderson-Halcomb Works at Syracuse, N. Y.

The program, which will double the company's capacity for producing high-purity vacuum-melted materials, will include a vacuum induction furnace capable of producing 3,000-lb. ingots, a melt shop building to house the furnace and additional space for expansion, and a metallurgical-chemical laboratory building for production control and development.

The expansion is being undertaken to meet increased demand for vacuum-melted high-quality bearing and high-temperature alloy steel.

Kaiser Aircraft Gets Contracts

New contracts calling for the production of more than $1,700,000 in guided missile testing equipment are being awarded the Electronics Division of Kaiser Aircraft & Electronics Corp., Toledo, Ohio.

Destined for use by the Air Force, the test equipment allows technicians to make automatic ground check of the operating characteristics of a missile before firing. The pre-flight "Go-No/Go" tester simulates functions of flight.

AF Awards $21 Million For *Navaho* Development

North American Aviation's Missile Development Division has received an additional $21 million for research and development work on SM-64 *Navaho* from the Air Force.

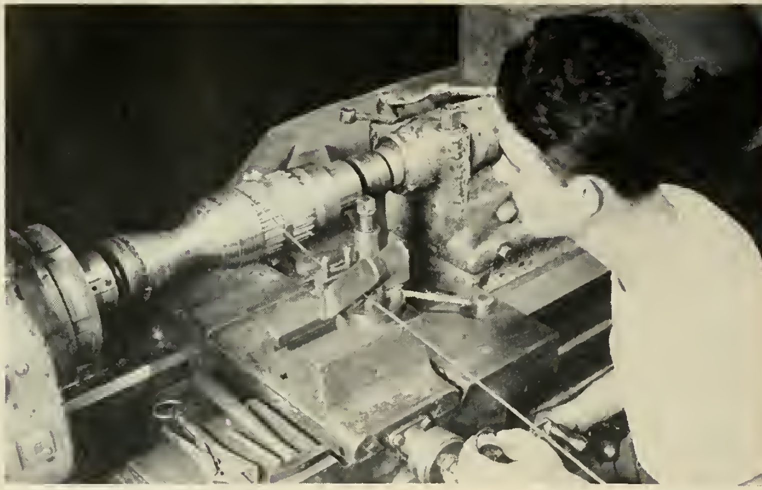
Navaho is currently undergoing tests at the Air Force Missile Test Center in Florida. Testing began after the flight program of the X-10 test missile was completed.

Northrop Employes Get 1 Cent Hourly Raise

Some 14,000 hourly-rated personnel at the Northrop and Anaheim divisions of Northrop Aircraft, Inc., received pay increases of 1¢ an hour effective April 29 as a result of an increase in the Consumer's Price Index.

Northrop's cost-of-living wage program is based on quarterly reviews of the price index. Personnel at the Hawthorne, Anaheim, El Segundo, Palmdale, Edwards Air Force Base, Pasadena, Torrance, Alamogordo, and Cocoa installations are affected. Northrop is producing the *Snark* missile.

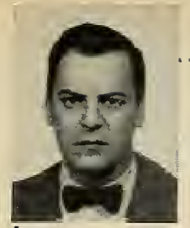
NACA Studies New Fabrication Methods



NACA 5000 lb. thrust rocket chamber in NACA sheet metal shop at Lewis Flight Propulsion Lab. This rocket chamber is wire-wrapped and then braced to provide extra structural strength.

Spun chamber with outer channels for fuel flow control. Left, casing. Right, throat.

Chambers left to right: Spun, finished, corrugated, hydraulically or cast formed, chamber with flow directors braced on and outer casing suitable for any type rocket chamber. Further information is available by contacting NACA and requesting NACA Technical Note 3827.



Aerophysics

By Seabrook Hull

A nose cone that melts or burns but remains lethal to the point of detonation continues to be the only feasible solution to the medium-to-long-range ballistic missiles. The same temperature-materials restrictions that put a known top limit on the efficiency of conventional liquid, solid and (soon) jellied chemical rockets also restricts nose cone design. There is not and may never be a material that will permit the design of a non-deteriorating warhead for IRBM's and ICBM's.

Post-World War II research into high temperature materials has shown that none remain solid beyond about 3500°C. This is a function not of man's ingenuity in devising new molecular combinations (which would give hope of a major breakthrough someday) but of the bonding forces of one atom for another. It is a matter of basic physics, not chemistry. The practical limit for the structural use of any material is 3000-3200°.

It is conceivable that the space ship of the distant future, making a fast reentry, may employ intense magnetic fields to shape ionized and dissociated gases into heat shields for its nose. But it is not practical to consider for the "ultimate" weapons of today.

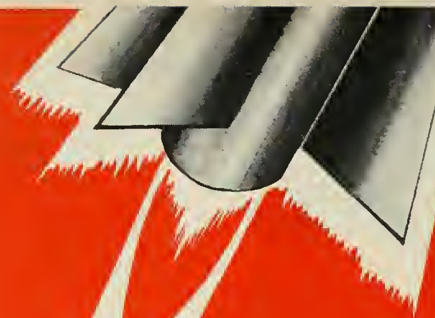
W. R. Warren, General Electric's Missiles and Ordnance Systems Department, in a paper, Hypersonic Experimentation, indicates the ball-park conditions surrounding reentry: "For typical values, if the flight Mach number is 16 and the altitude is 100,000 feet the temperatures immediately behind the shock front and at equilibrium are approximately 15,000°K and 6000°K, respectively."

Since materials cannot be looked to for the final answer in nose cone stability during reentry, aerodynamic design to minimize heat transfer is of prime importance. Recently devices for studying hypersonic flow and heat transfer have increased both in number and utility. These include the wind tunnel, shock tube, shock tunnel, plasma jet, shaped charged accelerator, rocket exhaust, solar furnace and the hypervelocity mass accelerator. This last, by timed electrical discharges into helium gas behind a piston holding the model, is capable of uniform acceleration to 60,000 ft/sec.

And for possible hypersonic flight application, two new materials: a crystalline material made from glass, now in the pilot production stage; and a ductile ceramic in the laboratory stage.

Pyroceram, a family of "extremely hard, fine-grained crystalline materials formed from special glasses," has just been announced by the Corning Glass Works as having "good mechanical strength, excellent electrical insulating properties at very high frequencies, high deformation temperatures, superior thermal shock resistance, and hardness." They are susceptible to conventional forming methods.

Under an AF Office of Scientific Research contract, E. R. Parker, J. A. Pask and J. Washburn at the University of California have produced in the laboratory single crystals of magnesium oxide (melting point, 5072°F) that are ductile. This was done by special surface treatment. While theoretically these crystals could be grown to any size and machined to desired shapes, work is accelerating on inducement of ductility into polycrystal structures.



Engineering Beyond the Expected...

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Withstanding torture is a specialty of Packard Bell's Doppler Velocity and Position indicator (DOVAP), designed and developed for an inter-continental missile (classified). In prototype environmental tests, this high powered Doppler Transponder was subjected to temperature, shock and vibration beyond the extremes expected in flight . . . beyond the extremes called for in specifications.

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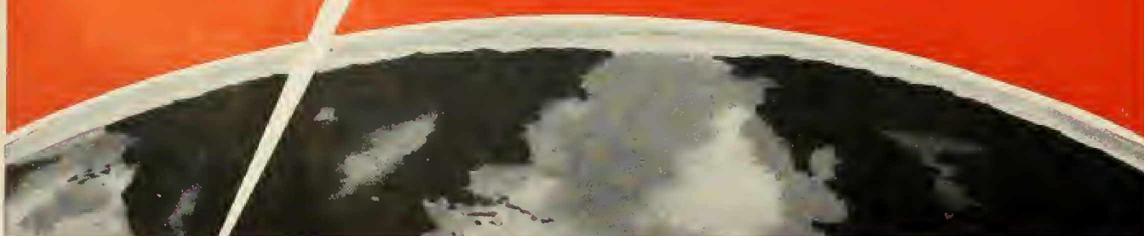


Spaceman Col. Bill Davis

Details Absolute Limits of Chemical Rockets
Suggests Magnetic Ramjet for Orbit and Escape
Emphasizes Need for More Relativity Studies

Colonel Wm. O. Davis, USAF, is Deputy Commander, Operations, Air Force Office of Scientific Research (ARDC). He's also a senior pilot having ended up World War II as a B-24 squadron commander—a member of Phi Beta Kappa and Sigma Xi and holds a Ph.D. in Nuclear Physics. But perhaps his greatest contribution to the future and security of the nation is that he has gathered a group of men under him who are not only willing to tackle the impossible but will try a new approach to it as well. Great scientific achievement never derived from wearing blinders.

Q. *Col. Davis, can you give us some idea of the future of propulsion, the practical limits on rockets, for example, and what comes after?*

A. The basic problem is fairly straightforward. Right now, all propulsion systems have one thing in common: They're heat engines. Heat, by definition is a random process, and when I heat a gas, whether to push a piston with it or to simply squirt it out the back end, basically I have one serious problem: My energy is going in all directions. A large percentage goes into the structure as heat.

This leads right to the fact that you are limited by materials. I don't know exactly what is the best material we've got now, but for sustained operations it's probably good to somewhere in the neighborhood of 1500° to 2000° centigrade. In the course of time we may be able to double that—up to about 3000° C.

Q. *What kind of material would that be?*

A. Probably magnesium oxide or something like that. Carbon goes to about 3200° C. Above 3500° C any material is in a gaseous state. You're not going to make an alloy or a ceramic or anything else out of gas. This is the end of the line. There isn't ever going to be a 10,000° C material, unless you actually learn how to modify an atom.

Q. *Where does that leave us?*

A. Well, if you double the temperature at which a solid or liquid rocket—any rocket based on heating a gas—can operate, by the equations of rocketry, you only increase your exhaust velocity by the square root of two. In other words a 40% increase in specific impulse is all that can possibly be expected, no matter how good the propellant is. It makes no difference whether I do this with ordinary chemical fuels, free radicals, nuclear piles or any other source. Where I heat and expand the gas through a nozzle in the way a rocket does. I'm limited to a 40% increase.

Q. *40% over what?*

A. Over what we now have in the way of a rocket.

Q. *Is it practical to think of putting a man in space at this time?*

A. Yes, for certain types of objective. For example, to pinpoint the location of, say, a satellite, if you rely on transmitting from the earth to the satellite, your uncertainty of where it is is quite large and at the distance of the moon or anything farther, your knowledge of its location is very poor indeed. You're faced with the fact that you're going to have to transmit and observe from the vehicle.

It may turn out, surprisingly enough, to be somewhat easier to do this with a man. Problems of communication, navigation, maneuver and return to base—for that matter, the interpretation of information—may be made an awful lot easier with a man than it will be to design automatic equipment to do it.

Q. *How would you put a man in space?*

A. The limiting factor of just about 40% more exhaust velocity is ultimately going to prevent you from using a heat engine. It will be neither safe nor economical. All right, what other properties do I have to work with? Electricity and magnetism are a possible approach.

With an electric or magnetic field I can make my particles go in a straight line, rather than just heating them up in a random way so that they push against the walls of the chamber in all directions and heat it up. Electrically or magnetically I can make them go in just the direction I want. I can use all the energy I've got effectively.

Q. *Won't this concept almost invariably require a conventional rocket booster in order to build up initial escape velocity?*

A. No. This is another thing that bothers me. People are under the illusion that the only way to get off the surface of the earth is with a straight up, 10 *g* blast off, or something of the sort. This goes back to a concept that was laid down and developed in about 1924.

I would start with an air-breathing engine, either an ordinary turbojet or a ramjet or a combination of both.

What I want to buy first of all is altitude, and I want to use a propulsion system which is most efficient for that purpose. Secondly, having gotten altitude, and not before, I want to buy speed. Speed at sea level costs too much. I wait until I'm up 150,000 feet or so; then I buy my speed.

Q. *Can you attain escape speed in a ramjet?*

A. Not necessarily with an ordinary ramjet by itself, though I could get some pretty high speeds, perhaps Mach 5 or 10. There I have reached maybe 150 miles altitude where most of the air particles present are charged.

Q. *Would you then cut in your ion propulsion system as a kind of boost to the ramjet?*

A. Yes. As I reach this region where I have charged particles available I will begin to apply part of my total energy magnetically. I'll just begin to. Then, as I go higher, I'll get an ever increasing portion of my thrust magnetically, until I reach an altitude where the thermal aspects of a ramjet won't be effective. By this time virtually all the gas is ionized—multiply ionized. Now I'm going much faster, so that the total volume of gas going through that I can act on is getting greater.

Q. *Well, using the ionized air at altitude in this way, don't you end up with a kind of magnetic ramjet?*

A. Yes. I don't know whether what anybody has in mind right now is practical or impractical, but I'm convinced that one way or another we're going to find out how to use electricity or magnetism for thrust. And, I think the logical way to do it is magnetically. If I use my energy to create a magnetic field that works against a charged gas, I can probably get orbital velocity within the atmosphere—at an altitude somewhat below 500,000 feet and just coast off into an orbit.

Q. *Now you've set yourself a kind of linear accelerator out in space. What's your power source?*

A. I have to carry it. This is where the true value of nuclear power really begins to be felt—as a source of energy. I can carry it with me and run it indefinitely.

Q. *Though space is popularly thought to be "empty," we understand there are charged particles out there. Is there any clue as to whether there are enough so that at very high velocities we can use them to effectively supplement the working fluid?*

A. According to Professor Fritz Zwicki of Cal Tech, yes. These particles would be very highly charged—many times ionized and probably stripped of all their electrons. He says that if you get going fast enough, you can scoop in enough of these things to where you get thrust out of them.

Q. *Would your working fluid be hydrogen?*

A. It depends on the velocity I get. I think that you would find that your working fluid would vary with the size of your vehicle and how far you wanted to go. Say I have the capability to accelerate my working fluid to a tenth the velocity of light. As soon as I get into this ballpark of exhaust velocities I have to worry about Relativity.

I've got to remember that what I'm after is not exhaust velocity which works fine at the lower exhaust speeds. I'm after momentum transfer. In other words as I begin to try to make the exhaust go faster, and I get it fast enough to where Relativity enters in, instead of making it go faster, I'm merely making it heavier.

Q. *Under the principle of conservation of energy, won't your momentum continue to increase proportional to the energy fed into the system whether it does so because velocity goes up or because mass goes up? Momentum is simply mass times velocity, isn't it?*

A. Actually momentum is mass times velocity only at relatively low speeds. The theory of Relativity defines momentum as $P = m_o v / \sqrt{1 - v^2/c^2}$. Thus when v, velocity is small with respect to c, the speed of light, the equation reduces to simply the product of the mass and the velocity. However, when, v equals c, the momentum becomes infinite. However, in answer to your question the momentum will continue to increase proportional to the energy fed into the system but not in the same way it does at low speeds.

Q. *On this business of Relativity, as we start thinking seriously in terms of space flight and the velocities it implies, doesn't Relativity begin to become not a theory for possible application to basic research but a matter of practical, operational consideration. For example, according to Relativity the only limit on a space vehicle's velocity is its own observation of the speed of light. Yet this is constant at 186,000 miles per second no matter how fast the vehicle goes. On this basis, is there any limit to how fast man will be able to go in space?*

A. Well, once you leave the earth, you will still exist in a frame of reference—the solar system, the galaxy or something.

Q. *Suppose you close yourself in and refuse to consider any frame of reference but your own—just calculate your acceleration on the basis of classical mechanics?*

A. Under these conditions you will observe a constant acceleration but since your measurement of time is changing with respect to the earth it works out to give the same answer. In other words I appear to have a constant acceleration in my frame of reference but since my measurement of time is changing with respect to the earth, my earth-measured acceleration appears to decrease.

Q. *What I'm wondering about is whether or not there aren't too many scientists who tend to accept Einstein's theories as the last word?*

A. Einstein himself said many times that there was no doubt in his mind that as time passed on his theory would be shown by somebody to be merely a special case of a more general theory. I don't think he ever had any feeling of an immortal theory, but a lot of people do and this is understandable—It's what they learned at school.

Q. *This proposal to send a small rocket around the moon—Is it practical to consider it at this time?*

A. Let's put it this way: We have the technical capability to do it.

Q. *In the case of so-called anti-gravity, what is the actual research and development situation there?*

A. First of all, there is a very great deal of misunderstanding of the whole question of gravity. We are very much concerned with its study. The Air Force works in the gravitational field at all times. Anti-gravity or what-have-you might possibly someday result from such studies. However, there's an illusion as to what you would buy with so-called anti-gravity.

. . . a 40% increase in specific impulse is all.

It may be easier . . . to put a man in space.

What I want to buy first is altitude . . .

One feeling is that all you've got to do is paint anti-gravity on the bottom of something and immediately you rise to the moon. But this is phoney, because nobody has ever suggested we're going to do away with the conservation of energy, and if I'm going to lift a pound 100,000 feet, I'm going to expend 100,000 foot-pounds to do it. I'm going to have to supply exactly as much energy to do it with the gravitational field as I'm going to have to apply to do it with a rocket.

There's no way I can get away from it. The only advantage I might gain is a more efficient use of energy. Clearly if I have a nuclear source, I can generate electricity or what-have-you. If I could now apply this to direct interaction with the gravitational field, presumably I could rise more efficiently. The mere fact that I can control the gravitational field won't mean that I can get something for free.

Q. *But you do have conditions where you do, in effect, get something for nothing. The crystal radio set is an example. True, energy is expended and it had to be produced somewhere, but you as the user of the receiver don't have to supply it. Might it not be theoretically possible for a vehicle in flight to get part of its energy elsewhere in a similar manner?*

A. Well, this is perfectly true, and I'm not ruling out that you can't do something useful with the gravitational field. Certainly when we progressed to the point where we could generate an electro-magnetic field, we could do a lot more than we could with a lodestone.

In particular there's one neat little trick that has always appealed to me. Whether mass is positive or negative, it still goes to infinity at the velocity of light. In the Special Relativity equations, on the other hand, if my mass is zero the equation becomes interderminent.

Suppose I could so shield my entire vehicle from gravitational influences that to an outside field its mass seemed to be zero. Under these conditions, it appears, I would have no velocity limitations. It would be a very nice thing to do, but it's not the answer to all problems.

Q. *The Air force has some contracts out now for studying ion and photon propulsion systems, doesn't it?*

A. Nothing on photon propulsion, but we have several people working on various aspects of ion propulsion. What we're trying to do now is not to build a rocket but to study the properties of electrically charged gases at very high densities—how to handle them; how to accelerate them; how efficient is the process; what are some of the problems. This can be done in the laboratory, and done rather cheaply. The plasma jet is very useful.

Q. *Is this the same plasma jet they use for nose cone testing?*

A. Yes. Such a jet can be used for a lot of things. This is a nice way of producing about 20,000 degrees Fahrenheit for cutting very high temperature materials or for melting materials that can't be melted any other way. You can also use the same plasma jet to do experiments on ion acceleration and on the control of large bodies of ionized gas at high densities.

Q. *When you try to accelerate a plasma flow either electrostatically or magnetically don't you have a problem with mixed negative and positive ions?*

A. Yes. Admittedly you're accelerating one group of particles in one direction and one in the other, but in general your positively charge particles are carrying most of your mass. So while you balance your charge, your momentum has to be conserved. It is not a complex problem to collect your negative charges, which are mostly electrons and simply reroute them so you exhaust them in the same direction as the rest of your flow.

Q. *What about electrostatic control and acceleration of your ions?*

A. We're not particularly enthusiastic about the classical approach to ion propulsion, which is simply electrostatic, where you have a large potential difference, and you accelerate particles along this potential difference. Reason is that as you begin to get a lot of current in your ion jet. It becomes an almost perfect conductor.

It's nearly impossible to maintain your potential difference. Furthermore, even if you could, at these very high voltages there's a tendency to start collecting electrons around the terminal. The space charge would defeat you. In other words, you'd eventually be pulling your exhaust gases back into you.

Q. *With excessive voltages wouldn't you also generate some very high intensity X-rays?*

A. You very well might. Thus magnetic acceleration looks a very great deal more promising because you get high energies, but you stay away from high voltages.

Q. *How do you think development along this line will progress time-wise?*

A. Assuming you begin to get a pretty good feel for how you best go about accelerating charged gases, one of the next things you might want to do would be to stick something on somebody else's rocket and see whether you get any positive thrust, and if so, how much.

Q. *What is your objection to photon propulsion?*

A. I'm not terrifically excited about it because basically you still come back to the fact that it's a heat engine. You can't charge a photon and accelerate it magnetically. There's the same old problem of materials limits.

Q. *Do you think you'll run out of developmental potential in the chemical rocket, considering problems of lead time, etc., in, say, ten years?*

Then, not before, I want to buy speed . . .

Electricity . . . a possible approach.

. . . orbital velocity within the atmosphere.

A. We're going to run out in a lot less time than that, you see, because just the trend curves themselves show you that in all probability you're going to want what comes after much sooner than most people realize.

Q. *Conceivably then, you will have ion propulsion weapons systems working well before the 1970's.*

A. Well, if the principle is sound. The whole thing that confuses people is the length of time it takes to engineer something versus the length of time it takes to have a new idea. Suppose in 1938 I had decided that I wanted to drop charges consisting of 20,000 tons of TNT: I could have spent the next 50 years trying to develop an aeroplane to carry it. But a simple new concept gives me the capability to accomplish that particular job in much less time.

Q. *Can you indicate moneywise how much effort is being put into ion propulsion?*

A. It is very small. And even the effort going into ion propulsion, since we are a research organization, is not necessarily related solely to ion propulsion. The work with plasma jets can be useful in many ways. You want to find out its properties. You don't say this percentage of our program goes for ion propulsion. For example, the earliest work in magneto-hydrodynamics now contributes to this knowhow.

Q. *Magneto-hydrodynamics—what's that?*

A. A fluid which consists of charged particles behaves differently from an ordinary fluid because as each particle moves it generates its own little magnetic field, which in turn causes motion on the part of an adjacent particle which is also charged and also generates a field. You not only have a damping effect but an entirely different method of transmission.

For example, a magneto-hydrodynamic shock wave will transmit itself in an entirely different manner from a normal shock wave. This field of study had its origin in astrophysics. So, would you say research into magneto-hydrodynamics was part of your astrophysics or part of your ion propulsion budget?

Q. *By when do you think there will be an operational requirement for an ion propulsion system?*

A. Let's face it. There never has been a new concept developed because of a requirement. Somebody discovers something new, and then says what can I do with it. I will say this, however. If at some future time—and this might be two years from now if we're lucky and everything we've got under way proves to be fabulously successful; or it might be five, ten or fifteen years from now—we are suddenly in a position to say: Look, here is a new propulsion concept, and it's been demonstrated in the laboratory; it will work and it will give you the following capability. When this happens, in a very short period of time somebody will have established a military requirement for it.

Q. *When do you think we'll leave the heat engine? When will the next hike in speed and altitude, the step into space, require that we have something else?*

A. There's always an intrinsic military requirement to do the next thing. It would be nice and convenient if this weren't so, but its the nature of the beast. As soon as you think you understand a military environment fairly well, the enemy outflanks you, and this is a strategic war we're fighting.

This business of scientific research may seem quite far from the battlefield, but actually, we're at war now. People who fly airplanes and drop bombs are preparing for it. In the laboratory, we're at it. We're at war.

We have entered space or certainly are about to with military vehicles. It is becoming the next major military environment. There is an intrinsic necessity that we understand this new environment and that we understand it first and that we understand it best. Every other military environment that's ever existed always had the same start.

We can't sit around and wait until the last minute. This is too expensive. We're going to have to evolve a new military concept before the fact. So, in this sense there already exists a military requirement for a non-thermal propulsion system. It's not a formal one, but in the sense that it's related to future progress it exists.

Q. *What's the commercial application, if any, of such things as ion propulsion?*

A. Well, consider the problem of going faster and further, whether it's for military or commercial purposes. A very large percentage of the total energy you're using, whether it be in the gasoline engine of the DC-7 or what-have-you does nothing else but overcome drag. And the faster you go the higher drag gets.

It is inherently cheaper when I want to travel great distances, and particularly if I want to do it fast, to go high first and then go fast, rather than try to beat my brains out against an atmospheric wall. These propulsion considerations are not entirely related to just some future far-off time when we're going to be fighting a war in space, they're related to the national economy. We're consuming our natural resources at a tremendous clip. How much can we afford to throw away?

Q. *Who gives the go ahead to start building towards a space force?*

A. It is not our job to decide whether the United States is going to build a space force. Somebody at some future time, and it may not be too far away, is going to have to face a decision at a very high level. Somebody is going to have to take note of the fact that the Soviet Union is heavily in the business of astronautics.

Somebody is going to have to decide if it is or is not worthwhile from a military point of view to push such a program. Now, we don't make that decision, but on the other hand you can't make it in the absence of facts. You first have to know what is the real capability. How much will it cost? What are the problems? How much of the national economy is going to have to be diverted?

Q. *Do you find it hard to get support for this kind of research?*

A. Within the last few years our top management has shown a very, very enlightened attitude. It's been quite remarkable that people have been able to understand this type of research. We've gotten excellent support out of the Air Staff and out of General Power in ARDC; also from the Assistant Secretary for Research and Development. We've gotten excellent support from every level.

Q. *You're primarily a basic research organization?*

A. Yes, but we do have a philosophy of management here which says that we believe we have to do more than just support basic research. If all we do is support it, we might as well turn our money over to somebody else and let them do it, but because of the fact that we are supporting basic research, we have a magnificent input of information in every field of science, and therefore with a very small group of people, we're in a position to try to synthesize results coming in from every field.

Q. *This provides you with an excellent opportunity, but doesn't it also require that you and your staff maintain completely free and open minds?*

A. Yes, and we have fought for this for a long time. This is not a casual accident. It's taken a great deal of effort on the part of a lot of people to develop and maintain this opportunity to work in the particular way that we do. ★

From Redstone to Jupiter

Army Philosophy in Development of Ballistic Missiles

by **Dr. Wernher von Braun**
Army Ballistic Missile Agency

THE BASIC CONCEPT behind the *Jupiter* development is that it is the natural and logical next step after development of the *Redstone* missile. The well-tested and successful *Redstone* became a natural test-bed for guidance and other components of the *Jupiter*. *Jupiter* components of all kinds have been test-flown in modified *Redstone* missiles.

We have conducted captive runs with complete *Jupiter* configuration on the test stand, and obtained an average of several hundred different measurements per run. These furnished information ranging from powerplant performance to intimate environmental data such as the vibration pattern on a certain spot in the missile where sensitive equipment will be mounted. Such captive test information, in addition to *Redstone* flight test results, leaves very little to chance.

This wealth of test stand in-flight experience, coupled with the methodical testing and evaluation of all components, enables us to feel quite confident about the forthcoming flight-testing of the *Jupiter* missile itself.

The Army has pursued a minimum-risk program in the development of the *Redstone* and *Jupiter* ballistic missiles which provides optimum development and performance.

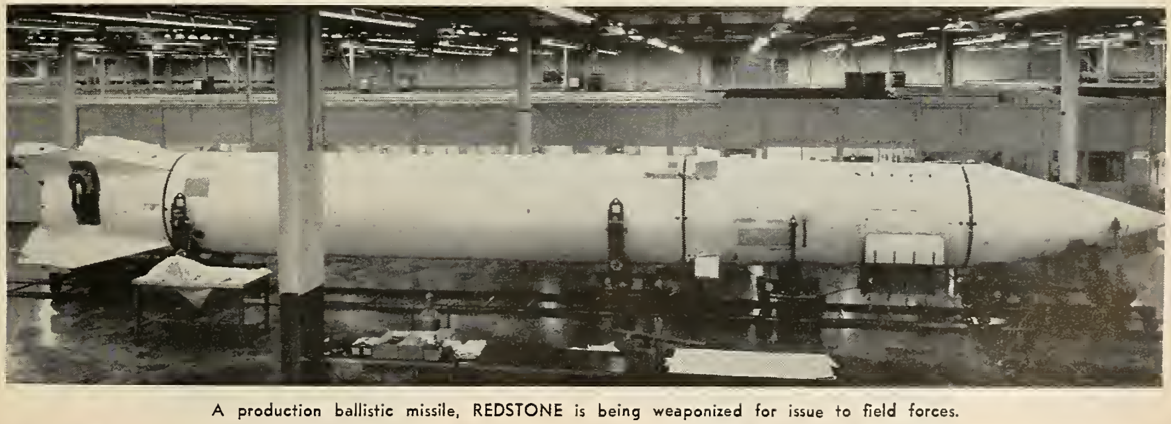
Basically it provides for the thorough testing of every component and minor and major assemblies, prior to launching of the missile.

There is a tremendous difference between delivering a block of research and development missiles to the proving ground, and firing them successfully on schedule. The former is essentially a question of shop capacity. The latter depends on the capability of the engineering team to evaluate flight results correctly and rapidly, make necessary changes, and furnish the modified missiles with a sufficient degree of reliability to the firing crew.

This development cycle—discrepancies uncovered in flight tests leading to modifications of further test missiles which are half-completed on the assembly line—is quite slow, thus it is difficult for even the most closely integrated team to keep the experimental missiles firing at frequent intervals.

The Army's *Redstone* and *Jupiter* missile programs are being handled by a closely-knit and tightly integrated team with many years of experience in the ballistic missile field. This team consists of experienced scientists and engineers of virtually every field involved in this relatively new art. It includes rocket engine men, structural engineers, physicists, aerodynamicists, gyro experts, electrical network specialists, as well as test stand engineers, tool designers and fabrication experts.

Such an integrated team is more than just a group of specialists working on the same premises. It is comprised of men who have what I call "practical systems experience," men who are familiar with the intimate functional cross-relationship of guided missile components, who know how an observed deficiency in their area of responsibility may affect an entirely



A production ballistic missile, REDSTONE is being weaponized for issue to field forces.


REDSTONE being hoisted into firing position.

different part of the missile. We thus have within the organization our own systems engineering group.

The need for utmost flexibility during the research and development firing period governs our design philosophy. We expect occasional surprises and setbacks, and the resulting need for modifications between test firings.

We do not believe it is wise to plan too high a rate of initial firings, nor to release too large a number of untested missiles to the production shops for the early flight testing phase.

We believe that by setting early production aims too high there is a very real danger of "drowning in one's own hardware." Too much hardware too early will tie up the bulk of shop manpower with the modification of half-completed missiles which failed their flight tests.

Our schedule called for a limited number of development missiles in the early phase, but for elaborate instrumentation and a maximum of telemetering. An extended inspection period, supported by comprehensive check and recording equipment, permits flight simulation for every missile and virtually all components.

We static-fire our missiles prior to final inspection and shipment to the firing site. This allows us to call freely on the design and development engineers for correction of any defects encountered. It also minimizes the strain on the proving ground facilities.

The proper places for shakedown testing of large ballistic missiles are the static test stand, the electronic simulator, the structural and mechanical test laboratories, and the environmental laboratory. Large missiles are too costly and too dangerous to be flight tested until every key man in the development is honestly convinced that he has exhausted every ground method of uncovering any deficiency.

Early development vehicles should be designed to use readily available and economical materials and construction processes, with final product engineering proceeding as a certain volume of experience is accumulated.

All the guided missile experience to date, including that on the *Corporal*, the *Nike*, and the *Redstone* indicates that this procedure is an effective and economical one for guided missiles. This becomes readily evident by comparison of preliminary layout and the final, operational product of any of these missile systems.

Close liaison is maintained with the production prime contractor during all stages of development. Thus production can begin almost immediately at any stage of the design.★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Shock from a first stick of explosive (below) causes sympathetic initiation of a second stick (above) in this series of frames photographed in the time sequence noted. The Model 189 Framing Camera used is a complete system with automatic controls for simple, reproducible operation. At rates up to 4.3 million frames per second.
explosive autograph
made with Model 189 Framing Camera
Photos, courtesy Ballistics Research Laboratory, Aberdeen Proving Ground
Beckman & Whitley Research Cameras of other types including sweeping-image models are solving analytical problems for many organizations. Send for details.
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Chemical Aspects of High-Energy Solid Propellants

By Alfred J. Zaehringer

VIRTUALLY ALL modern solid propellants can be considered in the high-energy class. The performance range is from a specific impulse of 180-225 sec. The average Isp is probably at the 200 sec mark. This corresponds to a heat of combustion of about 1.0 kcal/g for typical systems.

During the past ten years the performance has increased some 40-50 sec. However, during the next ten years, we will be doing well to drain an additional 25-30 sec. The probable practical limit for conventional solids will be under 300 sec.

The reason: we are running out of good, *stable* chemical systems which can yield enough energy. In addition, such important factors as physicals, ease in processing, and cost are becoming increasingly important.

In essence we now have two types of solid systems. One, homogeneous propellants, have oxidant and fuel (reductant) combined in one molecule or mixture of molecules. Binding is largely a result of the chemical bond.

The other approach has attempted to strengthen the bond by use of plastic fuel-binders. Here, in heterogeneous (or composite) propellants, we have a separate oxidant compound bound together with a plastic adhesive which also serves as fuel. Fig. 1 schematically outlines processing techniques for both classes of propellants.

In general, the properties of the mixed propellant will determine how the grain is to be formed. For very stiff mixes, hot or cold milling may be required. Extrusion can be used with solvent systems or heavy composites. The general aim now is to arrive at castable mixtures, viz., mixes which can be poured (like concrete).

Techniques used in making castable propellants are exactly the same as for making concrete. In all modern systems, then, we no longer have "powder" rockets. Although powders may be used, the finished propellant derives its "solidness" from chemical bonds rather than from mere mechanical bonds. Thus, literally, modern solid propellants are really solid.

The first breakthrough beyond the ancient black powder came with the discovery of nitrocellulose around 1830.

Figure 1
Solid Propellant Processing

Type		Processing		
Single Base		NC	Solvents Stabilizers	Solvent Removal Extrusion
Double Base	Cordite Ballistite	NC NG	Solvents Stabilizers	Solvent Removal Extrusion Hot Working Casting
Double Base	Solventless Cordite	NC NG	Plasticizer	Extrusion Hot Working Casting
POL Powder		NC DEGN	Plasticizer	Extrusion Hot Working Casting
Composite		Solid Oxidant Fuel Binder		Extrusion Cold Working Casting

NC: Nitrocellulose
NG: Nitroglycerin
DEGN: Diethylene glycol dinitrate

Nitrocellulose (cellulose nitrate is the more correct chemical name) combines both oxidant and reductant within the some molecule.

Normally it has a fiber-like structure. By use of solvents, other materials, and mechanical work, nitrocellulose can be formed to give tough, plastic-like grains. However, the energy release was fairly low and, more important, nitrocellulose is an unstable molecule even when very pure.

Stabilizers (such as diphenylamine) were found to prolong storage life and later nitroglycerin was added to increase the energy content. However, addition of nitroglycerin was a costly affair: it not only increased the price but also made the propellant much hotter burning and also more sensitive to shock and temperature.

Since both single and double base propellants were formed with the aid of solvents, solvent removal with larger and larger grains became more and more difficult. The newer solventless systems now offer almost unlimited grain sacle-up.

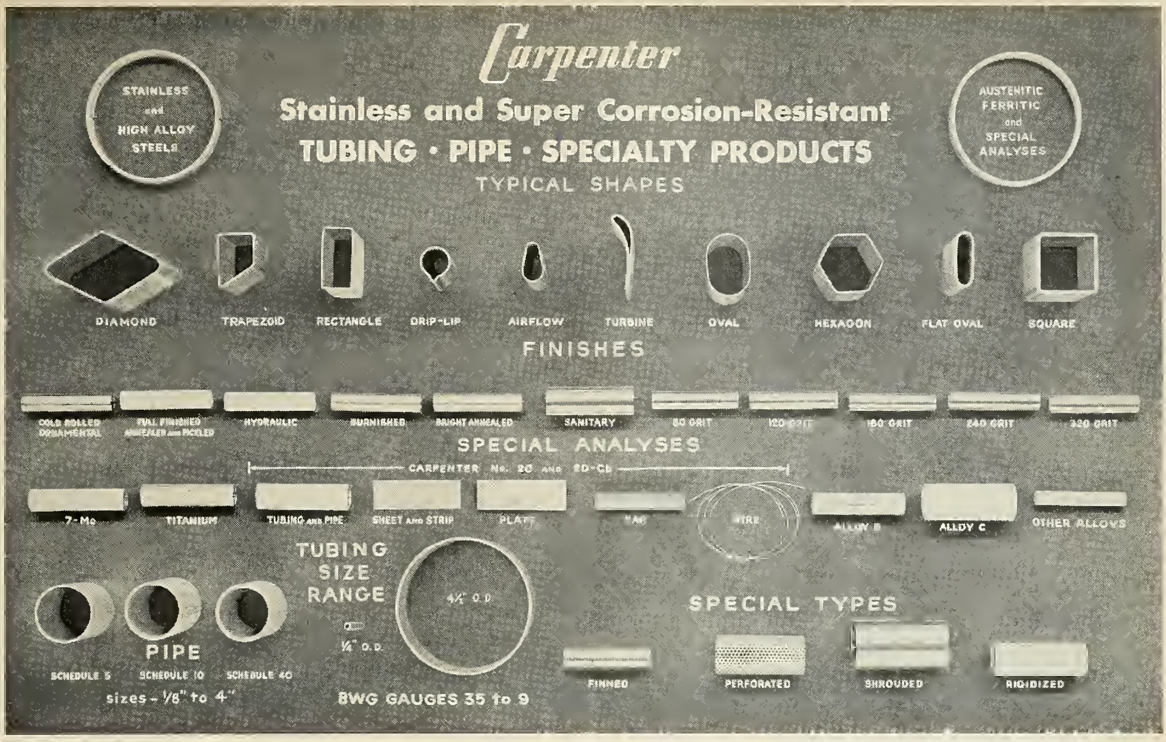
With plastics technology growing steadily after World War I, the solid oxidants (Table 1) were eyed seriously by researchers in a number of countries. The old GALCIT binders (asphalt-oil) and NDRC types (cellulosics or phenolics) are now familiar to all.

Late in the war, two important fuel-binders were added: the polyesters (Aerojet Aeroplex) and the polysulfides (Thiokol). It may be assumed that these materials form the backbone of most present composite systems.

Unfortunately, we are stuck with a meager number of good oxidizers at the present time, so, in the composite field at any rate, one might consider looking for better fuel binders.

The ideal fuel binder is a low molecular weight carbon-hydrogen compound containing as much oxygen as possible. It should be a low viscosity liquid that can bind together a large amount of solid oxidant. The mixed propellant then should harden rapidly to a thermo-setting solid.

Physicals should be good. Cost and potential availability should be attractive. In reality, however, a number of optimizations have to be made so that physicals, and ease in processing are more important parameters. Of



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309SCb	317L	443	Titanium 55 and 70

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the fuel binders in the table, the epoxies and polyurethanes hold promise for future composites.

It is interesting to note that the Soviets are now pushing for large expansion of epoxy resin production in East Germany.

In the homogeneous class, work is now underway at several labs in the synthesis of new, stable molecules to replace nitrocellulose or nitroglycerin. Most of the work seems to be centered around organic nitropolymers. However, improvements in German-developed diethylene glycol dinitrate systems are also taking place.

For composite propellants, the future seems limited to available or readily developed oxidants or fuel binders. Since the oxidant is the heart of a composite system, a breakthrough can only come when a new or ideal oxidant is found.

Summarizing we might say that solid propellant performance is now increasing at a decreasing rate. The big holdback is in available chemicals. If *new kinds* of compounds are developed solid propellants might be pushed into the ultra energy class.

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2. For smokeless operation no metallics or halogens.
3. Density of 1.0-2.0 g/cm^3.
4. Low viscosity, low vapor pressure liquid. High boiling point, low freezing point.
5. Polymerizes with heat (70-200 F) and/or catalyst. Pot life of at least 2 hours. No volatile reaction products liberated. No reaction with or decomposition of oxidizer. Low exotherm in large masses. Total cure time under 24 hours. Low shrinkage on cure.
6. Good binding at low total concentrations (10-25% of total propellant weight). Gives propellant tensile strength of $>$1,000 psi and compressive strength $>$5,000 psi. Allow cycling of complex grains over temperature range of —80 F to 180 F. Ability to resist moisture. Stable at 250 F for over 1 year.
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The Ideal Solid Oxidant:

1. Available oxygen content $>$50%.
2. For smokeless operation no metallics or halogens.
3. Density: 1.5-2.5 g/cm^3.
4. Stable solid at room temperature (insensitive to shock).
5. Melting or decomposition point $>$400-700F.
6. Low coefficient of thermal expansion.
7. Non-hygroscopic.
8. Low cost and high availability.

FILLING A NEED...

ıng the nineteenth century, the mechanics of fluids branched ıe main stem of physical science. Physics concentrated on the ɔration of the structure of molecules and their components; development of fluid mechanics was guided by the need for ɛrstanding the macroscopic phenomena associated with ships, ines, airplanes, etc. The separation between these disciplines been reflected in the organization of university departments several generations, so that there is little contact between ics and fluid mechanics departments. This lack of contact been reflected in our scientific graduates who typically have trained in one or the other of these disciplines, but almost r in both.

suddenly, however, the country faced an important problem ı we had to meet the challenge of rapidly creating an operable continental ballistic missile. The re-entry of this missile into earth's atmosphere was regarded as a very difficult problem; ely because here, for the first time, we faced a scientific prob- involving the mechanics of a fluid closely coupled with im- ant aspects of molecular physics. The Avco Research Lab- ory was created to fill this need. Its senior scientific personnel trained in classical aerodynamics, atomic physics, and ical chemistry, and saw in this interdisciplinary area a unique rtunity to broaden their background and to make creative ributions in a field in which the great advances are still to ıade.

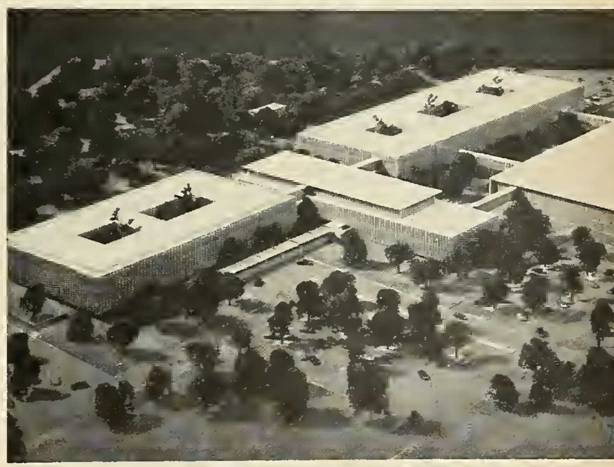
laboratory has been successful in supplying vital information h only a year ago was generally held to be obtainable only ostly and time-consuming flight experiments. Our research ess has resulted in a large development responsibility being usted to this company.

interdisciplinary strength we have acquired will enable us to a major role in such problems as the re-entry of manned cles into the atmosphere from satellite orbits, in the creation thermonuclear reactor, and in other fields involving the amics of high temperature gases.

Dr. Arthur Kantrowitz, Director
AVCO RESEARCH LABORATORY
a unit of the

avco | **research and advanced development division**

Dr. Arthur Kantrowitz



Pictured above is our new Research Center now under construction in Wilmington, Massachusetts. Scheduled for completion in early 1958, this ultra-modern laboratory will house the scientific and technical staff of the Avco Research and Advanced Development Division.

The Avco Research Laboratory at Everett, a unit of A.R.A.D., has a few openings for leading scientists who can help us expand our capabilities in:

Theoretical, Experimental and Solid State Physics
Physical Chemistry—Aeradynamics—Physical Electronics

There are other career opportunities for exceptionally qualified scientists and engineers in the Development Laboratory at Lawrence and the Electronics Laboratory at Boston, in such fields as:

Science:
Physics—Mathematics—Metallurgy—Thermodynamics—Aerodynamics

Engineering:
Aeronautical—Chemical—Electrical—Mechanical

Write to Dr. R. W. Johnston, Scientific and Technical Relations, Avco Research and Advanced Development Division, 20 South Union Street, Lawrence, Massachusetts.

engineering briefs

US-KG Engine Co.s Enter Agreement

The two largest U.S. rocket engine manufacturers have entered into agreements with British firms.

Aerojet-General has signed an agreement with D. Napier, Ltd., which has developed rocket engines for the Ministry of Supply. They produce a variety of engines for both guided missiles and for aircraft applications. The aircraft applications are for auxiliary high altitude speed boost and as a main powerplant. The Napier establishment at Luton is one of Britain's most extensive rocket test installations. Napier Ltd. has been developing and manufacturing rocket engines for six years.

Initial exchange of information with Aerojet will center upon hydrogen peroxide rocket engines. Great Britain has utilized high test peroxide for safe and reliable rocket engines to a much greater extent than the U.S. where peroxide is used for turbopump drives.

Similar negotiations have been entered into between Rolls-Royce, Ltd. and North American Aviation, Inc. (Rocketdyne).

Such negotiations are expected to speed up realization of British defense plans which will be dependent to a large extent upon offensive and defensive guided weapons.

Navy Dedicates Building

Navy has dedicated a $165,000 Bureau of Aeronautics building at El Segundo, Calif., to serve as a center for monitoring research, development and production of aircraft and missiles in eight western states and Hawaii.

R. Adm. John B. Pearson, BuAer general representative, Western Division will direct operation.

Grand Central Hikes Solid Mixing Capacity

Grand Central Rocket Co. will install a large process mixer to increase solid propellant mixing capacity by 2,500 pounds an hour.

The mixer, built by Bramley-Beken of New York, will be installed in a two-story, partly underground structure within the next two months. Mixer is reported to cost about $100,000.

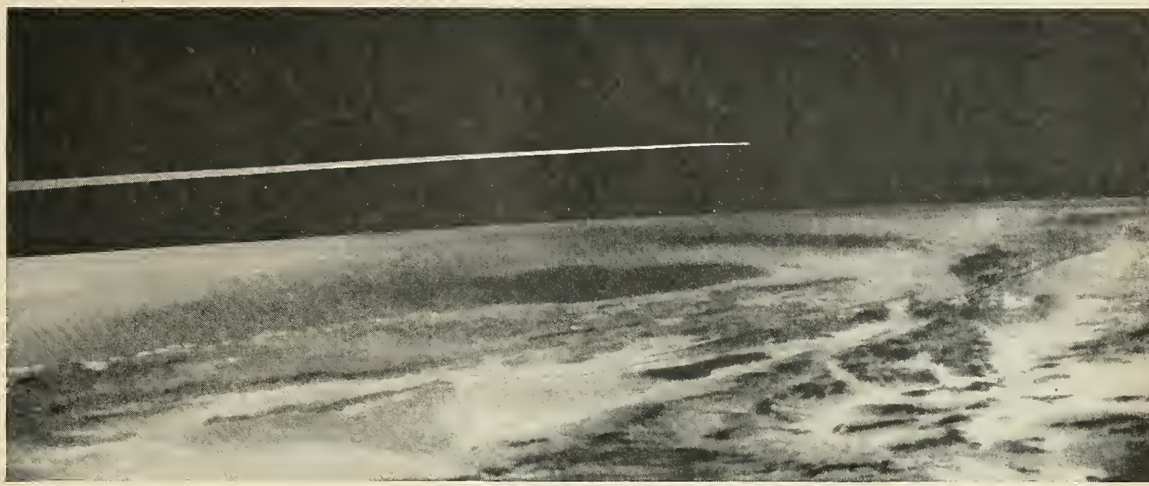
Bullpup Confirmed by Navy

The Navy and Martin finally have announced the new air-to-surface missile—the *Bullpup*. In a speech at Kansas City, Mo. last month, Vice Admiral William V. Davis, Jr., USN,

Career News for Engineers!

Flight Tests are under way on one of America's most important defense projects:

The Navaho Strategic Missile



Artwork based on Official U.S. Navy Photograph

The results are secret—but this much can be told. A test vehicle designated the X-10 has gathered new aerodynamic and electronic information which will help to speed progress on the SM-64 Intercontinental Strategic Guided Missile.

The opportunity—and the privilege—to implement this revolutionary data is yours.

Twenty-eight-year-old Army vet **WILLIAM T. SCHLEICH** was graduated from Georgia Tech in 1952 with a BSAE. He joined North American as a junior engineer the same year. Seven months later Bill was promoted to aerodynamics engineer for the Navaho missile program. He was appointed Supervisor, Stability and Control Unit in October of last year. With the help of North American's Educational Refund Plan, he received his MSAE from USC. Bill and his wife are hi-fi enthusiasts and have a sound system built into their Whittier, California home.

If you accept this challenge you'll be solving tomorrow's problems—today. Here facts are collected fresh daily. If yesterday's yield proves inconclusive you'll approach the problem from a new direction. You'll travel new paths and develop new inventiveness. And you'll be guided to each breakthrough by the world's best-informed missile authorities—your own associates.

One example of the new hardware evolving from this creative engineering effort is a fully transistorized electronic commutator. This instrument increases the information-relaying capabilities of the missile's telemetering system by commutating 27 outputs at speeds of approximately 100 cycles per second. It was developed by the Flight Test Instrumentation Group.

North American's Missile Development Division is a major center of missile activity — and a pioneer in the field. As far back as 1948 its first test instrument vehicle was fired from a launching platform. Today North American has complete weapons system responsibility for the Navaho — and its test program is being conducted at the Air Force's long-range missile proving ground which stretches more than 5000 miles across the Caribbean and far into the South Atlantic.

LYLE C. BJORN has lived aviation all of his life. As a high school boy he built a glider modeled after the Wright Bros.' first flying machine—flew it from ski jumps near his Utah home. He studied engineering at Utah State and earned his BSME degree from the U of Wyoming. Lyle joined North American in 1951 and is now Group Leader, Field Test Operations at the Missile Test Facility, Patrick Air Force Base, Florida. He lives with his wife and three children near Cape Canaveral where he is an active leader in Cub Scouts.

If this sounds like the kind of career-opportunity you've been looking for—write us today. We promise you a working climate that stimulates personal growth and rewards it with responsibility, professional recognition and material benefits limited only by your own ability. Further, you can continue to grow academically with the aid of our Educational Refund Plan—and some of the nation's finest universities are nearby.

Let us know what kind of creative engineering interests you. (Please include highlights of your education and experience).

CONTACT: Mr. R. L. Cunningham, Engineering Personnel Manager, Dept. 495-MAR-6
Missile Development Division, 12214 Lakewood Blvd., Downey, California.

NORTH AMERICAN AVIATION, INC.

Deputy Chief of Naval Operations for Air, outlined the development of the missile and said *Bullpup* is currently undergoing Navy evaluation and will be introduced as a service weapon.

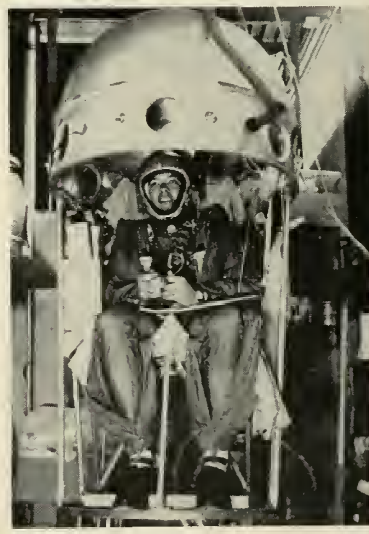
The *Bullpup* is designed to be launched from any position outside the effective range of enemy high-volume ground fire and provide sufficient accuracy to destroy small targets without excessive sorties and expenditures of many of bombs and rockets.

Industry Invests $100 Million for Missiles

Aircraft industry's investment in test and manufacturing facilities for the ballistic missile program is about $100 million, according to Aircraft Industries Association.

AIA president Orval Cook, in an editorial in *Planes,* said manufacturers put 60% of net earnings in expansion last year.

Winzen Balloon Sets Altitude Record



Capt. J. W. Kittinger, Jr. soared to 96,000 feet on June 2nd in a Winzen balloon to set a new record for manned, lighter-than-air flight.

The 28-year-old pilot landed about 80 miles southeast of St. Paul, Minn. after remaining aloft more than two hours.

The flight was part of a series of high altitude tests. Maj. David G. Simon, above, is scheduled to make a 24-hour endurance test at altitudes over 100,000 later this month.

The tests are being carried out by Holloman Air Development Center of Alamagordo, N. M. Kittinger's flight beats the old manned-balloon record of 76,000 feet set last November by nearly 4,000 miles.

Astrionics

By Henry P. Steier

Lockheed's Missile Systems Division has shelved plans to build a "hot" nuclear energy facility building at its Stanford University Industrial Park site in Palo Alto, Calif. Instead a Van deGraaff generator will be installed in the physics laboratory for work on nuclear reactions resulting from acceleration of charged particles.

•

Navy missile men are reportedly interested in the highly accurate low-frequency hyperbolic navigation system developed for USAF by Sperry Gyroscope Co. for position-fixing of ballistic missile launching ships. Stabilization of the launching platform and its exact location are key factors in effective use of such missiles. Reason for Cytac development has been a mystery, especially after AF dropped it and Coast Guard and Navy picked it up with plans to build a Cytac chain along the U.S. east coast. Tactical Air Command, it has been learned, had a tactical mission needing this type of position-fixing but found the system could not fill the bill.

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It appears that the planning program for use of SAGE (Semi-automatic ground environment) calls for control of the *Bomarc* missile as well as piloted aircraft. *Bomarc* will carry an 8-channel data link system for receiving interception data from SAGE centers. There is close similarity between *Bomarc's* data link system and that being readied for piloted aircraft use, with the exception that the latter has a visual display. One of the big contractors for the data link is Motorola, Inc.

•

Latest Pentagon "line" is high cost of electronics. Three military spokesmen in rapid succession recently hit at this matter. At the National Conference on Aeronautical Electronics Lt. Gen. Thomas S. Power, USAF Commander, ARDC said cost of maintaining leadership could reach crisis stage where it affected our civil economy. Rear Adm. Rawson Bennett, USN Naval Research Chief, said unless we force electronics cost down we will someday put the final straw on the taxpayers shoulders. James M. Bridges, Director of Electronics, Office of Asst. Sec. of Defense during AFCEA convention in Washington called attention to skyrocketing costs for weapon system electronics as a critical problem in the defense effort.

Interesting sidelight on the expenditure problem is Naval Research Laboratory record in this regard. In 1939, NRL received $2-thousand for research. In 1957 the figure is nearing $6-billion.

•

Dr. Bertram D. Thomas, Battelle Institute director, points out that "research and development is not the way to get new ideas." He says the character of the creative process has changed in the last 25-30 years. In the old days curiosity was the motivating factor. Today curiosity has given way to practical application. The character of research people has changed. He's "sure there are no pure scientists left"; there's too much need to earn a living. His parting shot—"The way to get new ideas is to give bigger salaries,"—was highly applauded.

•

Dr. Daniel E. Noble, Motorola's executive vice president, recently asked if his company has given any thought to space communication problems, quickly replied: "I have had some scientific training. Therefore I must first know the problems before I tackle the answers."

The Air Force, after a series of successful firings of the BOMARC XIM-99, has awarded Boeing Airplane Co. a contract for quantity production of the XIM-99 surface-to-air missile. The $7-million contract, initial phase of a larger one, will probably be utilized for the tooling program. Total funds allocated for the larger contract were not disclosed. Initial production plans have slated more than 70 per cent of the program for subcontracting.

According to the Air Force, the latest contract followed superior test results at Patrick Air Force Base. The XIM-99's were launched to seek out and intercept B-17 drones flying over the Atlantic. Individual XIM-99 flights have been carried out since fall of 1952.

BOMARC . . .

Enters Large-Scale Production

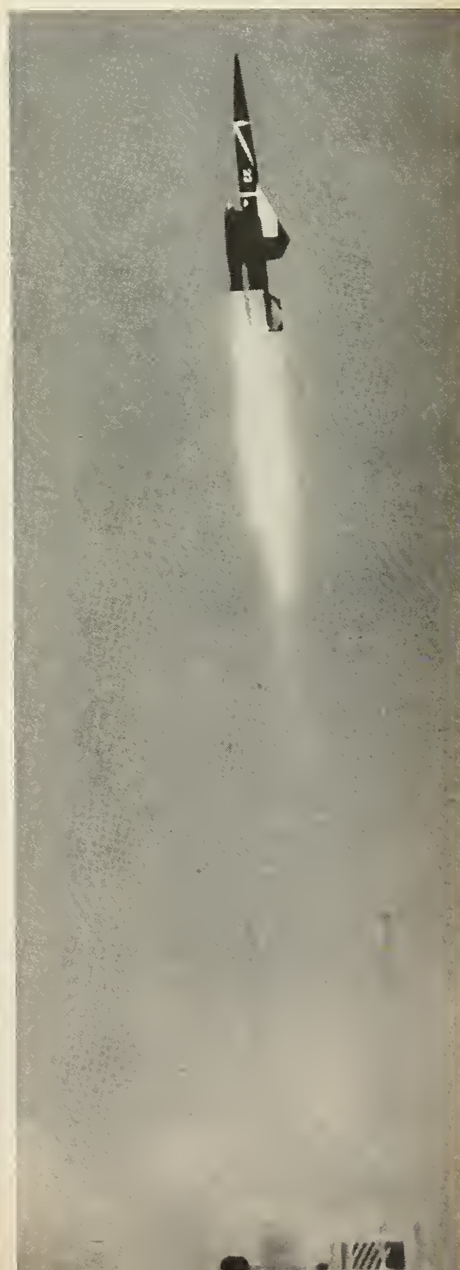
BOMARC missiles, with an operating range greater than any missile presently in use in air defense, will provide large perimeters of interception in strategic locations. This area defense role differs from the short-range point defense missiles such as NIKE and TALOS. The BOMARC is about 47 ft. long, has a wing span of 18 ft. 2 in., and weighs 7.5 tons. It is designed to operate at extreme altitudes and supersonic speeds with outstanding range characteristics. Energy required to lift the missile to operating altitude and velocity is provided by rocket and ramjet engines.

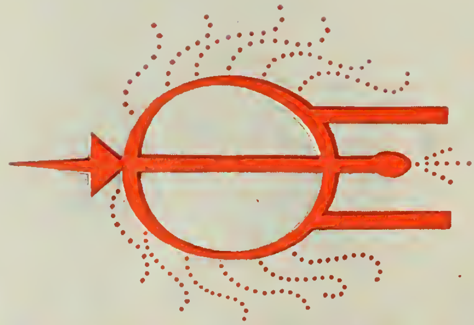
ɪn integral liquid propellant rocket engine esigned and manufactured by Aerojet General Corp. provides the boost, while two Marquardt ramjets supply sustainer thrust. OMARC is launched vertically from a combination erector and launch pad. The boost ocket provides the impetus necessary to raise he missile to altitude and sufficient velocity or operation of the ramjets. The ramjets, fter rocket burnout, provide the thrust for the cruise phase of the flight.

here are no recovery versions of the OMARC missile, although many designs ave been proposed. The advantages of a ecovery system have not appeared equal to he disadvantages imposed upon the missile levelopment. Instead, a system was devised or installing the guidance package of the OMARC in the nose of piloted aircraft, such as the B-57.

The recent decision to use existing production facilities in Seattle for the BOMARC production program brought to a climax the search for a location, which had extended over a period of several months.

Boeing presently holds additional contracts for the experimental production model XIM-99 and the service test model YIM-99. The first production missiles will be assembled at the Seattle division's Plant I, where the experimental models are assembled.





صفة بيضة تدرج وتحرق

er-Rammah's self-moving egg

Join two flat pans; fill with an incendiary mixture; add a tail; propel by two large rockets. In A.D. 1280, Arabia's Hassan er-Rammah, gazing centuries ahead, proposed this ovoid in his "The Book of Fighting on Horseback and with War Engines."

Today, rocket-powered ordnance is foremost in American defense...and Aerojet-General Corporation is foremost in rocket power. Aerojet's solid-propellant rockets are used on the Sparrow and Regulus and on the newest, most advanced American missiles.

Aerojet-General CORPORATION

A Subsidiary of The General Tire & Rubber Company — THE GENERAL TIRE — AZUSA, CALIFORNIA · SACRAMENTO, CALIFORNIA

We invite you—the engineer, the scientist—to participate at Aerojet in the creation of tomorrow's realities from yesterday's dreams.

Nuclear Radiation . . . New Challenge for Transistor Makers

Greater Exchange of Information Needed to Speed Future Missile Development

by Henry P. Steier

ONE OF THE MOST difficult prospects in store for astrionics designers is choice of components for a nuclear environment. A key component in the designs will be semiconductor devices. Their operation basically depends on a highly uniform crystalline structure. Such structures are susceptible to radiation damage.

Semiconductor devices are already making history through their utility as size-reducing and power-drain-reducing control components in the ever more complex astrionics gear being built.

Although the status of semiconductors today represents what Dr. Daniel E. Noble of Motorola, Inc., recently called "the first revolution in electronics," their use in future nuclear powered missiles, spacecraft, manned and unmanned aircraft and tactical environments will be even more wide-scale in some weapons.

The environments to which semiconductors will be subjected might be broken down into three classes: that near a controlled nuclear reactor for a propulsion system; near an uncontrolled nuclear reaction produced by bombs or missile warheads; cosmic radiation in the outer reaches of space.

The importance of knowing the effects of radiation on materials cannot be overemphasized and has been under study for some time. But in the final analysis material effects are the lowest common denominator in the interpretation of effects on astrionics components and systems.

Although several investigators have reported within the past six years that germanium and silicon are sensitive to nuclear bombardment, the information gave little help to semiconductor devices or application engineers.

Early in 1957 the Defense Department gave recognition to the urgent need for a further exchange of information in this field and sponsored an unclassified symposium on nuclear radiation effects on semiconductor devices and materials.

Sponsorship was under the auspices of the Office of Asst. Sec. of Defense, R&D, Advisory Group on Electron Tubes. A surprising revelation to the participants was that so much work is going on. It is being carried out under Air Force, Signal Corp., Atomic Energy Commission, and industry sponsorship.

Investigation of the radiation effects on semiconductors was reported by: Oak Ridge National Laboratory; Radio Corp. of America; Purdue University; Boeing Airplane Co.; Glenco Corp.; Cook Electric Co.; Diamond Ordnance Fuze Laboratories; North American Aviation; Jet Propulsion Laboratory; National Bureau of Standards; Bell Telephone Laboratories; Hughes Aircraft Co.; Haller, Raymond and Brown, Inc.

Work being done by these organ-

Table 1

Degree of Sensitivity	Transistor Type	Kind	Material	Manufacture Method	Manufacturer	Case Filling	Parameter Most Sensitive
EXTREME	2N43	PNP	Ge	Alloyed	GE	Grease	I_{co}, V_b
	904, 905	NPN	Si	Grown	TI	Gas	I_{co}
	XH5	PNP	Ge	Alloyed	MH	Gas	I_{co}
MODERATE	926	NPN	Si	Grown diffused	TI	Gas	I_{co}
	501	PNP	Ge	Grown diffused	TI	Grease	I_{co}
	2N27	NPN	Ge	Grown	WE	Varnish	..
	SB-100	PNP	Ge	Surface Barrier	Philco	Grease	..
	2N139	PNP	Ge	Alloyed	RCA	Grease	I_{co}
	2N43	PNP	Ge	Alloyed	Transitron	Gas	..
	2N99	NPN	Ge	Grown	GP	Red Paint on Junction	I_{co}
	2N260A	PNP	Si	Alloyed	Clevite	Grease	..
	2N167	NPN	Ge	Rate Grown	GE		I_{co}
LOW	2N198	PNP	Ge	Alloyed	Transitron	Gas	..
	CK790	PNP	Si	Alloyed	Raytheon	Grease	..
	2N34	PNP	Ge	Alloyed	Sylvania	Gas	..
	2N35	NPN	Ge	Alloyed	Sylvania	Gas	..
	2N109	PNP	Ge	Alloyed	RCA	Grease	..
	156	NPN	Ge	Alloyed	RCA	......	..
	951, 952, 953	NPN	Si	Grown	TI	Glit	..
	L6101	NPN	Si	Surface alloy	Philco	Grease	..

Boeing's Pilotless Aircraft Division found these relative differences in sensitivity of transistors to gamma induced transient effects. Gamma flux was approximately $2 \times 10^{\circ}$ R/hr.

izations has been under way for about two years, and the newness of radiation investigations in this field is revealed by sometimes divergent approaches to the studies.

In fields as complex and secret as nuclear energy, and as new as semiconductor technology, the effects of limited background information and decentralized research programming are quick to show up.

Test results on radiation damage to semiconductors as revealed thus far, show somewhat contradictory results and the data is not always comparable, or applicable to practical use.

It is generally agreed that nuclear effects of concern to semiconductors are fast neutrons and gamma rays. Protection of semiconductors against the effects of slow neutrons is relatively easy to achieve with shielding.

Such shields as boron carbide-aluminum alloy are light in weight and relatively inexpensive when compared with water, concrete and the so-called "rate earths" fast neutron moderators.

In the case of nuclear powered aircraft and missiles, distance between the reactor and astrionics gear would help radiation reduction. Intensity of a radiation source is inversely proportional to the square of the distance from the source. Radiation from a source with a diameter of two feet would be down to 0.1 per cent at a distance of 60 feet from the reactor.

Measurements made by early investigators on germanium and silicon reaction to nuclear radiation were concentrated on the majority (resistivity and Hall coefficient) carrier density properties.

Changes in these properties were attributed to imperfections produced in the crystal structure of the semiconductors. The imperfections could be caused by fast neutrons, gamma rays or recoil nuclei. Or the atoms could be transmitted by slow neutrons.

Much work which had been done was on static characteristics. In a recent study by G. L. Keister and H. V. Stewart, Boeing Airplane Co., they noted that only limited information was available on the minority carriers.

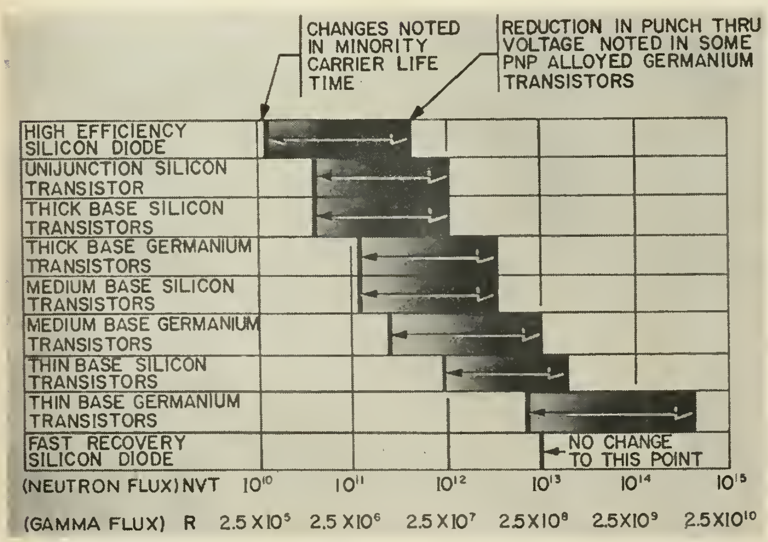
The lack of minority information, it was felt, was handicapping information important to the fabrication of acceptable nuclear radiation resistant semiconductor devices.

Under a contract sponsored by the AF Wright Air Development Center, Boeing's Pilotless Aircraft division ran a test program on electrical characteristics of the transistor while the device was being irradiated.

In any application of these devices it is the dynamic situation which is of first importance. To perform its job the circuit must be operating correctly.

Boeing performed its tests with the Materials Testing Reactor Gamma Facility at Scoville, Idaho. This facility uses spent fuel elements from the Materials Testing Reactor (MTR) there, and produces a full fission product gamma spectrum. Gamma flux was about 2 x 10^6 Roentgens per hour.

Static and dynamic tests were made with gamma radiation only, to permit separate observation of defects from gamma and neutron irradiations.



Relative sensitivity of selected semiconductor devices to neutron and gamma induced permanent damage as determined by Boeing. Light-shaded areas indicate beginning of permanent changes. As area becomes darker changes become sufficient to affect operation in more sensitive circuit applications.

Other tests were made in the MTR for neutron effects.

Neutron flux was about 5 x 10^9 neutrons per square centimeter per second (nv). Total neutron dose was measured in terms of neutrons per square centimeter (nvt)[6].

The *nvt* unit used in nuclear dosimetry is an abbreviation for the number of neutrons per cubic centimeter multiplied by their velocity in cm per second and the time in seconds.

A cadmium shield 0.025 inches thick was used to moderate the slow neutrons in most tests. Transistor characteristics chosen for test were those that would define the operating region of the device. These were: collector leakage current—I_{co}; current gain—beta; and the breakdown or punch-through voltage.

Tests were also run on junction heating effects with gamma radiation. A thermocouple was placed within the transistor case on the junction and the difference in ambient and junction temperature measured. The difference was less than 10 degrees C for a gamma flux of 2 x 10^6 Roentgen per hour.

The gamma radiation resulted in a number of transient changes. Most sensitive in this regard were I_{co}; Beta and floating potential. I_{co} increased with time until removal from the flux in some cases. In others it reached a saturation point. Floating potential varied in the same manner.

After removal from the radiation the transient effects disappeared quickly. The effects, however, varied widely between different transistors.

Examination of the types tested and their construction characteristics showed no particular relationship between construction and sensitivity to transient effects.

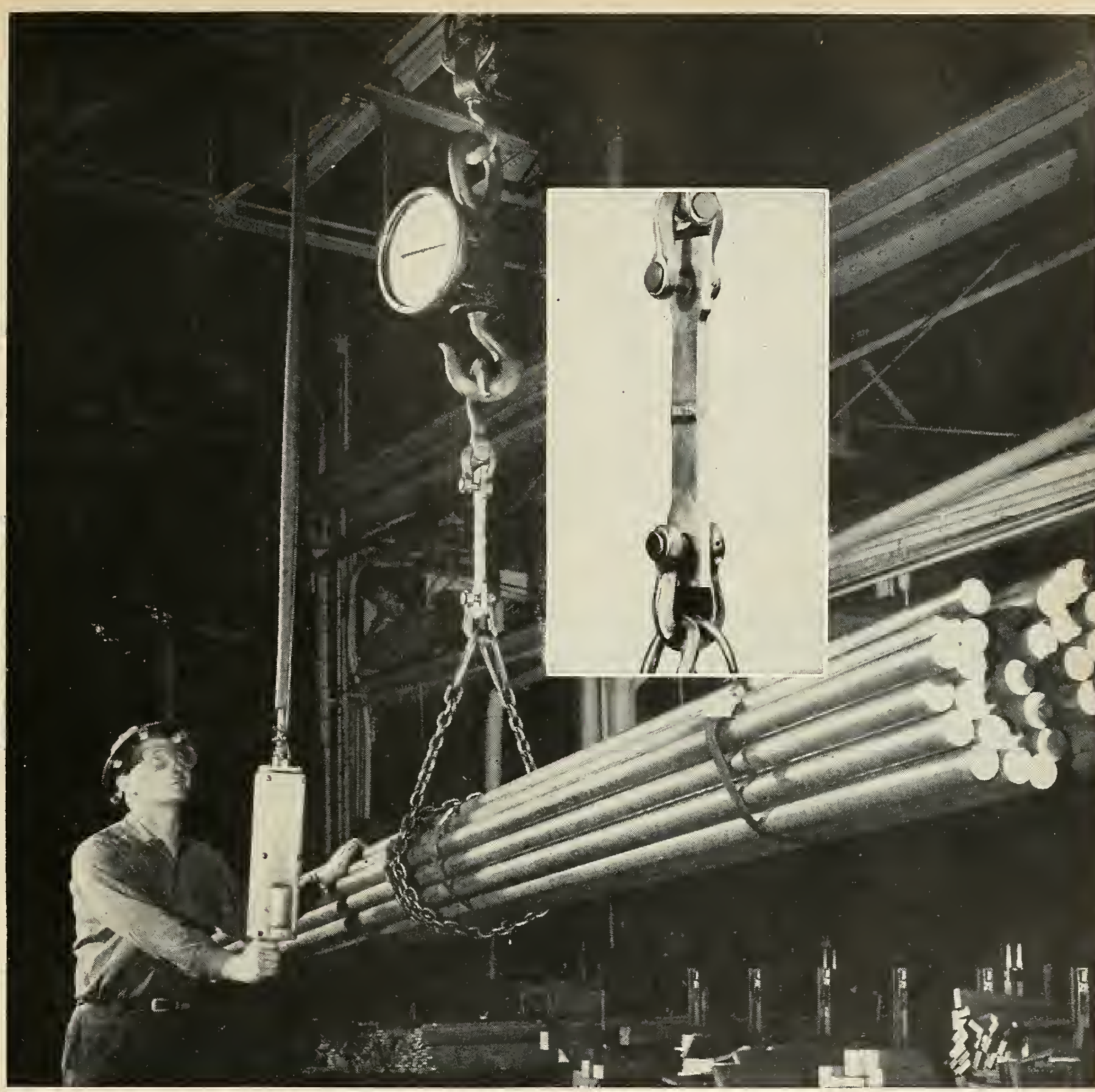
Another effect of radiation was induction of photovoltaic voltages in the pn junction. For a gamma flux of 2 x 10^6 R/hr. this was 10-50 volts. It was independent of circuit loading.

Noise was another effect. Noise level increased to about 25 db. This could be a big problem for applications using low signal levels. The noise disappeared after the transistor was removed from the flux.

Boeing concludes that high frequency, thin based, transistors are the most resistant to nuclear radiation, and the germanium types more resistant than equivalent silicon types.

Reports generally indicate that gamma and fast neutron radiation gamma fluxes of from 10^6 to 10^9 R/hr. and neutron fluxes of 10^{11} to 10^{13} nvt cause changes in some characteristics.

Gamma flux damage is often transient and anneals out. Neutron flux



damage is more permanent and changes remain after extended storage.

In the case of silicon semiconductors, it appears they are only subject to damage in characteristics depending on the minority carrier lifetime (current gain).

The new environment in which transistorized astrionics must operate presents a challenge that must be faced as rapidly as possible by researchers, manufacturers and users.

The problems are compounded by many factors. Each day more semiconductor types are put on the market. Many of them have similar characteristics but are made by much different methods and combinations of different materials.

Boeing proposes that more attention be paid to the method of manufacture and to establishing a new specification indicating a semiconductor's susceptibility to radiation.

The parameters of radiation present another challenging task for specification. The type of radiation, the spectrum it covers, integrated flux values, etc. are but some of these.

These factors are of major importance in comparing work on determining radiation damage. The flux values are not meaningful unless spectral information is included, for instance.

Boeing has suggested that punch-through voltage of a pnp type semiconductor might be used as a radiation dosimeter. This would be a true integration of spectral difference effects and germanium cross section variations. Dosimeters of this type would be inexpensive and allow accurate checks of dose or dose effects.

It may be found that the rate of radiation is very important in determining total damage. This factor would be very important in weapon systems concept planning.

There is a multitude of environmental conditions to be anticipated. These would be contingent upon the mission of a weapon. In a conflict near-misses can be expected. These might produce nuclear clouds through which another weapon must pass.

If the missile must penetrate this cloud, radiation conditions in terms of intensity and time would be much different than under the controlled conditions in a nuclear powered vehicle.

Whole new families of transistors designed for various nuclear conditions are likely to appear in time. One of these conditions might be the effects of cosmic rays.

Jet propulsion Laboratory reports that particles with 10^7 electron volts energy exist at 100,000 feet altitude. If a space craft were at altitude for a long time, say one year, cosmic radiation might be a matter to contend with.

At this time manufacturers do not have much information to go on for their radiation resistant designs. But there does appear hope for eliminating the possibility of a complete lack of suitable semiconductors for certain applications if the limited information available today is put to use soon.

This could result in production of limited numbers of semiconductor devices to meet immediate needs. And, these might be at least a few orders of magnitude more resistant to radiation than those we have today.

The systems concept planners of the future will have to dig much deeper into the electronics boxes than has been previously done. The transistor is only one of hundreds of items and materials that present radiation problems in an astrionics circuit.

To design black-boxes that have mission capability in all the various nuclear environments imaginable is going to be a science in itself.★

Redstone In-Flight Telemetering

Studying Ballistic Missile Flight Behavior Requires Careful Pre-Flight Preparations

By Charles T. N. Paludan

Army Ballistic Missile Agency

ONE OF THE MOST vital design parameters of a successful missile is temperature. In big high-speed missiles, temperature measurements in the different missile areas present a number of novel problems. These were solved for the *Redstone* ballistic missile largely by the use of conventional, available equipment. What new devices had to be designed and the special techniques developed provide a valuable basis for the instrumentation of subsequent larger, longer-range missiles.

From the initial development of the *Redstone* missile an extensive temperature measuring program was desired. These measurements were to be made during flight and telemetered back to earth.

Four measurements on the missile were required. They were: (1) surface temperature from aerodynamic heating; (2) structural temperature resulting from aerodynamic heating and from rocket engine exhaust; (3) propellant temperature and (4) ambient air temperature at various critical points within the missile.

Of the several types of gauges available, three have been used to date: thermocouples, resistance thermometers and thermistors. Thermocouples were used for those measurements where the temperature change would produce output suitable for use in the amplifier-telemeter system available.

Where low-span surface measurements were required, resistance thermometers were used. Thermistors were used for very low span measurements of the probe type.

Early in the development of the *Redstone's* temperature measuring equipment, no amplifier was available with sufficient stability under the severe environmental conditions encountered in a missile of *Redstone's* nature. Therefore it was not possible at that time to use thermocouples.

It was, however, possible to obtain large outputs from comparatively small spans of temperature change by using resistance thermometers and thermistors operating into deflection-type Wheatstone bridge circuits fed by high DC voltage. Besides ruling out thermocouples, this system had the additional disadvantage of requiring either several high voltage supplies or running the risk of one gauge's malfunction ruining the entire temperature measuring program of a given missile.

Furthermore, resistance thermometers were not readily available for measuring temperatures above 900°C because of the insulation resistance loss above that temperature. Because of the high stability of the nonamplified system, however, it continues to be used for temperature measurements of the liquid propellants power supplies (mercury cells).

Within the past year or two, second-harmonic-type magnetic DC amplifiers have become available with sufficient stability for use in the temperature measuring program. A large number of temperature measurements were required. Therefore, a universal system was evolved for use with any of the gauge types previously mentioned.

This system included a method of selecting gauge type, range, and span by means of a small plug-in unit. A stable 5-volt DC supply was available in the missile and was used in conjunction with deflection Wheatstone bridge circuits to give a small output from the resistance thermometers and thermistors. This small output was amplified in the same manner as a thermocouple

How the REDSTONE minds its measurements. Above is a typical signal adapter for converting inflight measurements into telemetry signals. Shown in the picture are the various plugs for gauge input, power supply inputs, outputs to go to the telemetering system and the large plug for pre-flight check-out service. These components can be spotted about the missile as space is available.

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NEW MICROMAG*

LOW LEVEL MAGNETIC D.C. AMPLIFIER

powered from 28 volt aircraft or missile system—
draws 20 milliamperes

For amplification of signals from thermocouples, strain gages, and similar low level transducers used in telemetering systems. DC voltage gain of 500 achieves 5 VDC output from a 10 millivolt DC input signal. Input electrically isolated from output. Designed for use in missile and aircraft telemetering systems, the amplifier has virtually no zero drift, and is temperature compensated to provide excellent gain stability. Operates directly from the aircraft 28 VDC supply. Draws 20 milliamps. No tubes are used, no warm-up time necessary. Potted and hermetically sealed to insure reliable operation. Designed to meet MIL-E-5272A specs.

immediate delivery from stock *specifications:*

Voltage Gain:	500
Input Resistance:	200 ohms
Output:	0-5 VDC into 100 kilo-ohm load
Response Time:	80 milliseconds
Compensated Temp. Range:	0 to 60°C (can be extended to 85°C upon request)
Power Source:	26 - 31 VDC, 20 milliamperes
Volume:	less than 7 cubic inches
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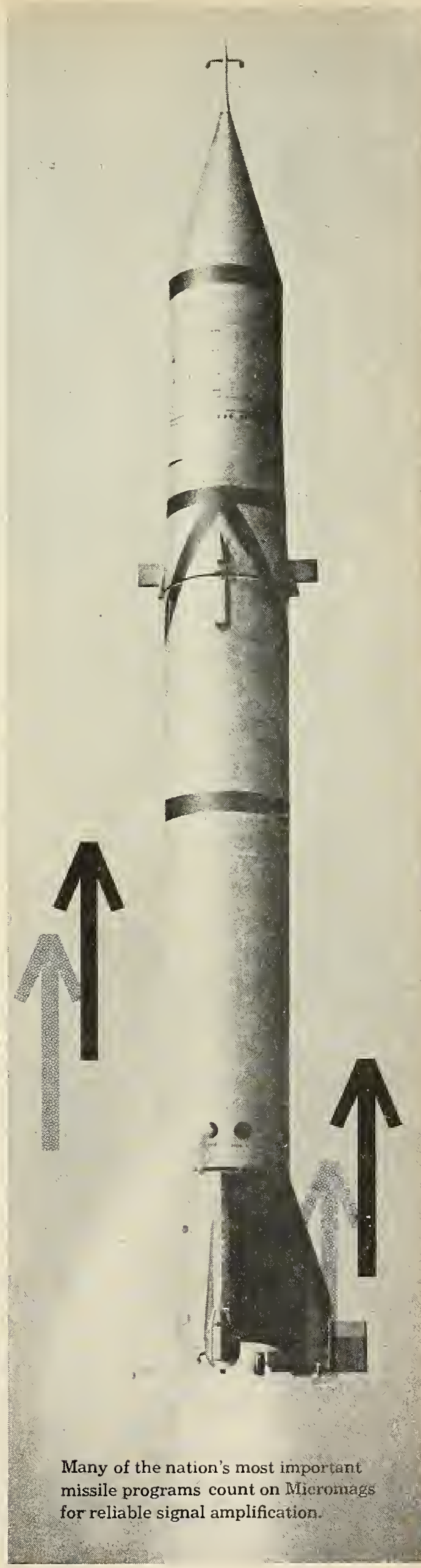

Many of the nation's most important missile programs count on Micromags for reliable signal amplification.

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output by the magnetic amplifier.

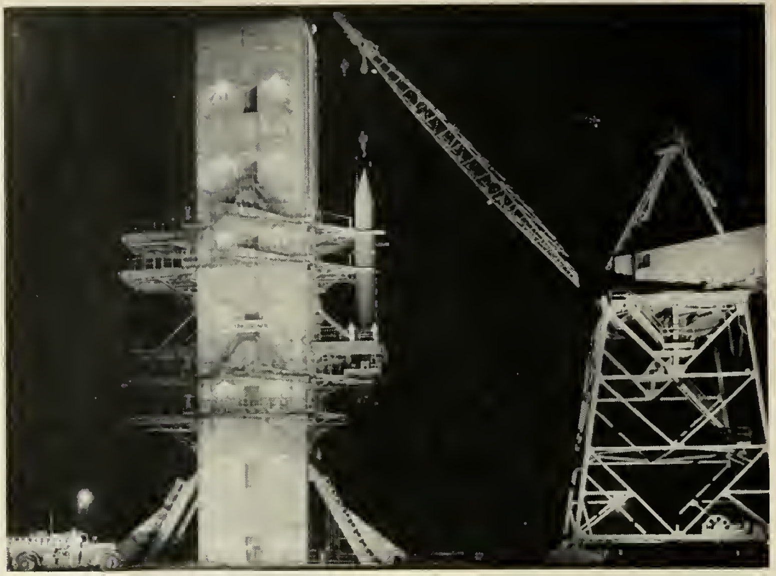
In the *Redstone* missile circuitry used to convert end-organ output to output suitable for telemetering is commonly called an "adapter."

It was very important that measurements operate as satisfactorily as possible because of the non-recoverable nature of a ballistic missile. The complexity of necessary checkout actions at the time of missile fabrication and at the launching site made a semi-automatic check-out of measuring equipment imperative.

This check-out had to warn of malfunction or misadjustment in either the sensing gauge, the adapter, or missile wiring. Accordingly, the adapter circuitry included provision for a fixed known output which could be inserted through the entire system by remote control.

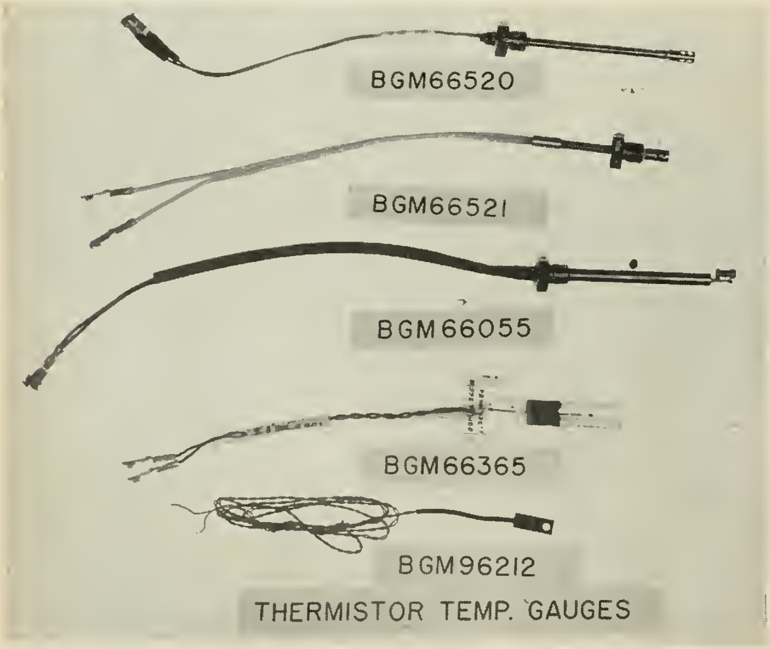
For all measurements an output was recorded on a strip-chart recorder and afterwards compared with laboratory data to prove proper function. Improper function would have called for readjustment, repair or replacement of equipment.

As may be seen in Fig. 1, a typical adapter included provision for six measurements. In many cases a number of adapters would be installed in various parts of the missile. The photograph shows the various plugs for gauge input power supply inputs, outputs to go to the telemetering system, and the large plug for a pre-flight check-out device. The back view reveals several magnetic amplifiers, the plug-in units for determining gauge type and range, and the wiring.



REDSTONE, predecessor to JUPITER, just before static test firing at Army's Redstone Arsenal, Huntsville, Ala.

The design of the adapter was dictated by three main requirements: (1) It must withstand severe shock and vibration conditions; (2) It must be easily accessible so that mass production techniques are applicable; (3) The finished enclosed adapter must be protected from injury or misadjustment because of rough handling during shipment, or after installation.



Above is an array of typical thermistor temperature gauges for measuring inflight conditions during test firing of the REDSTONE.

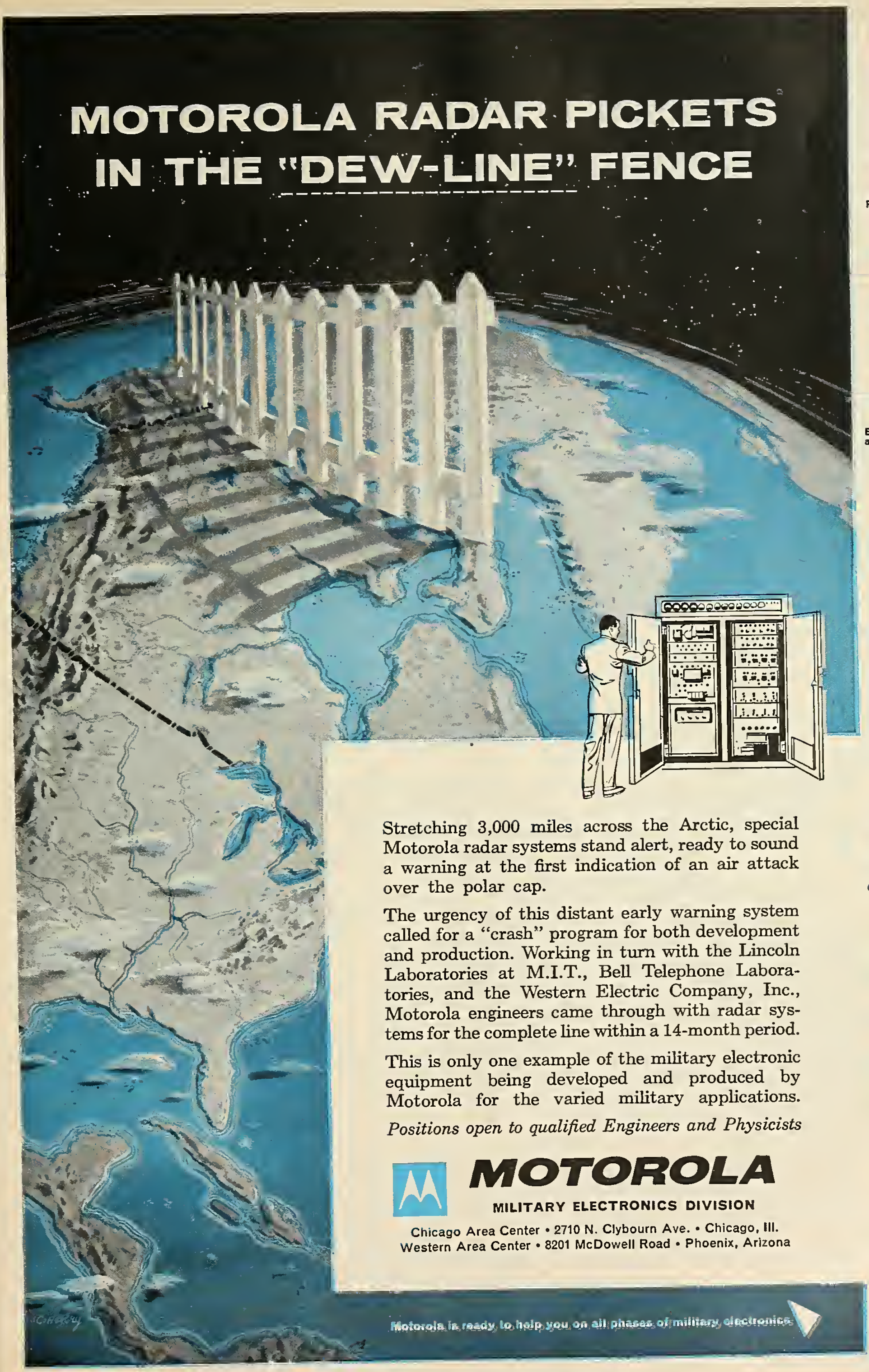
Before delivery to the missile, each completed adapter was calibrated in the laboratory, the missile conditions being simulated as closely as possible. A calibration curve was supplied for each measurement.

The design of all end-organs, some of which are shown in Fig. 2, was dictated by the same conditions mentioned for the adapter. In addition they were individually calibrated in the laboratory by means of water baths, ovens and in the case of the liquid oxygen gauge, a temperature-controlled liquid oxygen bath. Each type of gauge was studied in regard to time response, accuracy and reliability.

In particular regard to thermocouple measurements, a special cold-junction compensation device was developed which eliminated the need for long thermocouple leads and ice baths or ovens. One such device, referred to as a "zone box," was incorporated with each thermocouple. It used a resistance thermometer to sense the "cold" junction temperature, drew power from a mercury cell and applied a correction to the output so that the cold junction seemed to remain constant at a fixed artificial temperature. In addition the zone box was adjustable so that the "cold" junction could be set at any temperature within certain limits.

The measuring system described should not be considered the final design. However, the large number of temperature measurements have made a "design freeze" necessary in order to mass-produce hardware. Improvements and modifications are certain.★

MOTOROLA RADAR PICKETS IN THE "DEW-LINE" FENCE



Stretching 3,000 miles across the Arctic, special Motorola radar systems stand alert, ready to sound a warning at the first indication of an air attack over the polar cap.

The urgency of this distant early warning system called for a "crash" program for both development and production. Working in turn with the Lincoln Laboratories at M.I.T., Bell Telephone Laboratories, and the Western Electric Company, Inc., Motorola engineers came through with radar systems for the complete line within a 14-month period.

This is only one example of the military electronic equipment being developed and produced by Motorola for the varied military applications.

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Underwater Instrumentation

Problems of Missiles That Live Beneath the Oceans Require a New and Different Look at Instrumentation

WITH THE ADVENT of submarines that do 60 knots or better, Fleet Ballistic Missiles that can be fired from underwater to deliver a devestating thermonuclear blow in the heart of the Soviet land mass and torpedoes that top 150 knots, the underocean becomes a military environment of prime importance.

The need to know all there is to know about it gains a high priority. Not only must all the constants of its state be known for any particular moment, but these must be charted, if possible, as they change day-by-day and hour-by-hour.

As research rockets and balloons are sent into the upper air to learn about the fringes of outer space, so must instrument assemblies be sent into the deepest ocean depths to probe and record the darkness man knows least about. Underwater instrumentation, which for years has been the oceanographers more-or-less private tool, now becomes an esential military technology.

Perhaps the most critical factor in undersea warfare is sound: its attenuation at different frequencies and its refraction with changing water density. These properties are affected by temperature, pressure, salinity and the type and amount of biological life present. Some of these are in turn dependent on the penetrability of light, both visible and invisible, the tides, ocean currents, atmospheric conditions, proximity of fresh water sources, etc.

Underwater instrumentation is necessary to measure these and other characteristics. In the operational military field, new requirements are encountered—such as a passive listening device that can hear and identify a noise source several hundred miles away or a "smelling" device that can pick up and track a ship's wake.

The following takes a brief look at some of the problems encountered in underwater instrumentation and how they are solved. It is not so much concerned with detailing specific solutions to specific problems as it is in generalizing approaches to this unusual missile environment.

Oceanographic instruments may be conveniently divided into two major groups: Those which are designed to resist pressure or are pressure protected, and those which are in pressure equilibrium at the depth in which they operate. Generally these instruments are fluid filled. In the latter class of instruments it is obvious that all internal components, condensers, resistors, and electronic tubes must be designed to withstand the pressures at the operating depths.

In general design limitations, 15,000 psi is a working maximum. Where light sources are required, a standard flash-light lamp, Type G 3½ bulb, will withstand pressures of the order of 20,000 psi.

Sub-miniature radio tubes using the T 3½ envelope withstand pressures in excess of 15,000 psi. It should be pointed out, however, that not all makes of sub-miniature tubes are suitable. In normal operation the electron tubes and components are directly immersed in oil, frequently silicone oils where the dilectric characteristics are important. Cheaper oil such as Shell deodorized spray base, which is a highly refined, sulphur-free kerosene, is used.

DC motors, AC motors, relays and most moving contact electronic components will operate quite satisfactorily in this oil filled high pressure environment. In fact, oil filled vibrator type inverters have been used successfully. One of the useful by-products of this strange environment is the fact that under high pressure it is impossible to have any contact arcing.

Telemetering is done using standard RDB telemetering channels for subcarriers. The signals may either come up over single or multiple conductors and often use the sea as a return circuit. The approach at the Scripps Institution of Oceanography is toward simultaneous, continuous telemetering using FM and the RDB subcarriers and recording on deck or ashore using function plotters and magnetic tape.

Magnetic tape has many advantages. Perhaps most important is that it makes possible detailed analysis on return to the laboratory along with automatic data processing.

One example of underwater instrumentation is the telebathyphotometer, telemetering bathyphotometer. It is essentially a deep sea photometer. This particular instrument is controlled from the surface and telemeters all information back over a single wire circuit using a sea return. The instrument is relatively slow in response due to the fact that the functions being measured are not changing at a very high rate.

Its telemetering circuit is DC and is independent of external circuit voltages and polarization. The design depth of this particular instrument is approximately ½ mile. The major depth limitations are due to the somewhat uncertain strength of the pure crystaline sapphire window. The temperature sensing element is not designed for a high speed of response as this is not a fundamental requirement.

In order to facilitate operations in a high relative humidity when the case must be opened, the subassemblies which are susceptible to moisture, are unitized and are each hermetically sealed, having their cases flushed with anhydrous nitrogen. This makes it possible to operate under rather adverse circumstances when using high impedance circuits. On completion of assembly in the field or after a change of batteries the entire instrument is flushed out or purged with the anhydrous nitrogen.★

electronics briefs

Sperry Gyroscope Reveals New Plant

Sperry Gyroscope Co. has revealed that it is operating a completely new facility for producing super-precise gyroscopes needed for long range missiles, aircraft and missile-launching Naval vessels.

Recently the identity of one of the Sperry inertial platform projects was revealed when the SINS (Ship's Inertial Navigation System) was announced. Originally the term meant Submarine Inertial Navigation System.

According to F. D. Braddon, chief engineer, Sperry Marine Division, new and formidable navigation problems are encountered by atomic submarines capable of "sustained" submergence.

With new tactical uses planned for the submarines, present standards of navigation are unsatisfactory, Braddon said. One new use is believed to be underwater missile launching.

Such launching would require exact information on heading, roll, pitch and position. An added requirement, not imposed on airborne systems would be the requirement for operation of the inertial platform for periods of months.

Universal Transistor Takes Larger Plant

A 500% sales increase in two years—with even faster growth anticipated—has resulted in the acquisition of a new air-conditioned 12,500 square foot plant by Universal Transistor Products Corp. at Westbury, Long Island, N. Y.

Universal Transistor's sales and advertising offices have also been expanded to one and one-half full floors at 143 E. 49th St., New York City.

Universal Transistor manufactures commercial and military transistorized power supplies ranging from low-power consuming units for radios and radiation detectors to high power units for rockets, missiles, microwave stoves and electronic flash units.

Honeywell Aero's Employment up 1500

The Aeronautical Division of Minneapolis Honeywell Inc. now employs 6500 people, a gain of 1500 in 12 months. The seven-year old division attributes this gain largely to increased work on missiles and automatic flight control systems.

Space Medicine

by Hubertus Strughold, M.D., PhD.

A fifty-five page report is now available on the presentations at the Summary Session of the Astronautics Symposium held in San Diego, California, on February 18-20, 1957 under the sponsorship of the U.S. Air Force Office of Scientific Research and the Convair Division of General Dynamics Corporation. This publication also contains a summary of the Human Factors Panel, which dealt essentially with radiation hazards, human enigneering and psychological problems in closed systems, human logistics in satellite operations, and space law.

•

On May 10th, at Brooks Air Force Base near San Antonio, Tex., a formal groundbreaking ceremony was held for the new headquarters of the USAF School of Aviation Medicine. Among the many officials attending were Congressman Paul Kilday of Texas; Major General Dan C. Ogle, Surgeon General of the Air Force; and Major General Dean C. Strother, Commander of Air University. The ceremony was conducted by Major General Otis O. Benson, Jr., Commandant of the School, which now is at Randolph Air Force Base, Tex. The mission of the new school will include research and teaching in space medicine.

•

The Aero Medical Association held its 28th annual meeting on May 6-8, 1957 in Denver, Colo., under the direction of its president Jan H. Tillish of Rochester, Minn. The meeting was attended by more than 1,100 persons. A special session of the Space Medicine Branch was held on the last day. The following topics were presented: Cosmic ray dosage during the giant solar flare of Feb. 23, 1956; medical aspects of the U.S. Navy stratolab program; sealed cabin atmospheres; experimentation in the space cabin simulator; weightlessness in space operations and in water; and the visibility of artificial satellites.

On the afternoon of the same day, a symposium on space travel was conducted by Col. Paul A. Campbell, USAF (MC). This session presented views on space travel, as seen by the propulsion engineer, the astronomer, the astrophysicist, and the test pilot. In addition, problems of instrumentation and survival, the space travel implications of the Vanguard Project, and the possibility of a habitable extraterrestrial environment that could be reached from the Earth were discussed. The Symposium was attended by over a thousand people. The papers from both sessions will be published in the Journal of Aviation Medicine.

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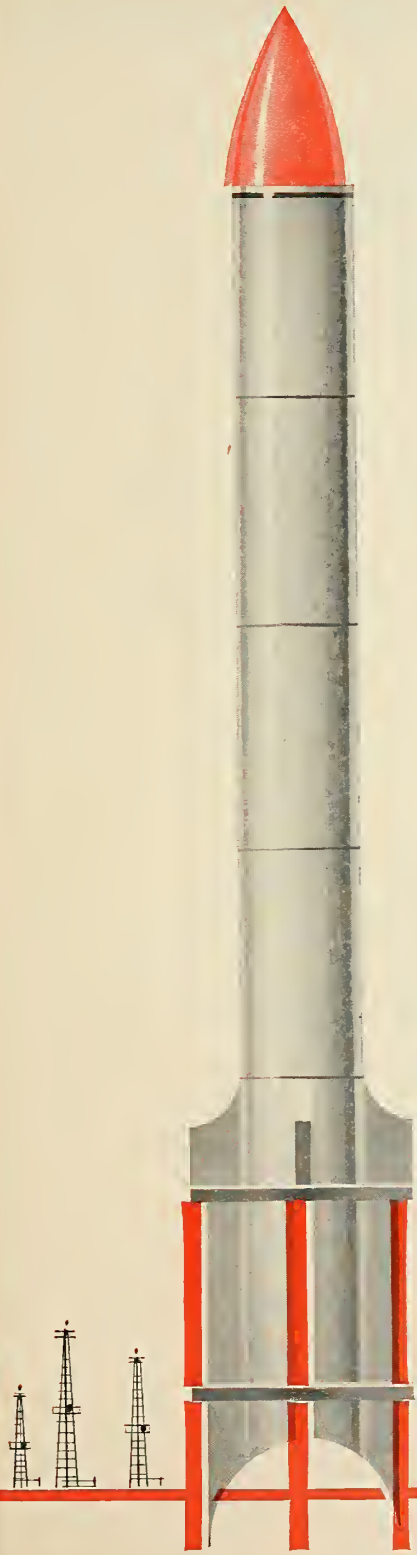
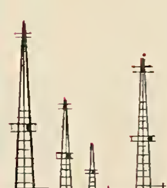
A series of thirteen half-hour educational television programs on space medicine, under the title, "Doctors in Space" is now nearing completion at the University of Houston, Texas. These programs, financed by the Ford Foundation, will be distributed by the National Education Television Center of Ann Arbor, Mich. Some two dozen experts in space medicine and its related fields, including rocket engineers, test pilots, and Air Force and Navy specialists, have taken part in the discussions, which cover the entire range of human factors involved in space operations. The scripts have been prepared by Mr. Green Peyton, Chief of Information Services at the School of Aviation Medicine.

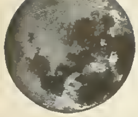
•

A Symposium will be conducted by the writer of this column on "Problems Common to the Fields of Astronomy and Biology," June 17-19 at a joint meeting of the International Mars Committee and the Astronomical Society of the Pacific.

The topics include a "Survey on Astrobiology," "Spectroscopic Evidence of Vegetation on Mars," "The Behavior of Micro-Organisms Under Mars-Simulated Environmental Conditions," "Balloon Capabilities for Astronomical Observations," and "Application of Recent Advances in Physiological Optics to Astronomy."







Missile Miscellany

Is AF rushing Thor into production in hopes it will be too late and too costly to give the nod to Jupiter even if Army missile proves best? That question from a top Army missile man who hopes AF in evaluating Jupiter won't "make the rules after the game has been played" and thus guarantee pro-Thor decision. He also thinks selection should be made solely on missile's merits—its ability to go accurately from point A to point B whenever button is pushed. Sounds logical.

Meanwhile, whole business may become academic as trading of Jupiter and Thor knowhow speeds up (Thor may adopt Jupiter thrust control guidance: Jupiter has incorporated Thor anti-slosh devices in fuel tanks) and the two controversial IRBM's take on a certain similarity. . . . And while Patrick wags have tagged Thor the civil service missile "because it won't work and you can't fire it," Jupiter—the first IRBM to break the record for the over-1000-mile dash—has solved its (and Thor's) gas generator exhaust problems. These stemmed from shift from peroxide to hot drive for auxilliary power turbine. Backwash burned out directional controls on main engine.

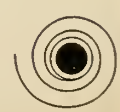
In the fantastic tales department, this page hears on what should be good authority, of 12 eight-or-nine-foot diameter spheres with three-eighth's inch thick stainless steel skins being rushed to Patrick AFB "to be crammed with instruments and fired before first Vanguard launching." Interesting, if true, for these toys tip the scales at a ton apiece empty!

Last month's speed for Aerojet torpedo should have read 155 knots instead of 140 . . . More on underwater: Power of single nuclear plant for submarines tops 30,000 horsepower . . . Will USAW system require volunteer frogmen to listen for lurking subs the way DEW requires Ground Observer Corps? . . . Japs are building a 30,000 ton underwater oil tanker.

And an expert on the subject suggests the difference between engineers and others who write is that engineers say "a coffee containing cup" when they mean a cup containing coffee . . . Aviation pioneer Glenn L. Martin could have meant missiles when he said: "Structures and machines are unforgiving of the cheater and inevitably indict those who toy with the facts."

Some signs of our times include the fact that you can now buy surplus Lark liquid rocket engines in Los Angeles . . . Space Flight Inc. has been formed in Washington, D. C. . . . Dr. Stuhlinger has an ion-propelled space ship design with a 150-ton payload and a 23,000 kw power plant . . . If General Schriever had had his way, Western Development Division would now be called Space Weapons instead of Ballistic Missile Division . . . Distribution of booklet "Toward Outer Space," prepared for employee take-home racks, now exceeds 500,000 . . . Something, this page hears, that "can hit a football 100 miles up" may soon be fired from Patrick—an anti-missile missile, maybe? . . . National Science Foundation is building 150-foot diameter celestial listening antenna in West Virginia. . . . A nuclear physicist probing space propulsion problems claims science-fiction writers are all wrong—"They're too conservative" . . . With the trend towards high-energy propellants, it may be significant that chemical industry can supply 100 tons of fluorine per day, if the market demands.

As though missile testers weren't having enough trouble fighting fires from fizzled missiles, radio-gremlins now rear their unpredictable heads. Note: The Bomarc whose engines were cut off a few feet from launching by a stray radio signal from the pad next door; the lady taxicab dispatcher in Los Angeles who unwittingly brought ulcers to Firebee developers by repeatedly popping drone's parachute ahead of time. Postal regulations prohibit publication of Patrick AFB views on radio hams in South America, who are beyond the range of FCC control . . . And for a new twist in travel, note to the right, a pattern for escape. . . .



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CHECK HOBART MGC

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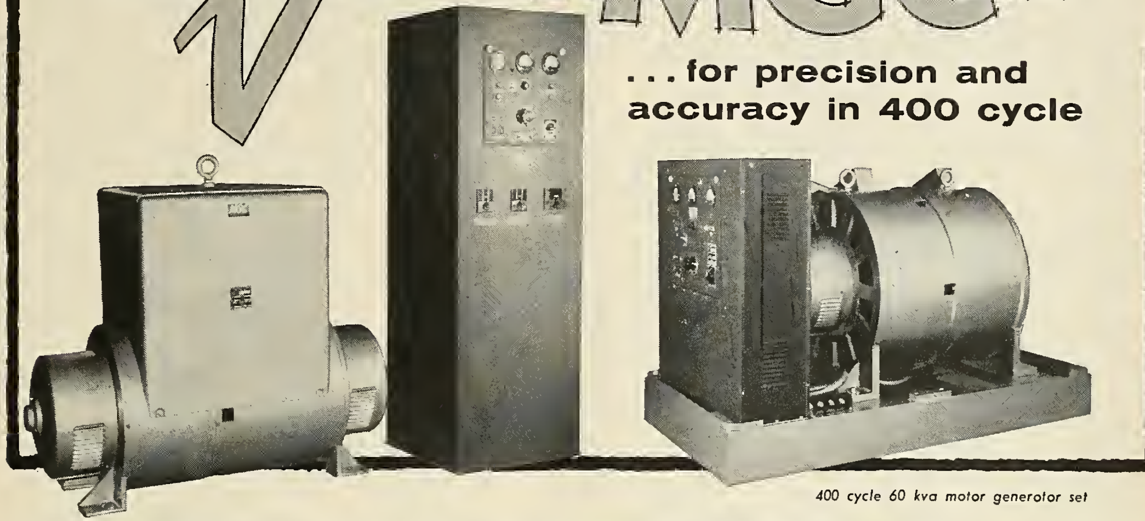
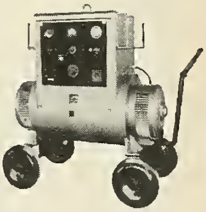


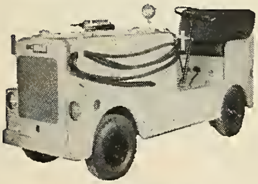
400 cycle 60 kva motor generator set

For the coming new jet transports, as well as for the military jet advancements, there is an even greater need for closely regulated, dependable 400 cycle generators. You need not look any further than the complete Hobart line—many models to choose from, all designed to do the specific job you have. You have a big investment in your aircraft and controls. Protect that investment with the best available equipment for ground tests and checks. It's better to buy the best than wish you had.

ELECTRIC MOTOR DRIVEN

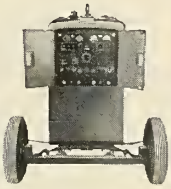


Induction motor driven 400 cycle generators with capacities of 3.75 to 37.5 KVA. Synchronous motor driven generators with capacities of 7.5 to 12.5 KVA. Furnished complete with all controls and instruments. Ideal for production or test line, or missile launchers.



SELF-PROPELLED

For busy airports and test areas, this self-propelled design saves space and time. 400 cycle AC generators of this type are available in similar capacities as trailer type.



GAS ENGINE DRIVEN

Commercial and military models are in production. 400 cycle AC generators with capacities from 12.5 to 125 KVA, gas engine driven, or 37.5 to 125 KVA with Diesel engine drive.

. . . also CHECK these versatile DC units–

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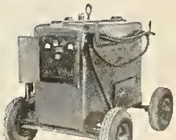

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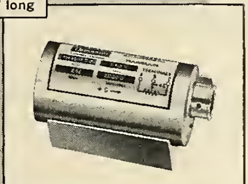
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International Scene

By Anthony Vandyk

The Bristol Aeroplane Company's investment in guided weapon development has now reached the point where it is the largest single activity except for the Britannia turboprop transport. This was revealed when the Bristol organization announced that its *Bloodhound* SAM is now in production. The ramjet powerplant of this supersonic missile is manufactured by Bristol Aero-Engines while the radar and servo control guidance equipment is supplied by Ferranti. Overall responsibility for the *Bloodhound* has been entrusted to Bristol Aircraft. Both Bristol Areo-Engines and Bristol Aircraft are subsidiaries of the Bristol Aeroplane Co. The *Bloodhound* is described by its manufacturer as a complete missile defense system including ground warning radar stations, control stations and the missile itself. As such it should be attractive to the many foreign nations in need of "packages" of this type.

•

The first launching of the de Havilland *Firestreak* infrared-seeking AAM from an aircraft took place in a most undramatic way. The aircraft, a Venom all-weather fighter, was stationary on the Pendine Sands near the Aberporth range in Wales. The nose of the aircraft was pointed out to sea and jacked up, and an anti-blast door was fitted over the landing gear. The chief test pilot of the de Havilland Propellers and the *Firestreak's* system's engineer, D. de Villiers and C de B. White, respectively, entered the cockpit and adjusted their safety straps. White pressed the firing button and the missile left the aircraft successfully.

•

The following data on French missiles have been published by the French Aircraft Industries Association. The association points out that the list is necessarily incomplete and contains only information on relatively old missiles which have been totally or partially declassified.

Manufacturer	Model	Range or Ceiling	Propellant	Max. Speed
SSM				
*Nord	S.S. 10	5,200 feet	Solid	190 mph
*Nord	S.S. 11	11,500 feet	Solid	430 mph
*DEFA	Entac	5,200 feet	Solid	190 mph
*Sud-Aviation	S.A. 4200	75 miles	Solid-Ramjet	High subsonic
SAM				
**Sud-Aviation	4.100	39,400 feet	Bi-fuel rocket	Mach 0.8
***Sud-Aviation	4.300	....	Bi-fuel rocket	Secret
*DEFA	Parca	82,000 feet	Liquid	Mach 1.7
	Maruca	....	....	....
	Masalca	....	....	....
AAM				
*MATRA	M.20	5,200 feet	Liquid	Mach 1.5
**MATRA	M.04	....	Liquid	Mach 1.5
*MATRA	M.051	....	Solid	Mach 1.5
*NORD	5103	13,100 feet	Solid	Mach 1
DRONE				
*Nord	5501-C.T.10	30 miles	Pulsejet	280 mph
	5501-C.T.20	120 miles	Turbojet	560 mph
SONDES				
**DEFA	Veronica	160 miles	Liquid	Mach 2
*ATEF	Monica	65 miles	Liquid	Mach 4

* Production; ** Experimental; *** Experimental Production.

World Astronautics

By Frederick C. Durant III

The American Rocket Society has completed a full circle on aims and interests. Originally founded in 1930 under the name American Interplanetary Society, the ARS published a journal, "Astronautics," from 1932 to 1944. The avowed purpose of the society was to encourage the development of manned space flight. Rocket engines were designed and operated by this small group of earnest amateurs.

By 1945, however, the problems of space flight appeared greater and greater. Some of the industrial barons of the rocket industry didn't like the "crackpot" influence. The society renamed itself—its present title—and hedged further by renaming its journal "The Journal of The American Rocket Society," later, "Jet Propulsion." Now, it is announced that this July the ARS will publish "Astronautics" as a sister magazine to JP.

The full story of the trials and tribulations of the directors and officers of the ARS during the past decade have never been disclosed. Certainly there has been a lot of heat behind scenes between right and left wingers. When the current president of the ARS was a director some years ago, he stopped attending board meetings because he was unable to elicit any enthusiasm over astronautics. But times change. Astronautics is no longer a dirty word and those who have had faith through the years, such as Ed Pendray, Bob Truax and Andy Haley may understandably be excused a grin of self-gratification.

In retrospect it might be argued that the conservative approach was actually the better. The society was accepted more readily by the professionals and the policy battles provided a natural yeast for the rapidly growing organization. Let's hope the yeast doesn't disappear.

•

At first thought one would believe that if a satellite is accelerated in its orbit by additional thrust, it would move to an orbit of greater altitude and have a higher velocity. The larger orbit would be expected from the balance between centripetal force and the force of gravity. Actually, in moving to a higher altitude the satellite velocity is reduced. Energy is absorbed by the satellite mass and retained as potential energy. Satellite velocity at 300 miles altitude is about 18,000 mph. At 8,000 miles altitude, satellite velocity is only 10,000 mph. Escape-velocity from the greater orbit is about one-half that of the lower.

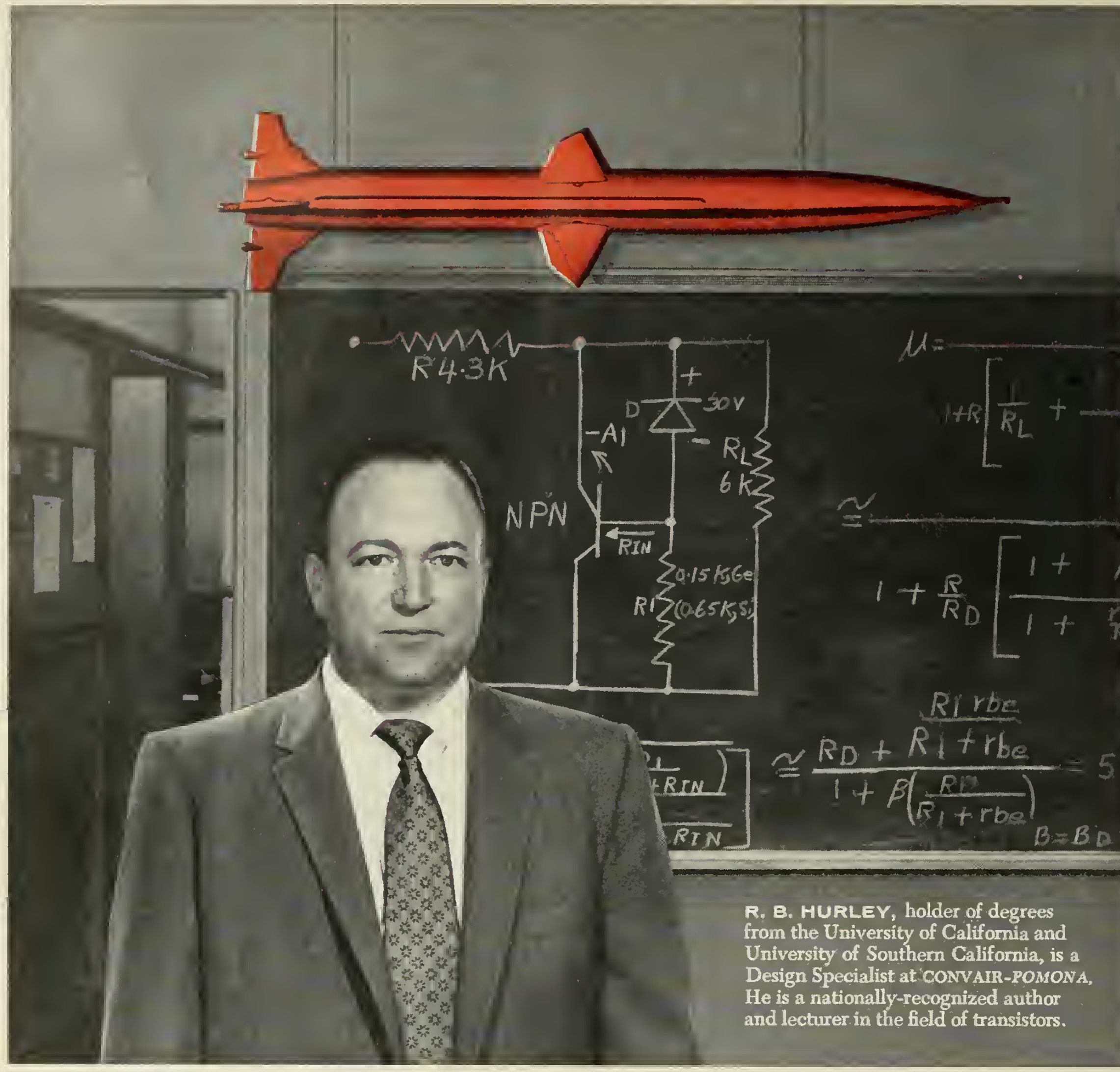
•

A. G. Haley, Washington lawyer and astronautical legal expert, recently witnessed a firing, under Eugen Saenger's supervision, of a hot water booster rocket in Stuttgart's Forschungsinstitut fuer den Physik der Strahlantriebe. One static run of this unit costs only about 25 cents. On noting Haley's surprise at this low figure, a German was overhead to comment, "That's the first time I ever saw an American amazed by a *small* number!"

•

At the Space Flight symposium held at the Cambridge meeting of the American Astronomical Society recently this question was asked of SAO Director Dr. Fred L. Whipple: "What are the odds of at least one of the U.S. satellites being placed in orbit?" The reply: "Ninety-nine per cent." When questioned as to the value of space flight to the man-in-the-street, Dr. Whipple gave serious consideration and replied, "About the same as the cyclotron was in atomic research 20 years ago." It is always hard to justify basic research, particularly in terms of dollar value. How much was $e=mc^2$, the postulated relationship, worth 20 years ago?

Another speaker, Dr. Gerard deVaucouleurs, who is a recognized authority on Mars related ". . . After many hours observing Mars, I came to the conclusion. . . . that is, it is a long way off and you cannot see much!"



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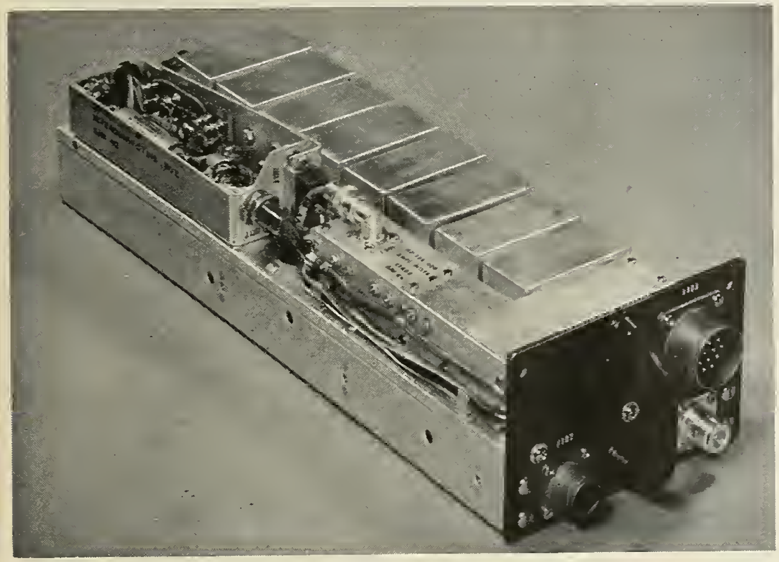

Modular packaging techniques have been applied to a 400 mc radio receiver designed by Bell Aircraft Corp. for conditions where vibration presents a problem. For use where demodulated signals for the activation of a communications system are needed, the receiver is said to provide a high signal-to-noise ratio, high sensitivity and stability, and wide bandwidth.

Bandwidth within the tuning range is 402-420 mc and plug-in assemblies are available to extend this to 500 mc. Easy servicing is accomplished by modular plug-in units. Power input required is less than 50 watts and the receiver may be operated in a 15g environment from 5 to 2000 cycles at temperatures from —55° to +72°C.

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AC ACCELEROMETER

A new accelerometer by Genisco, Inc. uses inductive output in conjunction with the sensing element of the Genisco Model DDL accelerometer. Standard range is 0.1 g to 10 g.

Voltage input is 28 volts or on an optional basis is 115 volts at 400 cycles or 5000 cycles. Output voltage is 10 volts maximum for 28 volt input for ranges of 1 g or higher.

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WIDE RANGE ACCELEROMETERS

Columbia Research Laboratories offers wide range Accelerometers, Series, 400, employing barium titanate in compression and having natural frequency of 75kc. These instruments operate over a broad acceleration range from 0.03g to 40,000g and over a frequency range from 0.05 cps to 20,000 cps, with a sensitivity of 30 mv/g±5% throughout usable range. Pickups are available in various sizes, weights and mounting configurations.

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MISSILE MOTOR

New dc motor developed by Electrical Engineering and Manufacturing Corp. for missile and rocket applications weighs 7.25 lbs. and conforms to Spec. MIL-8609.

EEMCO Type D-927 motor is rated at 0.5 hp at 9,900 rpm continuous, terminal voltage 27 v, 18 amps. An optional two-circuit noise filter for ungrounded systems adds one pound to motor's weight.

Circle No. 203 on Reader Service Card.

ELECTROLYTIC LEVEL SWITCHES

New electrolytic switches produced by Corning Glass Works are arc-shaped gravity sensor devices made for both off-on and proportional control of missile directional systems.

Level and deviation from level are indicated within tenths of a degree by means of the switches. The switches are filled with an electrolyte which is said to give them six times less mass shift than mercury counterparts. Temperatures of up to 200°C can be withstood. Units are supplied in regular and subminiature sizes.

Circle No. 224 on Subscriber Service Card.

SILICON RECTIFIERS

Four new silicon rectifiers are being produced by the General Electric Co. Designated 1N1115, 1N1116, 1N1117 and 1N1118 the new units are stud mounted. Voltage ratings for peak inverse conditions are 100, 200, 300, and 400 volts with a maximum rms of 70, 140, 210 and 280 volts respectively.

They are designed for a maximum output of 600 ma at a case temperature of 150°C.

Maximum operating frequency for the units is 100 kc. They have a 10-32 stud for chassis mounting and are housed in a welded, all-metal case.

Circle No. 226 on Subscriber Service Card.

MINIATURIZED GYRO

Model 55,000 floated rate gyro has been designed by Norden-Ketay Corp. for missiles. A variety of maximum rate ranges from 1°/sec. to 1000°/sec. can be supplied. Accuracy better than ½% is

claimed while the gyro is subjected to severe missile environments.

Damping ratio is obtained without a heater by an arrangement that provides for verying the gap between the gyro rotor float chamber and an adjacent member. Damping ratio can be established to suit requirements of customers and maintained within 0.1 over a temperature range of —55°C to 85°C.

Circle No. 208 on Subscriber Service Card.

RADAR BEACONS

Avion division, ACF Industries, Inc. is producing four radar beacons for missile and aircraft use in "C", "S" and "K" bands. The pulse-type tracking aids respond to coded and uncoded pulse interrogations from radars. The "C" band unit delivers 100 watts and weighs 61 oz. The "S" band units deliver 2 and 1000 watts and weigh 51 oz. and 25 lbs. The "X" band unit delivers 50 watts and weighs 59 oz.

The low power units operate from a self-contained transistorized power supply operating from batteries, and the large "S" band unit requires 28 volt dc.

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ENVIRONMENTAL TESTER

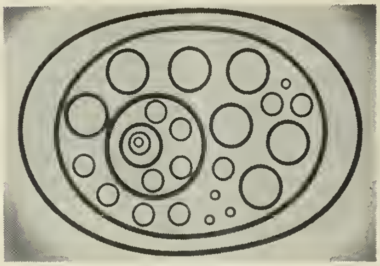
New environmental chamber for testing rocket and missile components, principally for electronic testing and stabilization of metals, has a range of —125°F to 350°F Produced by Webber Corp.

The Model WE-3-125 has a pull-down time from ambient to —100°F of about 45 minutes, to —125° in about one hour, and will raise temperature from —125° to 300°F in about 15 minutes.

Unit capacity is three cubic feet and internal dimensions are 16 x 16 x 16 in. Overall measurements are 28 in length, 32 in. width and 66 in. height.

Circle No. 201 on Reader Service Card.

"O" RINGS



A new line of red silicone rubber "O" rings designated Style 9599 has been announced by the Garlock Packing Co. of Palmyra, N. Y. The new rings are manufactured from 70 durometer hardness stock exhibiting low shrinkage and compression set.

The "O" rings, available in standard AN sized, are recommended for dry heat service on which synthetic rubber compounds and natural rubber do not maintain their rubber characteristiccs. The silicone rings resist oxidation, withstanding indefinitely continuous exposure to hot air and temperatures up to 300°F, and in most applications will withstand for long periods of time, exposure to dry heat at temperatures from 300°F to 500°F.

Circle No. 211 on Subscriber Service Card.

SILICON TRANSISTORS

Texas Instruments, Inc. has announced the recent addition of fifteen new silicon transistors to its line of high temperature devices and brings to 36 the number of such units currently manufactured by the company.

All of the new units are in round cases and are designed for production by automatic techniques in addition to meeting military requirements.

Three years ago the company introduced silicon transistors which are ideal for military use because they operate stably at temperatures up to 150°C.

The new line includes two switching transistors, tetrodes, medium power types and five small signal units.

Circle No. 204 on Subscriber Service Card.

THROTTLING VALVES

Greer Hydraulics, Inc., has developed a series of precision throttling valves which are adaptable to a variety of installations. The series is designed for use with oils, fuels and other liquids compatible with aluminum and steel in central hydraulic systems, missiles systems, and test equipment. They also can be provided in other materials for use with water, acids and other corrosive liquids.

Featuring low torque, the valves are available with 2", 1½" and 1¼" ported flanges adaptable to one basic body size; and 1", ¾", ½" ⅜" and ¼" ported flanges adaptable to another basic body size. Valve body can be removed without breaking the line, and valve seat replacement can be made without removing body from line.

Circle No. 215 on Subscriber Service Card.

ACCELEROMETER

Genisco, Inc., has made design changes in its Model GMO Accelerometer which make it particularly adaptable for use in guided missile flight control systems. The 8-oz., viscous-damped potentiometer-output instrument is available in ranges from ±2G's to ±30G's, hermetically sealed.

Specifications: Undamped natural frequency 15 to 40 cps; linearity within 1% of full scale from best straight line; damping 0.3 to 2.0 of critical; output resolution proportional to number of turns of

wire on the potentiometer, generally 0.34% of full scale; hysteresis generally less than 0.5% of full-scale output; potentiometer resistance 2 to 15K; power rating 2 watts; axis alignment within 1.0°; operational life 2 million complete cycles.

Circle No. 225 on Subscriber Service Card.

LOW G ACCELEROMETER

An accelerometer that measures values of g down to 0.03 has a minimum sensitivity of 40 millivolts per g. The Model 2218 unit has a natural frequency of 20 kc minimum and gives a response from 2 to 4000 cps with a linearity of 5 percent.

Response to high level noise is virtually eliminated by clamped crystal design and internal acoustic shielding. Temperature characteristic of the new unit made by Endevco Corp. is linear within 10 percent from —65° to 230°F. It weighs 2 ounces and is 1 inch hexigon in size.

Circle No. 221 on Subscriber Service Card.

SUB-MINIATURE TRANSDUCER

Electro Product Labs, Inc. has introduced a sub-miniature magnetic pickup that generates electrical signals from mechanical motion with physical contact. The unit weighs about 4 grams and is about ¼" in diameter.

The tranducer senses movement of ferrous objects and produces a signal proportional to the rate of movement. An Alnico magnet is used to energize the device.

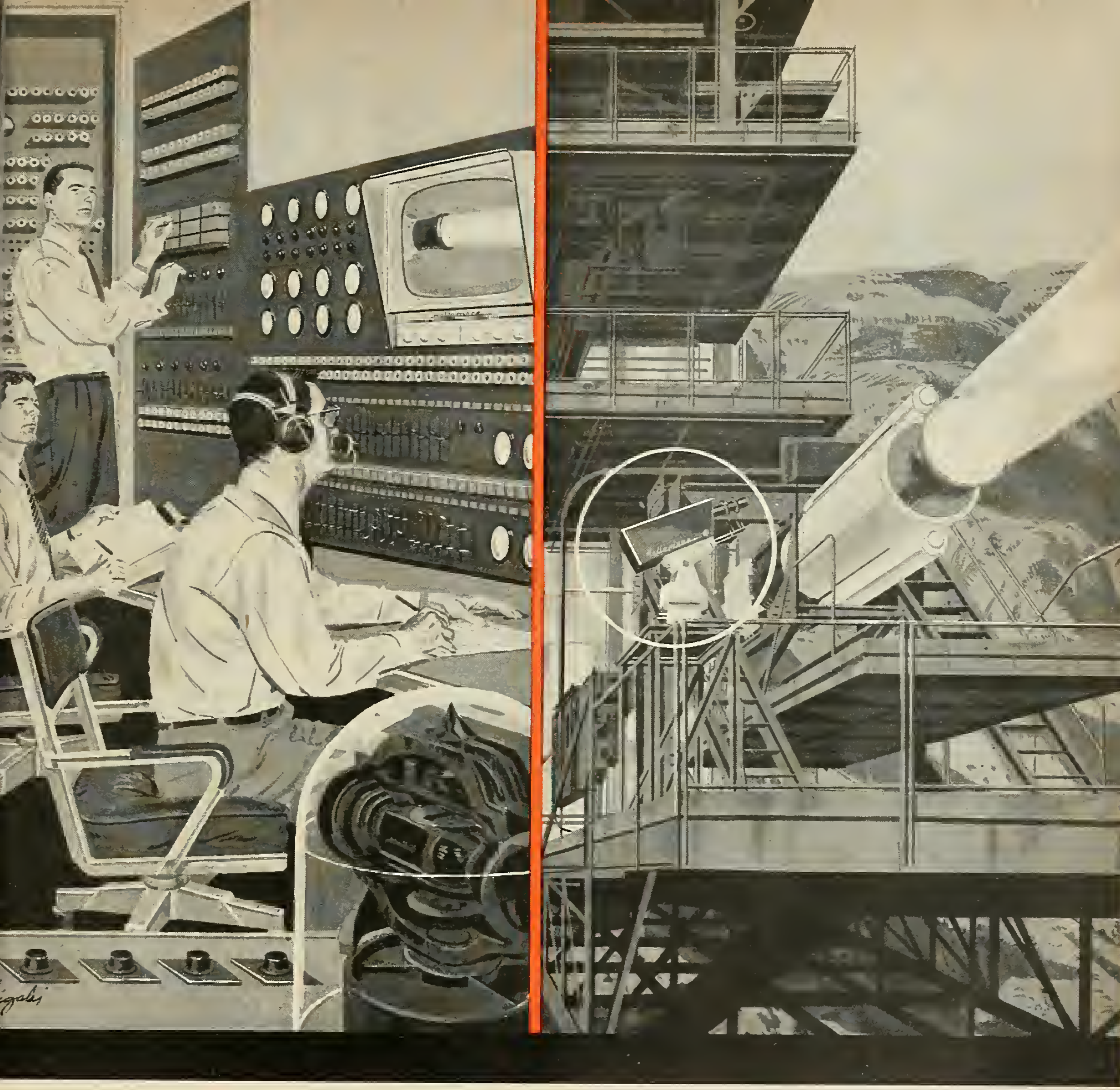
Circle No. 230 on Subscriber Service Card.

VERTICAL GYRO

Waltham Watch Co is producing a vertical gryo Type WG-2 which provides accurate and reliable two-axis vertical reference data in the form of two synchro output signals.

The spin-axis is slaved to gravity by a gravity sensitive vertical reference device which supplies electrical control signals to torque motors which maintain the gyro spin-axis parallel to the gravity vector.

Vertical repeatibility is to within 10 min. of the arc cone and the initial erection from any standing position at any temperature from —55° to 71°C to within



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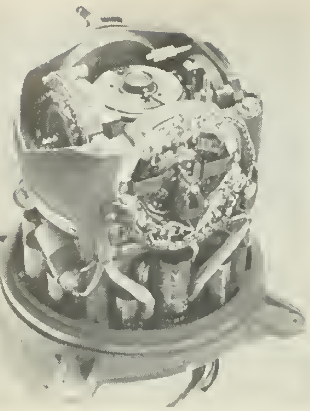


plus 30 min. of arc of vertical within 25 sec. after application of power. Altitude capabilities are unlimited and operating life is at 1,000 hrs. minimum.

Circle No. 200 on Subscriber Service Card.

PRESSURE TRANSDUCER

A pressure transducer being manufactured by Servonic Instruments, Inc. operates under vibration environments of 20g and temperatures to 400°F. The Model "H" transducer uses stainless steel sending elements that permit use of corrosive fluids in either gauge or differential models.

Case burst pressure is rated at 7500 psi and ranges from 1000 to 10,000 psig or psid are available.

Circle No. 206 on Subscriber Service Card.

DC GENERATOR

John Oster Manufacturing Co. has developed a permanent magnet dc generator which is said to have an unprecedented high output for its size and weight.

Type 13-PG-6901-01 has a 10-watt output at 10 vdc at 8,000 rpm continuous duty with 1,000-hr. life and 25°C maximum temperature rise. Diameter is 1.25", length 2.6", weight 7 oz., has 3 oz.in. input torque, face mounted. Designed for any dc generator application requiring exceptionally high dc output.

Circle No. 202 on Subscriber Service Card.

PERMANENT MAGNET MOTOR

John Oster Manufacturing Co. has unveiled a 1¼ in. permanent magnet gear reduction drive motor it believes is

the first of its type and size to be provided with a brake.

The Oster unit combines motor, brake and gear train into a single unit. Design features include a reduction to 2.5° maximum of the coast of the output shaft from no load speed to 30 volts dc. No load output is five to 10 rpm at 24 to 30 volts dc and minimum stall torque is 30 oz.

Overall length of unit is 3.89 in. plus shaft and operating temperature range extends from —65° to 160°F.

Circle No. 232 on Subscriber Service Card.

COMPUTER INDICATOR TUBE

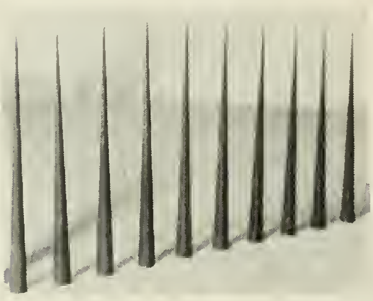
Amperex Electronic Corp. has announced a new Type 6977 filamentary subminiature indicator triode with fluorescent anode for visual monitoring of transistorized computers and other transistor circuits.

Heater voltage required is 1 volt at 30 ma ac or dc. The anode draws 0.6 ma from a 50 volt supply during 0-bias "on" conditions. A 3.5 volt signal is sufficient to cut off plate current and the light.

Circle No. 207 on Subscriber Service Card.

RF ABSORBER

Emerson and Cuming, Inc., makes a series of plastic rod and sheet forms of Eccosorb MF plastic for waveguide and coaxial lines as absorbers, attentuators, terminations and loads over the entire microwave frequency bands.



The material is nonporous and needs no moisture protection on machined surfaces. It can be used up to 350°F. Suggested designs for both step and uniform tapers are available.

Circle No. 209 on Subscriber Service Card.

MISSILE SOLENOID

A miniature pull-type solenoid for missile applications which operates with efficiency and low plunger friction loss. has been developed by Carruthers & Fernandez, Inc.

Operating range —65° to 100°F. Solenoid provides positive, trouble-free operation on computing devices in missile components at high altitudes and speeds. Operating voltage from 6 to 100 vdc with plunger operating under side force of 8 to 10 g. At .3 amps, 100 vdc and 78°F. force is 1.3 lbs. with stroke .03". At same conditions force is .8 lbs. with stroke .06"; and .4 lbs. with stroke .125".

Circle No. 217 on Subscriber Service Card.

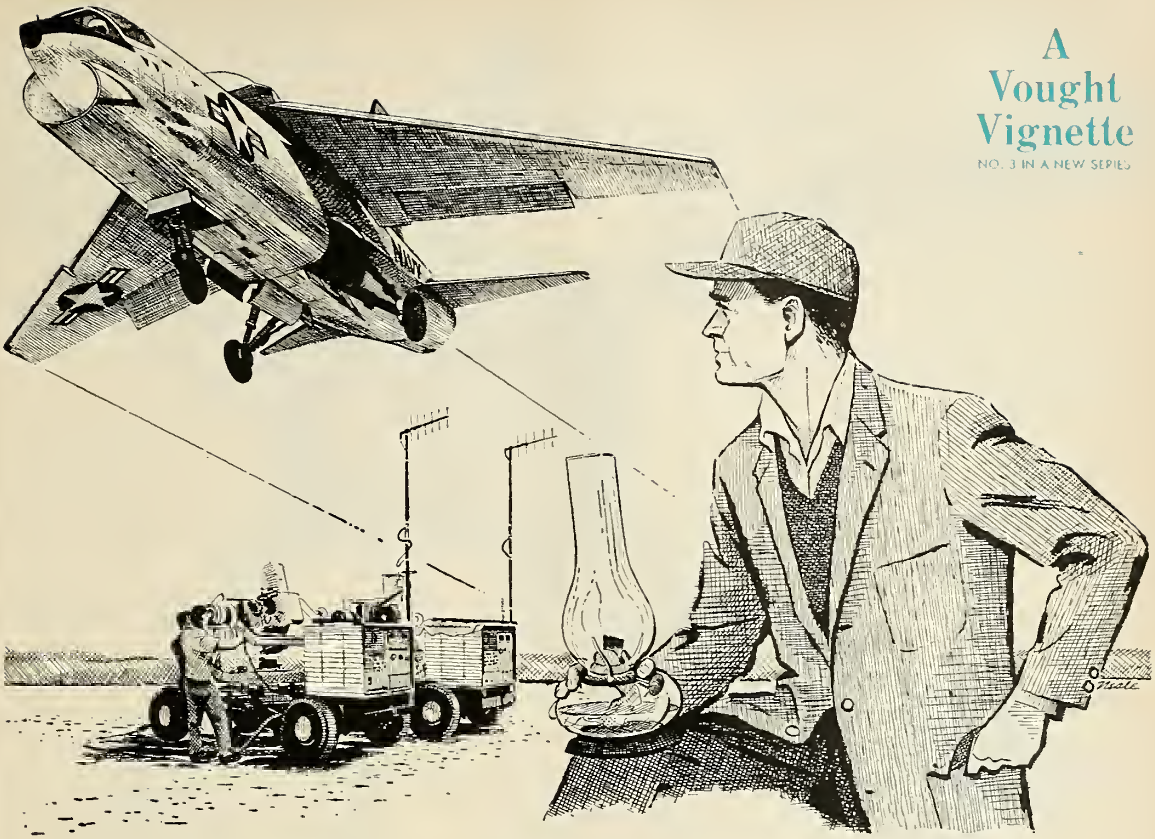
GAS COMPRESSOR

An oil free gas booster compressor, designed by Haskel Engineering & Supply Co., serves as a source of high-pressure, dry, uncontaminated helium or nitrogen for missile and test applications where gas cleanliness is of utmost importance.

The compressor uses a variable inlet pressure source and is operated without lubrication. It delivers outlet gas pressures from 6,000 to 10,000 psi with average capacities from 10 to 20 scfm using inlet pressure sources between 500 and 2,200 psi. Compression is accomplished

A Vought Vignette

NO. 3 IN A NEW SERIES



Soot Solved This Problem

One thing Richard (Rick) MacDonnell could say for flight test instrumentation — it had variety. Here he was, in line of duty, hunting a coal oil lamp on the Mojave Desert.

Looking back, Rick saw that the whole Crusader instrumentation program had been a series of shifting scenes. He'd started by talking to different specialists, finding out the kinds of flight information they wanted. He learned a lot about heats, loads, amplitudes and flutter. These were the things Rick's instrumentation would have to detect.

Designing and building the system took him in another direction. There was the airborne equipment — up to 12 miles of wiring and 600 pounds of black boxes for a single demonstration aircraft. Each sub-system was environment-tested, breadboarded, checked out and packaged to fit key corners of the Crusader structure.

Taking shape at the same time was a mobile ground station — another project with which Rick was associated. It brought flight test telemetering and data processing closer to automation than they'd ever been before. At Vought's Mojave Desert test base, Rick's equipment clicked. It speeded preparation for the Crusader's dramatic operational debut — the Thompson Trophy-winning speed run.

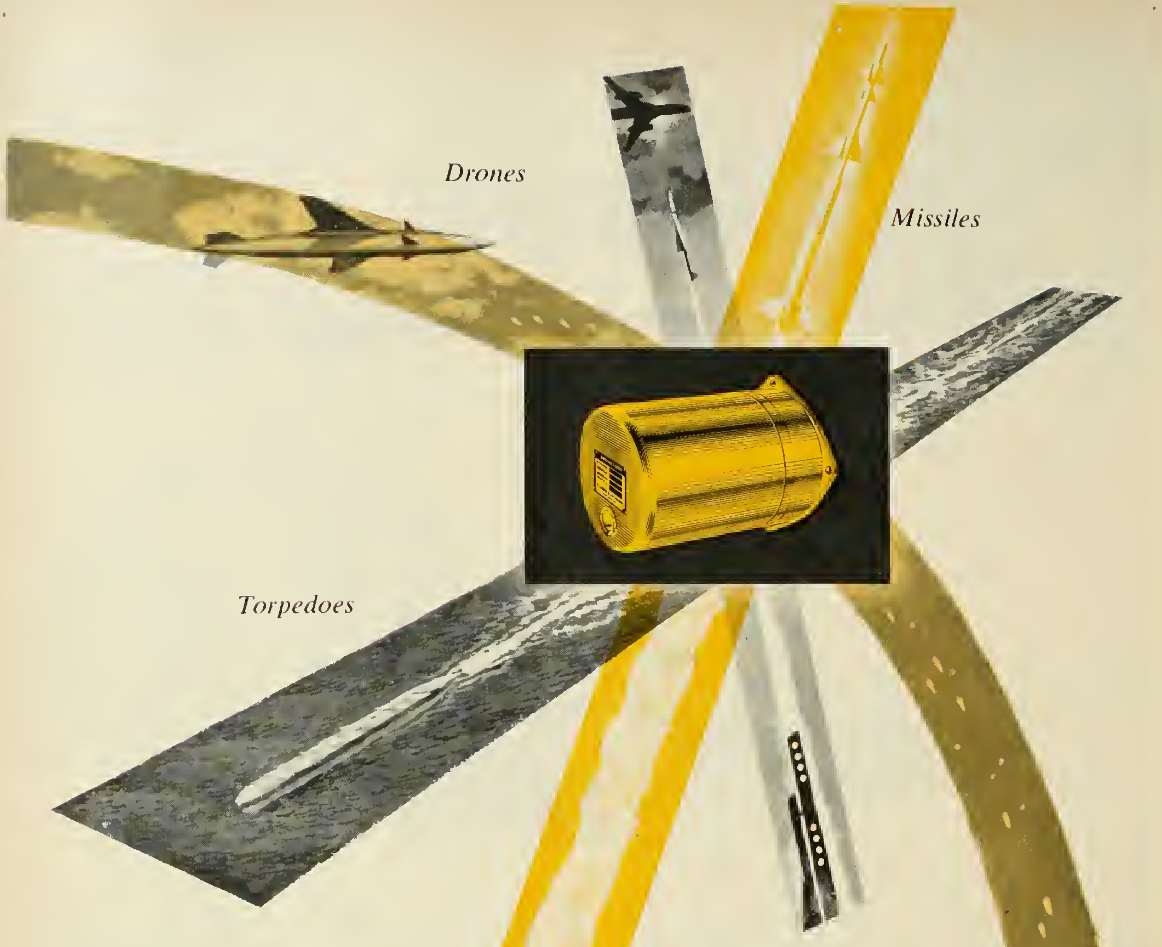
There was just one hitch — a National Aeronautical Association rule which would limit altitude deviation to 328 feet during the Trophy dash. A Bureau of Standards barograph would ride with the pilot, its stylus etching out exact altitude on a smoked cylinder. Fair enough — but Vought's desert crew didn't have a workable way to blacken duplicate cylinders for practice. And precise warm-up flights were essential.

That's why Rick went hunting for a coal oil lamp. He found one in the store of a desert outfitter. Back on the base, the lamp was lighted and the wick turned up. It "sooted" the purpose perfectly.

Instrumentation means development adventure and variety at Chance Vought. Here, engineers of all specialties use initiative and self-expression to contribute to some of the most advanced instrumentation techniques in the industry.

CHANCE VOUGHT AIRCRAFT

INCORPORATED DALLAS TEXAS



All guided by Whittaker Gyros!

Unsurpassed for accuracy and dependability, Whittaker Gyros are able to shrug off the effects of shock, acceleration, vibration, heat or cold . . . yet continue to function as smoothly as they did in the laboratory!

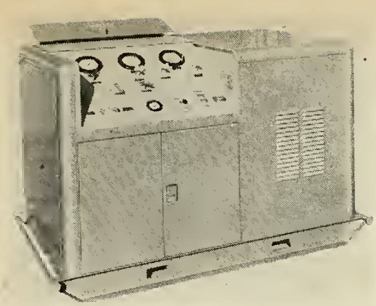
THE REASON? For all the foregoing conditions, Whittaker Gryos have been *100% tested!* Overall customer rejection – month after month, year after year – is consistently less than 2%.

And because Whittaker uses nickel alloys in frames and gimbals, steel components are permitted. The result is added strength with very little increase in weight . . . and much more overall component stability.

Whittaker Gyros are designed by engineers and built by technicians who have worked together for more than a decade. This background and experience insure exact specifications the *first* time.

Whittaker Gyro

Division of Telecomputing Corporation, Van Nuys, California • STanley 3-1950



by an integral two-stage, hydraulic driven, single-acting gas pump. Electric motor or gasoline engine prime mover is optional.

Circle No. 213 on Subscriber Service Card.

AIR COMPRESSOR

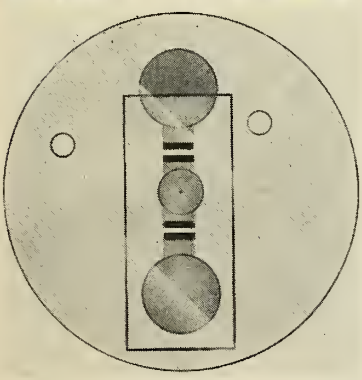
M. C. Manufacturing Co. is producing a new series of high-pressure air compressors for use in aircraft and missiles industries.

Basic compressor can be combined with 1,500 or 3,000 psi hydraulic motors, with ac or dc electric motors or mounted directly to engine pad. Compressor is of 4-stage piston type, using frictionless type bearings and has an oil capacity sufficient for 100 hrs. operation.

Rated capacity at sea level is 4 scfm, at 3,000 psi outlet pressure. Official life test is 550 hrs., weight of compressor proper 10.7 lbs.

Circle No. 214 on Subscriber Service Card.

BROADBAND DISC BOLOMETER



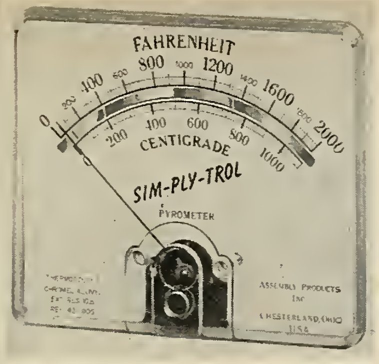
Two new broadband disc bolometers, Models N603 and N603-4.5 covering the frequency range from 500 to 10,000 mc, have been developed by the Narda Corp.

The bolometers consist of two 100-ohm Wollaston wire bolometer elements mounted on a mica disc. An rf bypass capacitor is included for the ungrounded end of the device as well as a blocking capacitor at the central junction between the elements. The bolometers are manufactured for either 4.5 or 8.75 ma bias currents.

Circle No. 205 on Subscriber Service Card.

INDICATING PYROMETER

An indicating pyrometer made by Assembly Products, Inc. is available in 21 standard ranges. The units are medium resistance and have a maximum sensitivity when connected to one thermocouple of 300°F for full scale deflection. Standard ranges begin with minus 400°



to plus 100°F and may be obtained from 0° to 3000°F.

Full scale accuracy of 2 percent is standard and 1 percent units may be obtained. Tbe units are thermistor compensated for ambient temperature cbanges. Sizes are 3¾ or 4½ inches wide.

Circle No. 220 on Subscriber Service Card.

PRESSURE VESSELS

Spberical, bigh-strength pressure vessels for aircraft and missile applications, formed from titanium alloy or other materials, are available from Titanium Fabricators,, Inc.

Vessels range in size from 12-in. to 25-in. diameters and are formed by hot spinning hemispheres then joining witb advanced welding techniques. Extensive research and development of tbe new welding and spinning techniques was sponsored by Convair-Astronautics.

Circle No. 248 on Subscriber Service Card.

CIRCUIT BREAKER

A circuit breaker line, designated Series AM17, which is intercbangeable for 400 cycle, ac and dc use, bas been developed by Heinemann Electric Co.

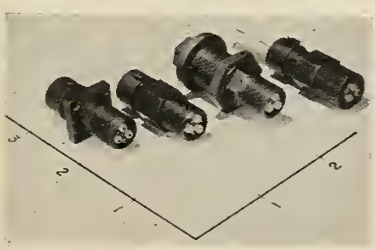
Designed primarily for aircraft circuits and airborne equipment applications, the AM17 can function either on 400-cycle ac or dc current witbout cbange in rating or essential time-delay characteristics. Series is manufactured in single-pole form only but can be readily linked to make two or three-pole companion trip units.

Breaker operates on bydraulic-magnetic principle and does not require derating for eitber temperature or vibration conditions.

Circle No. 235 on Subscriber Service Card.

HIGH-ALTITUDE CONNECTORS

Three series of miniature high-temperature, electrical connectors whicb are



reported to have superior electrical characteristics have been introduced by Consolidated Electrodynamics Corp.

Designed for high-altitude operation. the major design feature is a staggered construction which gives long creepage path between pins despite small connector dimensions. Body is of anodized aluminum for corrosion resistance. Each pin of the mated connector is surrounded by Teflon.

Design provides three separate seals—around entering wires, around each pin connection, and at the interlocking faces. This insures insulation resistance at 10^6 megohms.

Circle No. 228 on Subscriber Service Card.

RATIO TESTER

Allegheny Instrument Co., Inc., has introduced Model 11 ratio tester which can be used to measure dc voltage ratios in the range of 0 to 100% in aircraft and missile telemetering and measuring systems.

Wherever voltage or resistance ratios are more important than absolute values, Model 11 provides fast measurements to an accuracy of .05%.

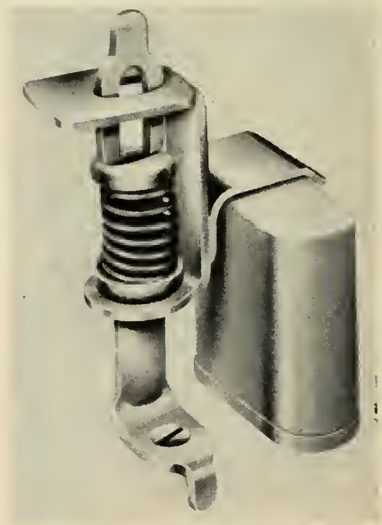
Model 11 has self-contained mecury cell and standard cell and provides voltages in two ranges, 1 v and 10 v.

Circle No. 246 on Subscriber Service Card.

CRYSTAL CLIP

A line of crystal retainers made from type 302 stainless steel has been developed by Birtcher Corp.

Designed to hold nearly all popularly used crystals, semi-conductors and other miniature components having similar con-



figurations securely in place under severe shock and vibration.

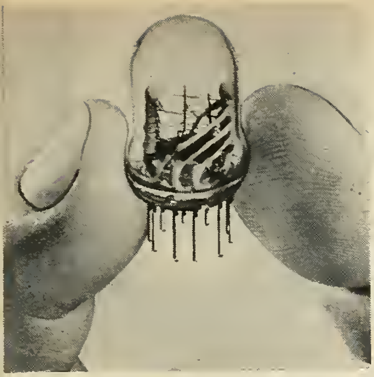
Chassis mounting is accomplished through one screw or rivet and a drilled hole for a positioning tab. Removal of crystal is done through slight upward pressure on the spring-loaded retaining flange which swings out of the way for easy access.

Circle No. 234 on Subscriber Service Card.

MINIATURE READ-OUT TUBE

A miniature, all-electronic device which converts electronic signals directly to readable characteristics has been announced by Electronic Tube Division of Burroughs Corp.

Named miniature N1XIE, the unit is gas-filled, cold cathode, 10-digit, numerical indicator tube having a common anode. The tube utilizes 100 v and operates at



1/8 watt. It measures 6/10 in. in diameter, 3/4 in. high.

Features include rugged construction, simple plug-in stem, perfectly formed figures, controllable brilliance, according to the manufacturer. It is not affected by environmental conditions.

Can be used whenever read-out is required.

Circle No. 244 on Subscriber Service Card.

AUTOMATIC PROGRAMMER

Model 183 Programmer, developed by Sanborn Co., automatically programs operation of Sanborn six-and-eight-channel oscillographic recording systems for analog computer read-out.

Joint operation of the 156- or 158-5490 Sanborn Console system and the Model 183 Programmer occurs automatically in the following sequence (unless manually terminated): Step 1: recorder turned on; Steps 2 to 16: calibration signal voltages of 0, 100, 20, 10, 5, 1, .2, 0, -.2, -1, -5, -10, -20, -100 and 0 fed to all channels; Steps 17 and 18; dc levels of computer read; Step 19: computer output recorded for predetermined chart length, or as controlled by computer; Step 20: recorder turned off, programmer reset for another cycle.

Circle No. 238 on Subscriber Service Card.

SQUIB-ACTUATED SWITCH

Atlas Powder Co. has developed a squib-actuated switch that has special characteristics attractive to designers and producers of aircraft, missiles and special weapons components.

Encased in metal housing, ½ in. x ½ in. x 2 5/32 in., the switch provides four sets of contacts which can be furnished in any combination of normally open and normally closed positions. It is unaffected by vibration of 100 g's amplitude from 20 to 2,000 cycles/sec. and is not damaged by shock acceleration of 15,000 g's in any direction.

Insulation resistance between open contacts at 500 v is 5 x 10^{11} ohms; contact resistance, closed contacts at 1 to 10 amperes, 4 x 10^{3} ohms; current capacity of contacts, continuous, 10 amperes; for 100 millisecond, 100 amperes. Actuation time of switch: carbon bridge, less than 1 millisecond; wire bridge 2-4 milliseconds.

Circle No. 247 on Subscriber Service Card.

DIGITAL TACHOMETER

A digital tachometer offering precise rotational measurement for instrumental applications for missiles is being manufactured by Nacimco Products, Inc.

Accuracy of the instrument is limited only by read-out method employed, and can be better than .001 rpm, with a scale of zero to 10,000 rpm. Output can be by sharp pulse or sine wave with signal set one to 100 per revolution. The tachometer is available with either single-ended or

feed-through shafts, for mounting on drive pads.

Instrument is said to be extremely rugged and has proven highly reliable in wide a range of applications.

Circle No. 245 on Subscriber Service Card.

SILICONE BLANKET

Hewitt-Robins, Inc., has developed a 6 ft. x 30 ft. silicone blanket for use in high temperature vacuum bonding of epoxy resins. Blanket will permit bonding of larger surfaces than previously possible.

Blankets are made in standard thicknesses of 1/16 and 5/16 in. but can be made in heavier gauges on special order. They can withstand operating temperatures up to 500°F and have good heat aging properties, high tear resistance, high elongation, high tensile characteristics and good recovery.

Circle No. 243 on Subscriber Service Card.

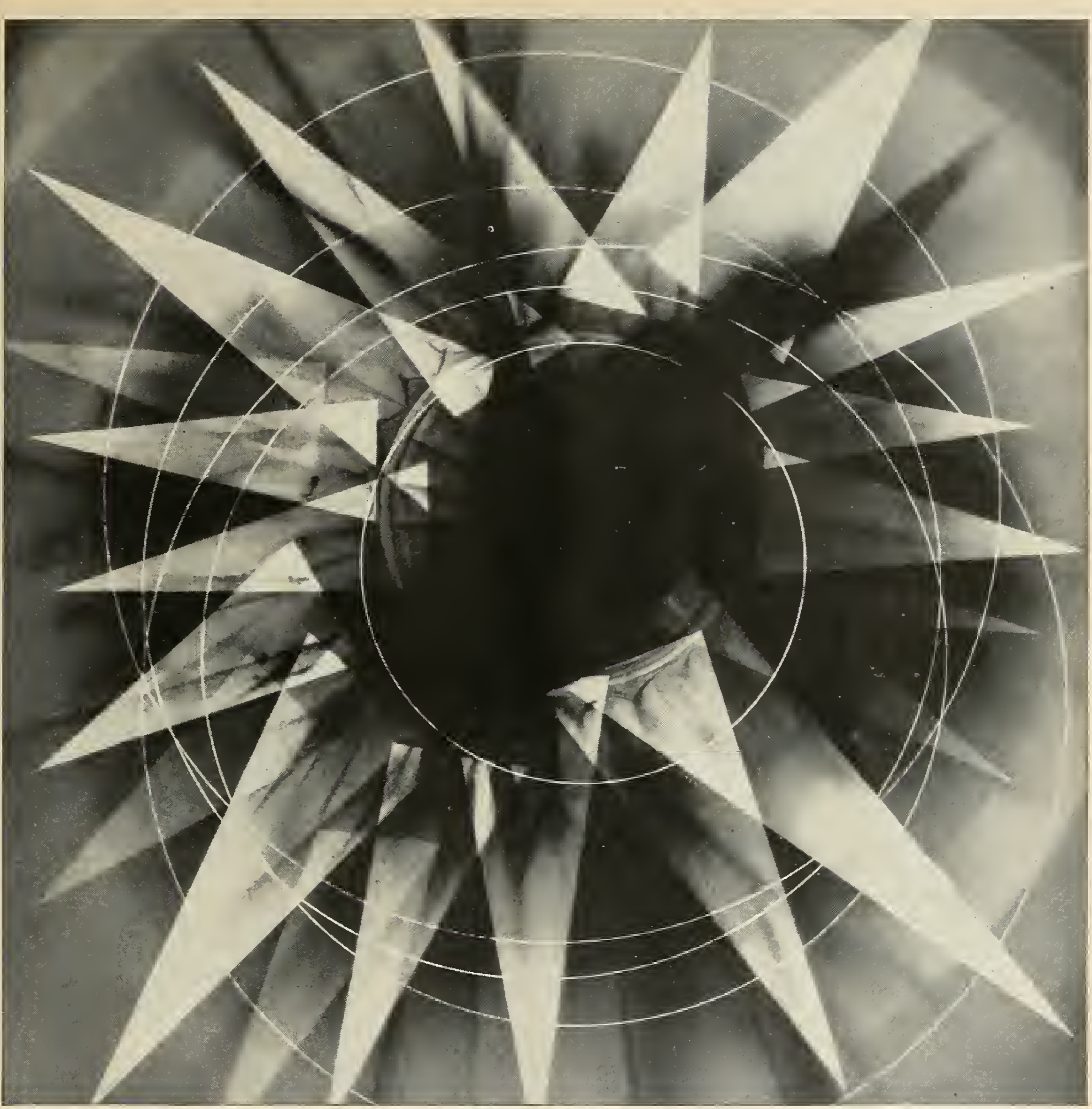
SILICONE RUBBER

Two silicone rubbers have been developed for service at temperatures in the range of 600°F by Dow Corning Corp.

Identified as Silastic 6535 and Silastic 2071, both are said to be primarily cloth-coating stocks, characterized by excellent bond strength, low compression set, and a high degree of resistance to reversion under clamps.

Silastic 6535 is a liquid dispersion type. Vulcanized, it retains resilience from 600°F to -178°F.

Silastic 2071 is designed especially for calendering, although it is also suitable for molding or extruding. Properties



after 24 hours in a circulating air oven at 600°F include a Shore A Scale hardness rating of 63, a tensile strength of 700 psi, and 200% elongation.

Circle No. 227 on Subscriber Service Card.

HEAVY-DUTY CIRCUIT BREAKER

A weatherproof, precision-type, heavy-duty circuit breaker for applications demanding precision, high shock and vibration resistant units, is in production at the Spencer Thermostat Division of Metals & Controls Corp.

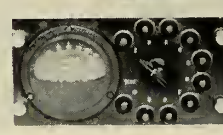
Breakers weigh 7½ oz., are compact and have snap-acting disc actuating elements. Ratings range from 105 to 200 amperes.

Automatic and manual reset types operate at predetermined current overload. Excess current passing through the disc causes it to heat to tripping temperature and snap into reverse curvature, opening the contacts and breaking the circuit. In automatic reset types, disc reverts to original curvature after short cooling time.

Circle No. 233 on Subscriber Service Card.

TEMPERATURE MONITOR

Arnoux Corp. is marketing a critical temperature monitor which is powered and operated entirely by magnetic ampli-



fier circuitry and simultaneously monitors up to 10 channels of temperature.

Model CTI-10D has adjustments for balance and sensitivity which enable each channel to be set for any desired critical temperature range and trip point. This point may be set accurately to within 1% of the operating range established.

Power requirements are 105-125 v, 380-420 cps, 25 watts. Unit includes warning panel, 5¾ in. x 3 in. x 3 in.; balance and power unit 5⅛ in. x 9¼ in. x 19 in. Weight of complete unit 15 lbs.

Circle No. 242 on Subscriber Service Card.

DYNAMOMETER

Development of a dynamometer to completely test torque and speed characteristics of shaded pole motors and induction motors has been announced by Magtrol, Inc.

The unit operates on the principle of feed back torque control such that when a decrease in speed is detected by the tachometer generator of the unit, a corresponding decrease in load torque is instantaneously effected and the motor stablilized in any portion of the curve. Motors may be tested for a maximum

PANORAMIC

TELEMETERING INSTRUMENTS

provide a simple, reliable, almost instantaneous method of checking FM/FM Telemetering System operation

Use these proven Panoramic Telemetering Instruments *BEFORE, DURING* and *AFTER* tests to detect cause/effect of deviations, pinpoint difficulties, make corrections in time to avoid expensive system failures. The specific functions of these instruments in checking both the airborne and ground station equipment are briefly tabulated here.

PANORAMIC TELEMETERING INDICATOR

MODEL TMI-1 Panoramic's Telemetering Indicator was specifically designed for checking FM/FM telemetering systems. In just one second and it automatically provides a visual display of the frequency and amplitude of composite signal components. Scans spectrum logarithmically from 350 cps to 85 kc, or linearly, any 100 cps to 20 kc segment centered anywhere between 400 and 70,000 cps. Permits measurement of spurious products down 40 db. Features 20 db linear and 40 db log amplitude scales; 2 mv full scale sensitivity; automatic optimum resolution.

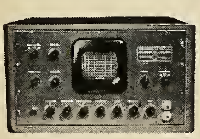
USES: Monitor entire subcarrier spectrum; measure and analyze subcarrier distortions; investigate hum, noise, microphonics and interference; detect channel spillover; set up subcarrier pre-emphasis; calibrate or linearize subcarrier oscillators (when used with Panoramic Frequency Calibrators); monitor magnetic tape re-recordings.

PANORAMIC ANALYZERS FOR RF SIGNALS

MODEL SA-3 Panadaptor, in three different types, is ideal as a tuning aid to permit rapid tuning-in of signal and detection of adjacent channel interference.

Type T-3000-CI is designed to operate with receivers having 21.4 mc IF.

Types T-2000 and T-3000 are designed to operate with receivers having 30 mc IF.



MODEL SB-Bb Panalyzor, in two different types, analyzes composite RF signal. Is used to set up deviation of RF carrier and to analyze sideband structure of FM'd carrier.

Type T-1000-CI is designed to operate with receivers having 21.4 IF.

Type T-200-R is designed to operate with receivers having 30 mc IF.

PANORAMIC TELEMETERING FREQUENCY CALIBRATORS

Three models, designed to meet the needs of different application requirements, provide precise frequency calibration points for all RD8 channels conveniently . . . rapidly.

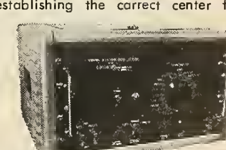
USES: Calibrate or linearize subcarrier discriminators; provide a precise frequency source for date reduction; calibrate or linearize subcarrier oscillators (when used with Panoramic Telemetering Indicator).

MODEL TMC-1 Panoramic's Telemetering Subcarrier Deviation and Three Point Calibrator sequentially furnishes upper limit, center and lower limit frequencies channel by channel. (Automatic switching with 20-second dwell per channel available on request.) Limits are ± 7.5% for all channels and ± 15% for upper five. Other limits optional. Frequency accuracy 0.02%. Built in channel selector automatically establishes proper center frequency and sweepwidth in companion Model TMI-1 to enable, through visual comparisons of subcarrier oscillator frequencies and corresponding calibrator frequencies, rapid set-up or check of maximum deviation limits and center frequency of subcarrier oscillators.

MODEL TMC-307 Panoramic's Seven Point Calibrator sequentially furnishes seven equally spaced frequencies per channel with an accuracy of 0.02%. End limits ± 7.5% for all channels and ± 15% for upper five channels. Other end limits and spacings can be furnished as required. Channel and frequency point switching may be either manual or automatic. On automatic, minimum dwell period is 10 seconds per channel.

MODEL TMC-211 Panoramic's Simultaneous Eleven Point Calibrator differs markedly from the TMC-1 and TMC-307 in that it provides 11 equally spaced frequencies having a 0.002% accuracy, for **all** channels **simultaneously** within the ± 7.5% or ± 15% limits. On automatic, switching of calibrating frequencies is controlled synchronously and cycling time is adjustable from 1/4 to 8 seconds per frequency point. All channels can be sampled in as little as 2 3/4 seconds. Synchronization may be turned off and any channel calibrating frequencies may be selected manually. The instrument may also be remotely controlled through land wires making possible its use at a central station from which various subcarrier channels may be diverted to different locations.

PANORAMIC TELEMETERING CHANNEL SELECTOR



MODEL CHS-1 Panoramic's Telemetering Channel Selector is a companion instrument to Model TMI-1 automatically establishing the correct center frequency, sweepwidth and resolution of any of the individual subcarrier channels selected for display on the screen of the TMI-1. An internal signal switcher permits alternate display of subcarrier vs. external calibrating markers, available from the TMC-307, TMC-211, or other source, for visual comparison of linearity or spread of subcarrier.

the pioneer is the leader

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Be SURE of the accuracy of your telemetering system . . . be ASSURED by checking system operation with Panoramic Telemetering instruments. Write, wire, phone TODAY for complete details and catalog sheets. A Panoramic Applications Engineer is available to work with you on your special problems.

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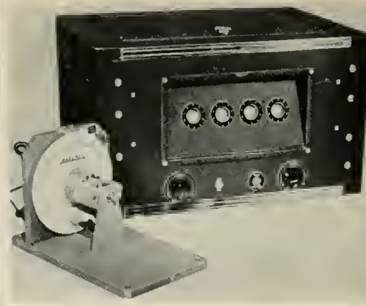


speed as low as 100 rpm with no additional controls or adjustments necessary.

Seven dynamometers with torque ranges from 750 oz.-in. to 1 oz.-in. full scale may be obtained. Tachometer generator can be supplied to indicate speed up to 8,000 by 1 rpm increments, or 30,000 rpm by 10 rpm increments.

Circle No. 239 on Subscriber Service Card.

MINIATURE RF CABLE CONNECTORS

Dage Electric Co., Inc., has introduced a sub-miniature series of RF coaxial cable connectors, designated DM and including 12 different groups of jacks, receptacles and adapters.

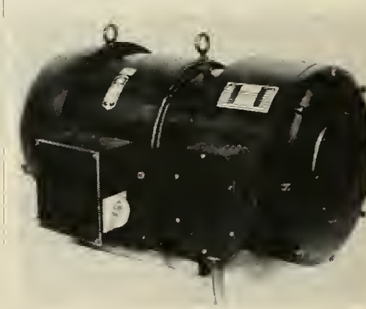
DM connectors are half the size of BNCs, yet can withstand a cable pull of better than 50 lbs. Twelve polarities—one for each group of connectors—prevents wrong connections. Bayonet locking meets MIL-C-5015 specs., provides vibration proof coupling. Teflon insulators permit use over wide range of temperatures with low electric loss.

Circle No. 250 on Subscriber Service Card.

POWER SUPPLY

A lightweight 400-cycle power supply designed to meet military environmental specifications has been developed by Georator Corp.

Unit delivers 400-cycles, 3-phase, 120/208 v, 15 kva continuous, 22.5 kva for short period overloads. Totally enclosed fan-cooled construction is utilized,



use of light metals and "Nobrush" design holds weight within 500 lbs. for complete motor-generator combination.

Dimensions 36" x 19" x 21". Motor operates at 1,800 rpm from standard 220/440 v, 3-phase, 60-cycle supply.

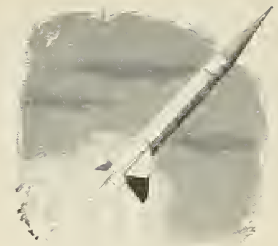
Circle No. 240 on Subscriber Service Card.

PRESSURE-OPERATED VALVE

Hydromatics, Inc., is producing 8-in. ball-type control valves for high pressure systems up to 2,000 psi and temperatures to 225°F.

Controlled by pressure actuated operator, valves are said to have rapid re-

Typical assortment of missile batteries engineered and manufactured by Exide.



Surface to surface

Surface to air

Air to air

Air to surface

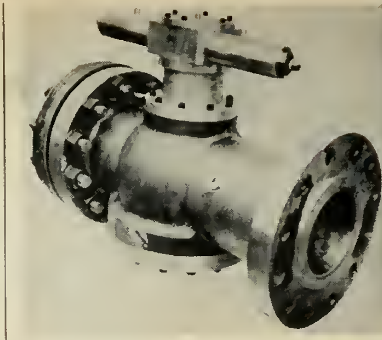
Exide missile battery program aims at giving you the battery you need, when you want it, with the maximum assurance of reliable performance

Behind the Exide Missile Battery Program lie the full engineering resources of the Exide Laboratories. Engineers in the Missile Applications Section concentrate exclusively on silver zinc missile batteries designed for applications requiring maximum power with minimum weight and space. At their disposal is the extensive knowledge and background of colleagues working in a wide variety of research and engineering fields related to missile batteries.

Benefit from Exide's experience and facilities—unduplicated by any other battery maker in the world. You are invited to submit your auxiliary power requirements and problems to us for study and evaluation by our engineering staff. Exide Industrial Division, The Electric Storage Battery Company, Philadelphia 2, Pa.

Exide®

Circle No. 60 on Subscriber Service Card.



sponse and capable of 2 full travel cycles/sec., or 10 cycles/sec. through any 10% portion of a full stroke.

Overall valve envelop is smaller than any unit previously available for full flow operation at high pressures. May be used with wide range of liquid or gas media.

Circle No. 237 on Subscriber Service Card.

PRESSURE-FILLED "O" RINGS

Development of pressure-filled metal "O"-Rings, which improve sealing characteristics at elevated temperatures and provide increased resilience with greater flange deflection, has been accomplished by Advanced Products Co.

Standard .010 stainless-steel "O" rings are filled with gas at various pressures ranging from 500 to 3,000 psi at room temperature. Internal gas pressure offsets the inherent loss of metal's strength at elevated temperatures.

Missile and other applications requiring operating temperatures above 1,000°F are principal uses for the rings. Rings are made with variations in pressure filling, silver plating, Teflon coating and use of special metals such as Inconel X to meet specific requirements.

Circle No. 236 on Subscriber Service Card.

TIME DWELL SERVO VALVE

Unit designed to convert electronic signals into control forces for missiles, drones or aircraft has been introduced by AiResearch Manufacturing division of Garrett Corp.

Weighing 1¼ lbs., the unit is known as a time dwell servo valve and serves as a link between a missile's electronic computer and control surface actuators. It converts electric signals into hydraulic forces.

Hydraulic oil flows can be regulated from 1/10 to 5 gal./min. at pressures from 750 to 4,000 psi.

A spool and body assembly controls quantity and direction of oil flow to an actuator and a torque motor converts electrical signals into forces to activate the valve spool.

Circle No. 249 on Subscriber Service Card.

MINIATURE PISTON-TYPE MOTORPUMP

Vickers, Inc., is producing a line of miniaturized motorpumps for use in missile systems.

Typical unit, Model AA-19054, delivers .84 gpm at 7,400 rpm and 1,000 psi. Hydraulic pump weighs 1 lb., and electric motor 7 lb. Overall length of both pump and motor is 9 15/16 in.

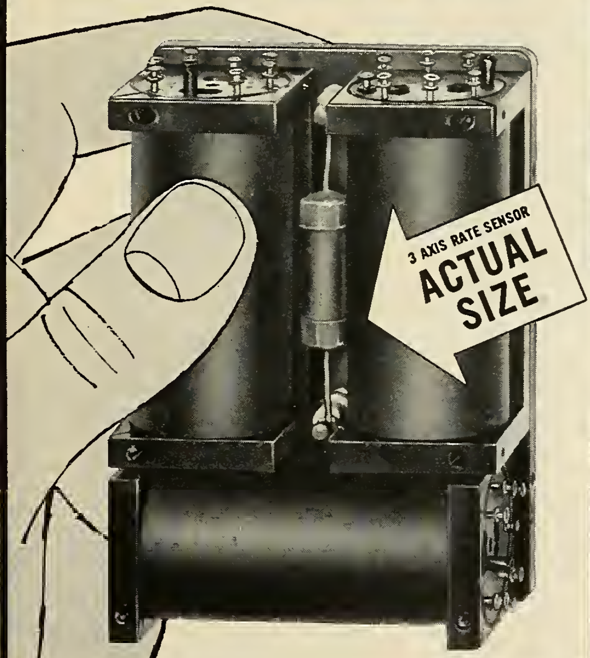
Starting torque is less than 10% over maximum running torque. High pump efficiency and low starting torque permit use of smaller, lighter motor. Pump

In Control—with U. S. TIME GYROS

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

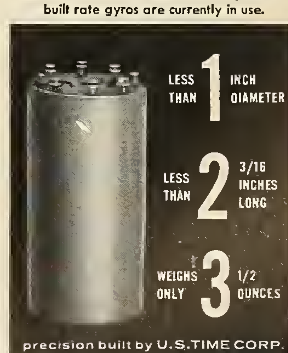
SUBMINIATURE!

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

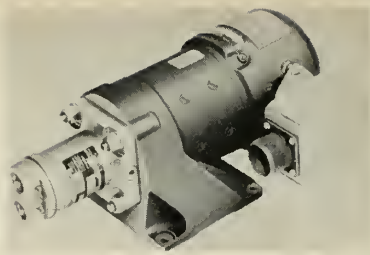
A new edition of our technical data handbook available upon request.

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

Circle No. 64 on Subscriber Service Card.



efficiency reduces current drain, and ability to operate at high speeds permits direct drive. Motor is 28 vdc unit rated at .84 hp. It has radio noise filter and is explosion proof.

Circle No. 241 on Subscriber Service Card.

RECORDING SYSTEM

A Series 3,000 multi-channel magnetic tape recording system featuring a 300 kc band width is being manufactured by the Recordata Division of American Electronics, Inc.

Featuring unusual versatility, extreme accuracy, single switch for the selection of six speeds, and modular construction, the system is said to simplify all recording operations.

The system accommodates reels up to 14 in. as standard equipment and may be ordered to handle 19-in. reels. A single switch on the front panel selects any of the six standard speeds up to 60 in./sec. eliminating the need for changing of belts, pulleys, etc.

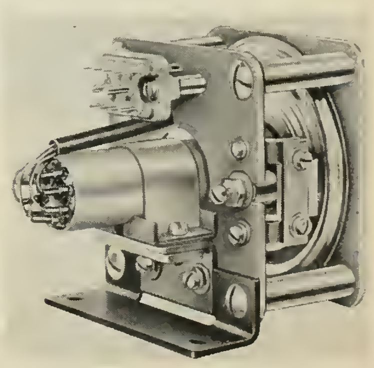
Tape transports are available which accommodate ½, ¼, or 1-in. tape. Tape guides may be easily interchanged. Backlighted control buttons, on the primary panel face, control high-speed fast-forward and rewind functions, record, playback and stop operations.

Convenient module housings provide plug-in facilities for record and playback amplifiers. By plugging the proper modules, instant selection of Direct FM or PDM recordings or playback in any combination can be achieved.

Circle No. 264 on Subscriber Service Card.

PRESSURE TRANSDUCER

Fischer & Porter Co. is producing a pressure transducer for use in data reduction systems. The device converts a 3 to 15 psi signal to ac millivolts directly propertional to pneumatic input.



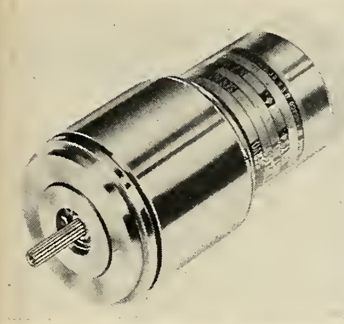
When pressure is applied to the sensing element of the transducer, the resultsing movement of an expandable capsule displaces an armature which induces opposing voltages in twin secondary coils. This voltage is linearly proportional to the pressure input. The output may be used to position an indicator, recorder or control device. Accuracy of the F&P pressure transducer is high 0.25% of the full scale.

Circle No. 266 on Subscriber Service Card.

MOTOR GENERATOR

G-M Laboratories, Inc. has developed a new size 18 motor-generator in which the maximum rms null voltages are 13 millivolts total and 8 millivolts fundamental.

The motor and generator are the equivalent of the BOURD Mark 16.



Motor and generator are combined in an assembly having a single shaft. Motor has a diameter of 1.750 in. and is designed for operation on 400 cycles with a stall torque of 2.35 oz. in. Customary voltages are 26 v or 115 v on the fixed phase, and 26 v, 115 v, or 230 v on the control phase. Other voltages can be provided if needed.

The generator is 1.5 in. in diameter and is designed for operation on 400 cycles.

Circle No. 265 on Subscriber Service Card.

SHAFT POSITION TRANSMITTER

A highly accurate shaft position transmitter having infinite resolution and a null point at the center of rotation has been developed by engineers at G. M. Giannini & Co., Inc.

Designated Model 58175S-5, the instrument consists of a standard three-turn, slide-wire Spiralpot potentiometer which has incorporated within its case fixed resistors wired in a bridged circuit. One leg of the bridge is shunted with the variable section, and output can be read on a sensitive light beam galvanometer. Linearity over ±360° rotation is about ±0.11%. Over the entire ±540° range linearity is ±0.37% or better.

Physical configuration is identical to the Giannini Model 85175 Spiralpot which has a bushed mounted back anodized aluminum case 1.5 in. in diameter by 1.5 in. long. The precision ground, corrosion resistant shaft is supported in miniature ball bearings and an indexing pin provides for panel alignment.

Circle No. 260 on Subscriber Service Card.

SUB MINIATURE CONNECTOR

Automation-Engineering Corp. is producing a sub miniature snap-lock coaxial cable connector and mating receptacle in 50, 75 and 95 ohm sizes. Plug is spring loaded and snaps into position to engage special receptacle firmly. Plug cannot be removed by pulling on the cable, or by vibration, but only by sliding the knurled sleeve toward the cable end.

Connectors will withstand temperature range of —70°F to 550°F and shock of 100 g's on any axis. Vibrations at 5 g's from 10 to 20,000 cycles.

Circle No. 261 on Subscriber Service Card.

INDUSTRY SPOTLIGHT

By Joseph S. Murphy

Lawmakers Censure Guided Missile Program

The military guided missile program is wasteful, duplicatory, poorly coordinated and badly managed, according to the Surveys and Investigations Staff of the House Defense Appropriations Subcommittee.

The staff submitted a 200-page report on the missile program to Subcommittee Chairman George Mahon (D-Tex.) at the outset of hearings on the Defense Department's request for $38.5 billion in new money for fiscal 1958. While the report itself was classified and therefore withheld from the record, a substantial portion of its findings were suggested by the questions of Rep. Mahon and his colleagues.

One of the principal things which apparently bothered the subcommittee's staff was the decision to go ahead with the Northrop *Snark* intercontinental missile while failing to request adequate support for North American's ramjet intercontinental *Navaho*.

"Our investigative staff has reported the Special Assistant for Guided Missiles (then Eger V. Murphree) termed the *Snark* program a questionable one," Mahon said. "The committee was advised that Gen. Curtis LeMay, Strategic Air Commander, under whose command the *Snark* will function, has frequently and consistently favored its cancellation . . . It appears to the committee that available dollars might be more profitably used for the more advanced weapons such as the *Navaho* . . ."

Reuben Robertson, Jr., former Deputy Defense Secretary, responded to the criticism with a stout defense of the *Snark*. He praised the accuracy of the turbojet missile, declared that it is firmly scheduled to go into operation with SAC and hinted that the *Navaho* will be dropped entirely. "We view the *Snark's* and *Navaho's* approach in the air-breathing intercontinental group quite similar to the *Thor* and *Jupiter* competitive situation," Robertson said. "One of them is going to win that race and should be put into inventory."

Other staff criticisms which filtered through the interrogation of witnesses:

1. The USAF *Bomarc* interceptor missile is overly vulnerable to jamming and is too expensive in relation to its contribution to national defense. (First production contract for the Boeing missile was announced last month.)

2. One of the outstanding weaknesses in the military missile program has been the failure of the Defense Department to have an adequate organization for the evaluation of military missile projects. Too little use has been made of the Pentagon's Weapon Systems Evaluation Group.

3. Duplication exists in many areas, including the *Thor-Jupiter-Polaris* IRBM program, the *Atlas-Titan* ballistic missile program and the *Nike Hercules* and *Talos* air defense program.

4. Efforts by the military services to establish anti-ballistic missile programs are not coordinated.

5. The Navy wasted millions on the Army's *Jupiter* IRBM before striking out on its own with the *Polaris* Fleet Ballistic Missile.

6. The *Nike I* is not an effective weapon and introduction of the *Nike Hercules* has been delayed through failure to utilize the Douglas Santa Monica plant as a prime source in addition to the Charlotte Ordnance Plant, also operated by Douglas.

The former Deputy Defense chief offered a rebuttal for most of the charges, plus some criticism of his own for the way the subcommittee's staff put together its report. Most of the duplications which now exist were ordered deliberately as insurance against technical setbacks, he observed. Exceptions are the Navy *Regulus* and the Martin *Matador*; latter was to be abandoned, but the decision was reversed when the Korean War developed, he said.

Robertson also said the staff was

A "confidential" presentation of the Air Force's overall missile procurement program for fiscal 1958 slipped into the published record of the USAF hearings. Reason for the security label was the fact that it included an exact breakdown of the ballistic missile program. Apparently it was overlooked by the censors when they cleaned classified information out of the record.

The figures show that almost half the total of missile procurement funds requested by the Air Force for next fiscal year will finance the *Atlas-Titan-Thor* ballistic missile development program. The airmen have programmed $955.7 million for the ICBM-IRBM projects, compared with $994.8 million for all other missiles. Included are comparisons with fiscal 1957 and 1956 (in millions of dollars):

	Fiscal 1958	Fiscal 1957	Fiscal 1956
Ballistic missiles	$676.9	$659.4	$267.0
Ballistic missile spares	37.5	15.7	11.6
Ground handling equipment	234.6	203.6	29.3
Center support	6.7	3.7	0
Subtotal	$955.7	$882.4	$307.9
Other missiles	737.9	1,016.4	551.8
Other missile spares	68.2	81.1	32.6
Ground handling equipment	188.7	188.9	105.1
Subtotal	$994.8	$1,286.4	$689.5
Total	$1,950.5	$2,168.8	$997.4

The procurement program does not include outlays necessary to provide contractors with the manufacturing, development and testing facilities they need for the ballistic projects. USAF is seeking $13,500,000 for these facilities in fiscal 1958, down sharply from the $84,500,000 voted last year and the $65 million voted in fiscal 1956.

arbitrary in its recommendations to cut off projects of many years' duration, that it gave undue weight to low-level staff studies as opposed to top policy-making points of view in its report, and that there is, despite all the talk of interservice rivalry, a rather extensive interchange of missile information between the services.

Here are the missile high-lights of the appropriation hearings:

Air Force

USAF is currently devoting its anti-ballistic missile efforts primarily to the task of early detection of the so-called "ultimate" weapon. Former Air Force Secretary Donald Quarles said the ICBM could be detected as much as 15 minutes before impact through modification of the SAGE system and the early warning radar lines. This scant warning could reduce casualties enormously as well as alert the armed forces to retaliation. The job of positive defense against the ICBM is much more difficult, and its creation would probably lag several years behind the introduction of the ICBM itself, Quarles said. He estimated the cost of an effective anti-missile defense as "comparable" to the cost of the ICBM itself. Maj. Gen. Bernard Schriever, chief of ballistic missile development for the USAF, underscored the difficulty. "There is . . . no doubt in anyone's mind that it (the anti-missile) is a very difficult technical problem, and that is only to take care of the most unsophisticated type of a ballistic missile nose cone."

Air Force will put money into at least two Navy airborne missiles. It will buy the infra-red *Sidewinder* air-to-air missile from the Bureau of Ordnance for its Lockheed F-104A day interceptor. It also expects to put the Navy-developed Martin *Bullpup*, an air-to-surface missile.

Procurement of the Douglas MB-1 nuclear air-to-air rocket will climb sharply in fiscal 1958. In addition to buying increased quantities for operational use, USAF expects to purchase more than $19 million worth of the weapons for its mobilization reserve.

USAF appears to have abandoned the idea of putting the Radioplane *Crossbow* (a derivative of the *Firebee* drone) into production. But two new drones, the Q-4 and Q-5, were revealed. Latter appears to be a derivative of the Lockheed X-7 ramjet test vehicle.

Navy

The Fairchild *Petrel* air-to-surface missile has been discontinued and will not be produced any further.

The *Vanguard* satellite launching

system is proving far more costly than the original $20 million estimate. Office of Naval Research has asked a total of $56.4 million for the project to date, including $25 million from the Pentagon Emergency Fund.

Bureau of Aeronautics is requesting $236,800,000 for procurement of missiles and drones in fiscal 1958, while BuOrd is requesting $179,332,000 for missile procurement.

For missile research, BuAer is asking $36,420,000 and BuOrd is requesting $128,300,000, including $68 million for *Polaris,* up $10 million from last year.

Rear Adm. William Raborn, Jr., director of the *Polaris* project, said the Navy's decision to abandon the fleet ballistic missile version of the Army *Jupiter* and proceed with independent development of the *Polaris* FBM will save U.S. taxpayers $500 million. He said the solid-propellant *Polaris* will be a cheaper, safer and better weapon for shipboard use than the liquid-propellant *Jupiter.*

Navy is also requesting $500,000 for advance planning of a nuclear submarine capable of launching the *Polaris* formal request for authorization to build will come next year.

A "major improvement" of the infra-red *Sidewinder* is under development and an improved version of the radar-guided *Sparrow* will go under development soon. Both are air-to-air weapons. A *Terrier II* is under development which will double the range of the present 20-mile ship-launched air-defense weapon.

The Marine Corps is contributing funds to the development of the Army's *Hawk* low-altitude aid defense missile. *Hawk* is an outgrowth of Raytheon's *Sparrow III.*

Two new air-launched weapons for use against submarines are in advanced stages of development, and production has commenced on one. A third new ASW weapon has just completed the research phase. The weapons were not identified, but it is believed one of them is the *Lulu,* a nuclear depth charge.

Army

Nike Ajax, the nation's first anti-aircraft missile to go into operational use, has been phased out. The soldiers canceled plans to buy the weapon with funds voted for the current fiscal year, and also dropped orders for 300 *Nike Ajax* placed with 1956 funds. They may drop another 400 *Nike Ajax* from the 1956 program. The money is being diverted to the more advanced *Nike Hercules,* with procurement of the latter transferred from the Douglas-Santa Monica plant to Charlotte Ordnance

Plant to build up production there as rapidly as possible.

Funds have been requested to support development of the *Talos* during fiscal 1958. This is the shore-based version of the Navy-developed air defense weapon transferred from the Air Force to the Army in the same Pentagon order last November which gave the *Jupiter* to the Air Force. The Army plans to evaluate *Talos* as a possible supplement to *Nike Hercules.*

The Army has given top priority to the development of an anti-ballistic missile. It has requested $12 million to finance study of the problem in fiscal 1958. "We must get on with the job," declared Lt. Gen. James Gavin, chief of Army research.

Corrosion and deterioration have taken their toll of *Nike Ajax* now installed at launching sites. Army is asking funds to rebuild some 4,000 of the weapons. Nitric acid and exposure to the weather have been the chief troubles, but synthetic rubber components like gaskets have also shown signs of deteriorating.

Solar Furnace to Aid Missile Metal Studies

The study of the effects of rapid temperature changes on metals used in missile structures is expected to make the greatest use of a huge solar furnace to be constructed by Air Research and Development Command near Cloudcroft, New Mexico.

The furnace will be the largest in the world and more efficient than the existing one in the Pyrenees Mountains between Spain and France. Completion is scheduled for early 1959. Use of the instrument will be under ARDC'S Holloman Air Development Center.

The new furnace is expected to produce temperatures as high as 8,000°F—about 70% that at the surface of the sun. A staff of about 100 will be needed for its operation.

The furnace will be composed of three basic parts: a heliostat, which is the primary sun-reflecting mirror, measuring 130 ft. high and 140 ft. wide; the attenuating shutter, a venetian blind-type device which regulates the amount of sunlight traveling from the heliostat to the parabolic mirror; and, the parabolic mirror which collects the sunlight and concentrates it on the focal spot.

Thiokol Gets Contract

Thiokol Chemical Corp. has received a $790,758 contract for solid-propellant boosters for the Martin *Matador* TM-61B. Work will be done at company's Utah Division at Brigham City.

industry briefs

SIEGLER CORP. reports record sales of $22,688,892 for the nine months ending March 31. This almost doubles the sales figure for the comparable period in 1956.

RAYTHEON MANUFACTURING CO. has taken over management of Navy's plant at Bristol, Tenn., for production of *Sparrow III* missile for which Raytheon is prime contractor. Plant had been used by Sperry-Farragut Co. to produce *Sparrow I*, now in operational use.

THE GARRETT CORP.'s AiResearch Manufacturing division has started construction of a 40,000-sq.-ft. working area to consolidate electronic and pneumatic control activities at Phoenix. Master plan calls for 120,000-sq.-ft. building employing 500 workers.

THE MARTIN CO. has released 50 engineers and transferred another 50 from Baltimore to Orlando and Denver. Moves are results of Air Force cancellation of contract to develop high-speed bomber and failure of Martin to win contract for seaplanes.

BEECH AIRCRAFT CORP. will move its Boulder Division manufacturing operations to Longmont, Colo. Engineering and general offices will stay at Boulder. About 50 of division's 200 employes will move.

RETMA, Radio - Electronics - Television Manufacturers Association board of directors have unanimously voted to change the organization's name to Electronic Industries Association. Proposal will be submitted to membership.

McDONNELL AIRCRAFT CORP.'s employment reached all-time high with the recent hiring of the 25,000th employe. Current employment is five times World War II peak and weekly payroll now tops $2,600,000.

SUMMERS GYROSCOPE CO. is seeking Securities and Exchange Commission registration for 250,080 shares of $1 par common stock to be offered for subscription to current stockholders at rate of two new shares for each five shares held May 31, 1957. Proceeds will be added to working capital and used for general corporate purposes as needed.

RYAN AERONAUTICAL CO. has acquired an assembly plant and a 27-acre site adjacent to Torrance, Calif., Municipal Airport. New facility contains 137,000 sq. ft. of floor space.

AMERICAN BOSCH ARMA CORP. board of directors declared a dividend of 25¢ per common share, payable July 15 to holders of record June 14, and voted the regular quarterly dividend of $1.25 per share on the 5% cumulative preferred stock Series A and B, $100 par value, payable July 1 to stock of record June 14.

FIRESTONE TIRE & RUBBER CO. has received a subcontract from The Martin Co. to develop and test components of the *Matador* TM-61B missile. Work under the contract will be done at Firestone's Defense Research Division and Engineering Laboratory, Monterey, Calif.

RESEARCH ENGINEERING SERVICES CORP., Sandy Springs, Ga., is a newly incorporated firm of aeronautical engineers and research scientists in Atlanta. Principal officers are: president, Willi Jacobs; v. p., Peter Fielding; secretary-treasurer, Erik Sieurin.

Industry Highlights

By Fred S. Hunter

They're back on the beam at Hughes Aircraft's Tucson plant, where the *Falcon* is produced. The five-day week (cut back to four last February) has been restored and most of the 496 employes laid off at the same time have been called back to their jobs. Moreover, Hughes-Tucson now has about 100 openings for workers having special skills. Reports that Hughes spent its own money in making fixes to restore the *Falcon* to its previous high degree of reliability are not confirmed by the company, but may very well be true. Hughes has never hestitated to do this sort of thing at its own expense. The Hughes *Falcon* now has a formidable competitor in the new Douglas MB-1 rocket. But Hughes has new models of the *Falcon*—the GAR-3 and the GAR-4—coming along, too.

•

Liquid oxygen has hazardous characteristics, such as its temperature of minus 297 degrees F, which can damage skin or eyes on contact, but rocket makers have found it creates no special problems if handled properly. At Rocketdyne, they handle it like water around the house—just try not to spill it—and they've never yet had a handling accident.

•

The Douglas MB-1 *(Ding-Dong)* has a tear-drop-like configuration incorporating four fins.

•

First Bay area headquarters of Lockheed's Missile Systems division is no more. It was opened in San Jose in February, 1956, with a handful of employes, built up to a maximum of 290, and diminished as space became available at Palo Alto and Sunnyvale. Lockheed closed its doors the other day after Building 102, the second 96,000 square foot structure at Sunnyvale, became available. The new Sunnyvale building also provided a home for members of the Navy's resident staff, who previously had occupied temporary quarters at Moffett Field. Capt. W. A. Hasler, Jr., formerly chief of the Navy office at the Army Ballistic Missile Agency at Huntsville, Ala., heads up the Bureau of Ordnance Technical Office providing field technical liaison and direction to Lockheed on what is known at Lockheed as the XN project, but which you know as the Polaris.

•

Highest Nike battery in the nation is in the protective ring of 16 guarding the Los Angeles area. It's at 6000 feet on Mt. Gleason.

•

Northrop Aircraft, which has been paying $100 awards to employes for successful referrals of engineers, is now also paying $50 for referrals of needed machinists.

•

Willy A. Fiedler, now on the scientific staff of Lockheed's Missile System division, received a superior accomplishment award—with a $595 check to add to a $300 incentive award check previously received—from the Navy for a new-type dummy missile design he proposed while working at the Point Mugu Naval Air Missile Test Center. The design saved the Navy $300,000.

•

Every now and then Rocketdyne encounters an extra problem getting equipment into the back canyons of the Santa Susana Mountains, where its Propulsion Field Laboratory is located. A pressure vessel weighing 109 tons was a recent example. Took an entire day to haul it the 11½ miles from the Chatsworth rail siding. It also took two 250 hp diesel tractors in tandem. When the Rocketdyne crew tried pulling the low-bed semi-trailer carrying the pressure vessel with one diesel, the front wheels of the tractor were pulled off the ground. Heavy weight of the vessel, tractors and trailer was spread over 48 pneumatic tires.

ENGINEERS—SCIENTISTS

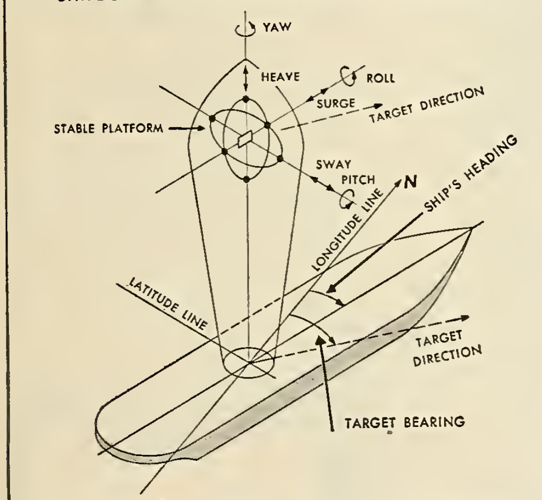
GENERAL ELECTRIC SELECTED TO DEVELOP GUIDANCE AND FIRE CONTROL SYSTEMS FOR NEW NAVY MISSILE, POLARIS

New Group Forming as Missile & Ordnance Systems Department of G.E. Adds Navy Project to Nose Cone Development Program.

POLARIS is the most challenging development undertaken by industry for the Navy since the nuclear propulsion program. It is an Intermediate Range Ballistic Missile, whose specifications call for launching capability from both surface vessels and submarines.

PROBLEMS UNIQUE IN MISSILE TECHNOLOGY

SHIPBOARD LAUNCHING: INITIAL CONDITIONS



The diagram above presents the primary parameters involved in shipboard launching of a ballistic missile in its simplest form.

For Polaris, MOSD must not only surmount these initial conditions but solve fire control problems more complex than heretofore encountered. Pinpoint accuracy in missile guidance is an impressive accomplishment under the most favorable conditions. But how do you achieve it with a missile hurled from a moving platform and aimed at an object approximately 1,500 nautical miles away?

In addition, the Polaris guidance and fire control systems must also operate effectively under the difficult conditions created by submarine launching.

HOW IS MOSD EQUIPPED TO SOLVE THESE PROBLEMS?

As prime contractor for IRBM and ICBM Nose Cone Development, MOSD can draw on a reservoir of top level experience and skill. This G-E department also has a backlog of significant experience in the development and manufacture of Naval Fire Control Equipment, such as range-finders, computers and radar antennas.

NEW OPPORTUNITIES FOR ENGINEERS WITH EXPERIENCE IN THE DEVELOPMENT OF GUIDANCE & FIRE CONTROL SYSTEMS

A new group is now being formed to work on Polaris Missile Sub-Systems at MOSD. It will be located at Pittsfield, Mass. in the heart of the Berkshire resort and vacation area. Openings are at all levels for men with experience in:

GUIDANCE & ELECTRO-MECHANICAL COMPONENTS

- Design, evaluation of guidance and fire control equipment
- Design, development of electro-mechanical components and servomechanisms
- Design, development, evaluation of inertial components, synchros, pick-offs, accelerometers, stable platforms, platform gimbals, verticals, etc.
- Design, development, fabrication of analog computers for guidance and fire control systems

GUIDANCE & CONTROL SYSTEMS

- Mathematical analysis, feasibility study of control systems and techniques
- Synthesis, design, evaluation of guidance and fire control systems
- Laboratory development, testing, modification of control systems

ELECTRICAL & ELECTRONIC COMPONENTS

- Development of amplifiers and associated circuitry
- Development, packing of electronic, magnetic, transistor servo type circuits and components
- Reliability, evaluation, analysis of electronic circuits and components
- Design, development of fire control consoles
- Systems integration, design of electrical and electronic components
- Development of electronic and solid state devices, semi-conductors, new transistor applications

OPPORTUNITIES OPEN ON OTHER MISSILE PROGRAMS

Engineers and Scientists with experience in other areas of Electrical Engineering, Aeronautical Engineering. Aerodynamics, Mechanical Engineering, Physics or Mathematics should inquire about positions on other missile programs at Missile and Ordnance Systems Department.

AN INVITATION

If you would like to contribute to any of the advanced missile development programs at MOSD, you are invited to send a resume of your education and experience. Or write us for a convenient application form. All resumes will be carefully reviewed by the MANAGERS *of our various technical components. You will be invited to visit our offices and discuss work we are doing directly with the Manager with whom you will be working. Communications will be entirely confidential.*

Please send resume to Mr. John Watt, Room 595-5

MISSILE & ORDNANCE SYSTEMS DEPARTMENT

GENERAL ELECTRIC

1617 Pennsylvania Blvd., Philadelphia 3, Penna.

Curtiss-Wright Profit Up for 1st Quarter

Curtiss-Wright Corp. reports a consolidated net profit of $9,942,256 for the first quarter of 1957. More than 60% of these earnings stem from commercial business, it was noted by Roy T. Hurley, president and chairman.

Consolidated net sales for the same period were $147,427,760. Unfilled orders plus scheduled production under advanced contracts amounted to $147,-427,760. A year ago, figures showed profits of $9,196,100 on sales of $132,641,353. Commercial business accounted for half the earnings in 1956.

NAA's Neosho Plant Producing *Thor* Engines

North American Aviation, Inc., has begun production of rocket engines at its Neosho, Mo., Rocketdyne plant following the receipt of an Air Force contract for a number of *Thor* IRBM propulsion systems.

Engines for *Thor* are in the developmental production at Rocketdyne's main plant at Canoga Park, Calif. Production at the Neosho plant will employ more than 1,500 persons by June 1958. About 650 of Rocketdyne's 10,000 workers are now at the Missouri facility.

Rocketdyne also is developing high thrust rocket engines for the *Jupiter*.

GE Adds Vermont Plant To Missile Systems

General Electric Co. recently has added guided missile production facilities to the Missile and Ordnance Systems Department.

According to MOSD General Manager George F. Metcalf, the production capability was added to supplement existing research and development capacities. The department has acquired existing GE facilities at Burlington, Vt., consisting of 400,000 sq. ft. and 1,600 trained employes.

Chief production items will include missile nose cones and arming and fuzing systems.

WDD Name Changed

Western Development Division of Air Research and Development Command has been renamed "Headquarters, ARDC, Ballistic Missile Division."

No changes in mission or organization were involved. The name change was made to provide a more descriptive title in keeping with the expanded scope of Air Force responsibility in the ballistic missile field.

GE to Design *Polaris* Fire-Control System

General Electric's Missile and Ordnance Systems Department has been awarded a Navy contract for $1,500,-000 to design and develop a fire-control system for *Polaris* mid-range missile.

Missile, which may be launched from surface ships or submarines, is built by Lockheed Aircraft Corp. Engines are solid-propellant rockets built by Aerojet-General Corp.

Convair-Astronautics Receives Work Assist

Convair-Pomona will give an assist of 50,000 hours of direct labor to Convair-Astronautics under terms of an inter-division work transfer agreement approved by the Air Force and Navy Bureau of Ordnance.

Pomona has nearly completed an earlier 75,000-hour engineering assist program begun last year for Astronautics Division.

Fast Tax Writeoffs Granted Missile Firms

Douglas Aircraft Co., Sacramento, has been granted a certificate of necessity for accelerated tax amortization for a missile test facility in the amount of $2,455,600 at 70% by the Office of Defense Mobilization.

Other fast writeoffs for the missile industry include:

Tele-Dynamics, Inc., Philadelphia, telemetering systems for guided missiles, $203,575 at 70%.

Lockheed Aircraft Corp., Sunnyvale, Calif., research and development, $927,188 at 60%.

Lockheed Aircraft Corp., Sunnyvale, Van Nuys, and Palo Alto, Calif., research and development, $713,049 at 65%.

The Martin Co., Jefferson County, Colo., missiles, $110,000 at 60%.

Aerojet-General Corp., Sacramento, research and development, $945,000 at 60%.

The Martin Co., Denver, guided missiles, $108,296 at 65%.

Kansas Plant to Produce Boron Chemicals

Callery Chemical Co. has begun construction of a $3 to $4 million plant at Lawrence, Kan., for production of boron specialty chemicals for commercial use.

The facility is slated to begin production early next year and will employ 150 persons. It will consist of 11 buildings and four chemical processing areas. The plant is slated for a 200-acre site two miles north of Lawrence.

Callery is owned jointly by Mine Safety Appliances Co. and Gulf Oil Corporation.

Litton to Build Factory At Salt Lake City

Litton Industries is planning a 60,000-sq. ft. plant at Salt Lake City for manufacture of magnetrons, klystrons and other microwave tubes. The plant, Litton's 11th, is expected to employ about 600 people. No completion date has been announced.

Olin-Mathieson Sales Up, Earnings Down

Olin-Mathieson Chemical Corp. reports first quarter sales of $135,479,249 and net income of $10,009,979 compared to $144,340,677 and $10,080,099 last year. Earnings per share amounted to 75¢ compared to 76¢ at the same time in 1956.

Radioplane to Become Division of Northrop

Radioplane Co. will become a division of Northrop Aircraft, Inc. later this year and the current subsidiary status will be dissolved. The name Radioplane will be retained.

Under divisional status, the vice president and general manager of Radioplane will have operational responsibility and authority. Whitley C. Collins, president of Northrop is also president of Radioplane.

Radioplane recently received a $6,631,765 contract for target drones and radio receiver selectors.

NAA Separates Missile Administration

North American Aviation, Inc., is separating manufacturing administration of its Missile Development Division from its Los Angeles Division in a series of steps to be completed by July 1.

The MDD organization will be headed by J. Y. Cunningham, general superintendent. Missile work at Los Angeles has consisted of tooling and sheet metal parts, machined parts, welding, assembly of large structural components on both SM-64 *Navaho* missile and booster.

R & D Costs at Temco Curtail Earnings

Temco Aircraft Corp. had sales of $27,226,605 for the first quarter of 1957 resulting in net earnings of $294,798. A year ago the figures were $19,621,602 and $644,847.

President Robert McCulloch said that the drop in earnings was because of costly research and development projects from which financial results have not yet been felt.

Among Temco development programs are the XKDT-1 rocket-powered missile target drone and the Navy *Corvus* missile.

Rocketdyne Engines Power Test Sleds

Liquid propellant rocket engines built by Rocketdyne division of North American Aviation, Inc., have accelerated 5,000-lb. test sleds to 900 mph in 4.2 sec.

The engines have been in use at Edwards and Holloman Air Force Bases for more than four years in connection with missile and aircraft development programs. They produce between 35,000 and 50,000 lbs. of thrust.

The Rocketdyne engine reaches 80% of full thrust in 1/10 sec. accelerating at 10 g's. One of the engines has been fired more than 120 times.

Rocketdyne describes the engines as nitrogen pressurized systems using propellant mixtures of alcohol and liquid oxygen. The propellants, pressurized at 3,000 psi, are introduced by high speed valves into the thrust chamber through an injector plate. Multiple holes in the plate, drilled at various angles, effectively mix fuel and oxidizer for the most efficient combustion combination. Mixture burns at about 4,700°F at full thrust.

The sled engine principle of operation is basically the same as larger liquid propulsion systems manufactured for long-range missile use.

Rocketdyne Sets Up Service Division

North American Aviation's Rocketdyne Division has set up a service division to speed up and simplify maintenance and supply for ballistic missiles.

Manager of the unit is J. A. Broadstone, former manager of Rocketdyne's propulsion field laboratory. Rocketdyne responsibility will include maintaining inventory of all parts through a warehouse system, operation of an overhaul and modification center, and the manufacture of spare and modified parts.

Army Seeks Money To Overhaul *Nikes*

Army has asked for funds to rebuild some 4,000 *Nike* missiles in fiscal 1958, according to House Appropriation Subcommittee testimony.

Corrosion and deterioration of parts from exposure and repeated testings were cited as reasons for the rebuilding. Some of the *Nikes*, Army revealed, have been in launchers for 20 months.

No costs have been mentioned.

Garrett Sales Up 33.5%

The Garrett Corp. reports a net profit of $3,563,651 from consolidated sales of $131,468,678 for the nine months ending March 31. Sales figures represent an increase of 33.5% over the same period last year. Current backlog is reported at $155 million, $50 million more than at same time in 1956.

Olin Mathieson Sales Down

Olin Mathieson Chemical Corp. reports first quarter sales in the U.S. and Canada of $135,479,249 and net income of $10,009,979. Year ago sales were $144,340,677, earnings were $10,080,099.

Boeing Vibrator Mount Aids *Bomarc* Testing

A vibrator mount which eliminates unwanted outside vibrations is being used at the Pilotless Aircraft Division of Boeing Airplane Co. in the testing of instruments used in the *Bomarc*.

The Boeing-developed tool consists of a 5,000-lb. concrete triangle which is suspended on six oppositely-wound coil springs inside a steel frame.

The vibrator is suspended in a large cup inside the triangle. The depressed housing of the vibrator places it at a point which is both the center of suspension and center of gravity. As a result, when the vibrator is pivoted to any degree between horizontal and vertical, gravity will not create a conflicting force upon the direction of the vibration.

The equipment is called a "Seismic Mount for a Vibration Calibrator." It virtually eliminates unwanted vibrations except those near and below 1½ cycles per second.

Vibrations varying from 2 to 2,000 cycles per second and attaining a force of 20 g's can be generated.

Converter Translates Computer Data

A bilingual electronic computer that "speaks" in both analog and digital terms is making faster, more flexible and more accurate calculations in Convair's *Atlas* ICBM performance study.

Analog and digital computers, essential tools of aircraft and missile designing, do not "speak" the same language. Analog systems, for example, express quantity by measurable physical characteristics such as voltage, rotation and resistance. Digital systems express quantity in exact numbers.

Analog computers are fast, but lack accuracy and flexibility. Digital computers are highly accurate and flexible but often are not fast enough.

Convair-Astronautics and Epsco, Inc., have succeeded in mating the two computing systems on a large scale. A $200,000 computer-converter called Addaverter converts problem data from analog to digital and digital to analog, thereby uniting the best features and decreasing the disadvantages.

To bridge the equipment with the Addaverter requires 7,700 lbs. of electronic materials housed in cabinets eight ft. high, 15 ft. long and two ft. deep. The Addaverter contains 2,000 vacuum tubes and about 4,500 germanium diodes. Its display panel contains nearly 600 flashing lights. It uses 15,000 watts.

Terrier Missiles Get Radar System

U. S. Navy's *Terrier* missiles are guided by long-range radar capable of scanning airspace many miles beyond the horizon, according to Sperry Gyroscope Co. which makes radar system.

The SPQ-5 radar can select individual targets from close-flying groups and track them for missile guidance and interception.

Now installed on the missile cruiser Canberra, the radar antennas resemble giant searchlights. The USS Boston is also *Terrier*-equipped and three other ships are being fitted—the *Topeka, Providence* and *Springfield.*

Sperry Piedmont Co., a Sperry facility, is producing the radar at Charlotteville, Va.

Elgin Watch to Build R & D Plant Near LA

Micronics Division of Elgin National Watch Co. will construct a research and development plant in the Los Angeles area to handle expanding west coast operations.

The 20,000-sq. ft. building will be at Canoga Park and occupancy is expected by September 1. Micronics is engaged in the development of high-precision missile and aircraft parts.

Aerojet Workers Get 7 Cent Wage Hike

Aerojet-General Corp. hourly employes received a 7¢ per hour wage increase effective May 13 in accordance with a two-year agreement negotiated a year ago with the International Association of Machinists.

At the same time the company announced a 3% general increase for salaried employes, effective May 16. The company had about 6,500 hourly and 3,300 salaried employes.

Hoffman Sales Increasing

Hoffman Electronics Corp. realized a first quarter net profit of $512,802 on sales of $11,493,599, compared to net of $467,994 and sales of $12,155,019 in same period last year. Company predicts 1957 sales and earnings 10% above 1956.

German Rocket Growth Slow But Sure

There is little rocket industry as yet in Germany but from numerous points there are indications that development is underway. One such organization, Bölkow Luftfahrtenwicklungen KG (Bölkow Aero Developments) have a Sam or anti-tank rocket in advanced stages of development. Bölkow, 42, of Stuttgart, is well acquainted with U.S. developments. Another organization becoming active is the Raketenfertigungs-GmbH (Rocket Assembling, Inc.) of Giessen.

From Munich it is learned that Mr. Richard Stangler, head of German Association of Aircraft Standard Parts Industry, Frankfurt, has formed a Verband der Raketenindustrie (Association of the Rocket Industry).

Ingots Produced From Compacted Sponge

Oregon Metallurgical Corp. is producing titanium and zirconium ingots and billets from compacted sponge, utilizing the technique of consumable electrode, arc melting under vacuum or inert gas in a water-cooled copper crucible.

Ingots are available as pure titanium, zirconium, or alloyed with chromium, manganese, tantalum, columbium, platinum or other alloy combinations.

North American Gets Options on Nevada Site

North American Aviation, Inc., has obtained options to purchase some 12,600 acres in Washoe County, Nev. The property is located 10 miles northeast of Reno.

The location is being considered among others for future development of manufacturing and test facilities, possibly in electromechanical and rocket fields, according to J. S. Smithson, vice president—administration.

Marquardt Sales Up

Marquardt Aircraft Co. reports sales of a 16-week period ending April 27 were $11 million, up 110% over the comparable period a year ago. Net profit for the period was $235,000.

Stockholders have approved an increase in company's stock from 300,000 to 1 million shares.

Aerojet gets JATO Order

Aerojet-General Corp. has received a $3.5 million contract from Navy Bureau of Ordnance for manufacture of JATO units and spare igniters. The solid-propellant perchlorate oxidizer units will be made at Sacramento.

Ryan Gets $4 Million For More *Firebees*

Ryan Aeronautical Co. has received a contract in excess of $4 million for a quantity of KDA-1 *Firebee* jet target drones for the Navy. The new order closely follows other *Firebee* contracts totaling $15,500,000 from the Air Force and Navy.

Orders for the drone missiles will require expanded production schedules well into 1958, according to president T. Claude Ryan.

Republic Quarter Sales Top $76 Million

Republic Aviation Corp. consolidated sales for the first quarter amounted to $76,645,222 and net income stood at $1,776,738 or $1.21 a share. This compares with figures of $81,798,731 sales and $2,129,663 or $1.45 a share earnings in the first quarter of 1956.

Republic's backlog March 31 was $177 million and contracts being negotiated at that time were valued at an additional $371 million.

ARDC Opens Office In San Francisco Area

Air Research and Development Command has opened a new development field office in the San Francisco Bay area to provide a close link with private research institutions and industries in the region.

The office is temporarily located at Moffett Field but the permanent location will be in or near Palo Alto. In charge is Capt. Otis R. Hill, formerly of ARDC headquarters, Baltimore.

Siegler Gets Contracts For *Atlas, Titan* Gear

The Siegler Corp.'s Hallamore Electronics Division has received a contract of more than $9 million for engineering and production of a high-priority guided missile program.

The contract reportedly is for electronic test and check-out equipment for the Martin *Titan*. Earlier Siegler received a $4 million contract for similar test and check-out gear for Convair's *Atlas*.

Speakers at Southern Research Institute's recent Space Flight Symposium included: Erik Bergaust, Exec. Ed., m/r; Dr. Ernst Stuhlinger, ABMA; Dan A. Kimball, pres., Aerojet-General; F. L. LaQue, v.p., International Nickel Co.; Gen. D. C. Ogle, AF Surgeon General; Dr. J. P. Hagen, Project Vanguard Chief; Dr. C. C. Furnas, former Assistant Defense Secretary.

KERR

James R. Kerr has been appointed president of Lycoming Div., Avco Mfg. Corp. His current assignment is head of Avco's Office of Defense Planning.

Joseph F. Caslin has joined the Associated Missile Products Corporation as staff assistant to the gen. mgr. Prior to this appointment he was head of the guided missile ground support equipment div. of the Turbo Div., American Machine and Foundry Co.

Dr. J. Victor Hughes has joined the scientific research staff of Republic Aviation Corp. as an associate scientist. He was director of the general physics laboratory of Continental Can Co.

Kenneth B. Boothe has been named director of sales for Kahn Research Laboratories.

Robert N. Himmel and **R. Kenneth Davis** will staff the new Semiconductor-Components division marketing office of Texas Instruments at Camden, N.J.

Gene Lowe has been appointed vice president—manufacturing at the Benson-Lehner Corp.

Leroy W. Collins, formerly with International Latex Corp., has been appointed personnel mgr. of the Mechatrol Div. of Servomechanisms, Inc.

Harold W. Gear of Magnavox Corp. has joined the Chemistry Div. of the Atlantic Research Corp., Alexandria, Va., as processing supervisor of solid propellant rocket fuel charges. **Howard H. Niederman** has joined the Western Div. of Atlantic Research as consultant in solid propellant rocketry and chemical engineering.

Samuel M. Kinney, Jr., has been elected secretary of Daystrom, Inc., Roy Sandquist has been elected treasurer, and Robert R. Whelan, asst. secretary.

Col. John P. Gibbons of the Air Materiel Command will be the Air Force plant representative for The Martin Co.'s Guided Missiles Division at Denver.

J. Russell Clark has been promoted from asst. chief engineer—aircraft projects to chief engineer—aircraft, and Samuel O. Perry from asst. chief engineer—missile projects to chief engineer—missiles at Chance Vought Aircraft, Inc.

TERRY

Philip D. Terry, formerly an aircraft field engineer with the Los Angeles Valve and Pump Co., has been named field engineer in charge of missile equipment and systems for Wm. R. Whittaker Co., Ltd.

Oscar T. Simpson has been named gen. mgr. of the new Western Development Laboratories of Philco Corp.'s Government and Industrial Div., at Redwood City, Calif. **Dr. Walter LaBerge** has been named mgr. of systems engineering. **Donald H. Clague** is business mgr.

MERRILL

Howard W. Merrill, director of operations at the Martin Baltimore Div., has been named a vice president of the company and gen. mgr. at Baltimore, succeeding **William B. Bergen** who remains executive vice president.

Robert L. Trent has joined Texas Instruments Inc. to direct a new engineering branch for applications and test equipment in the Semiconductor-Components Div. **R. J. Hanschen** has been appointed Mid-America region sales mgr. for the division.

Reaction Motors' Robertson Younquist, Tiokol's H. W. Ritchey and Douglas' R. B. Canright talk it over at recent French Lick, Ind., meeting of the Commercial Chemical Development Assn.

missile literature

ELECTRONIC EQUIPMENT RACKS. Illustrated 4-page brochure describes aluminum racks designed to accommodate standard RETMA panels of mobile electronic equipment. Craig Systems, Inc.

Circle No. 100 on Subscriber Service Card.

SHAFT ANGLE CONVERTERS. Instrument which converts rotary motion into coded system of numbers described in 4-page brochure. Specifications, drawings, other data presented. Instrument Development Laboratories, Inc.

Circle No. 101 on Subscriber Service Card.

TESTING FACILITIES. Environmental, metallurgical, chemical and quality control testing facilities outlined in 24-page brochure. Burgoyne Testing Laboratories, Inc.

Circle No. 102 on Subscriber Service Card.

METAL CASES. Stock sizes and shapes of instrument cases for special requirements of humidity, pressure, corrosion and MIL specs available to designers given in 62-page catalog. Zero Manufacturing Co.

Circle No. 103 on Subscriber Service Card.

BREATHING UNIT. Data sheet describes unit to protect workers during missile and rocket fuel handling operations. Scott Aviation Corp.

Circle No. 104 on Subscriber Service Card.

MISSILE FACILITIES. Capabilities and facilities of Rocket and Guided Missile Division to handle applied research and engineering, mass production of missiles and components described in 20-page brochure. National Electric Products Corp.

Circle No. 105 on Subscriber Service Card.

STAINLESS STEEL DATA. Handy 32-page booklet has 20 tables including detailed data on stainless steel finder, corrosion resistance of various stainless steels, fabrication properties, weight tables. Allegheny Ludlum Steel Corp.

Circle No. 106 on Subscriber Service Card.

REINFORCED PLASTICS. Complete ranges of fiber glass fabrics and fibers, polyester and epoxy resins and catalysts covered in 14-page book. Two pages of property tables of polyester resins and fiber glass cloths included. Cadillac Plastic & Chemical Co.

Circle No. 107 on Subscriber Service Card.

SCREW-LOCKS. Comprehensive 8-page specification bulletin contains tables with thread sizes, insert numbers and sizes, complete information on drilling, tapping, gaging and installation. Heli-Coil Corp.

Circle No. 108 on Subscriber Service Card.

BATTERY CONNECTORS. Information on battery connectors, power connectors and heavy duty connectors for many applications contained in 32-page catalog. Cannon Electric Co.

Circle No. 109 on Subscriber Service Card.

HYDROFORMING. Complete service for forming prototypes and pre-production parts in missile and other industries outlined in 4-page pamphlet. C. B. Kaupp & Sons.

Circle No. 114 on Subscriber Service Card.

TURBINE FLOW METER. Device for precise measurement of liquid flow is detailed in 8-page catalog, giving missile and aircraft applications. Fischer & Porter Co.

Circle No. 115 on Subscriber Service Card.

TIME DELAY RELAYS, REPEAT CYCLE TIMERS. Two 2-page bulletins contains details on construction of three basic time delay relays in new extruded hermetic housings, and three basic miniature repeat cycle timers. A. W. Haydon Co.

Circle No. 116 on Subscriber Service Card.

COUPLINGS, MISSILE APPLICATIONS. Complete line of hydraulic couplings, military test results, sizes, advantages covered in 4-page brochure. Second 4-page booklet lists missile uses, describes types used in launching, fueling, electrical checkout, rigid fuel lines, monofuel exhaust line. E. B. Wiggins Oil Tool Co., Inc.

Circle No. 117 on Subscriber Service Card.

AUXILIARY POWER, COMPRESSOR, PNEUMATIC SYSTEMS. Two 12-page brochures outline operating and weight characteristics of compressors, pneumatic systems, auxiliary power systems for missiles or manned aircraft. Walter Kidde & Co., Inc.

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76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99

• • **Missile Literature**

100 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121 122 123 124 125

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