This Issue

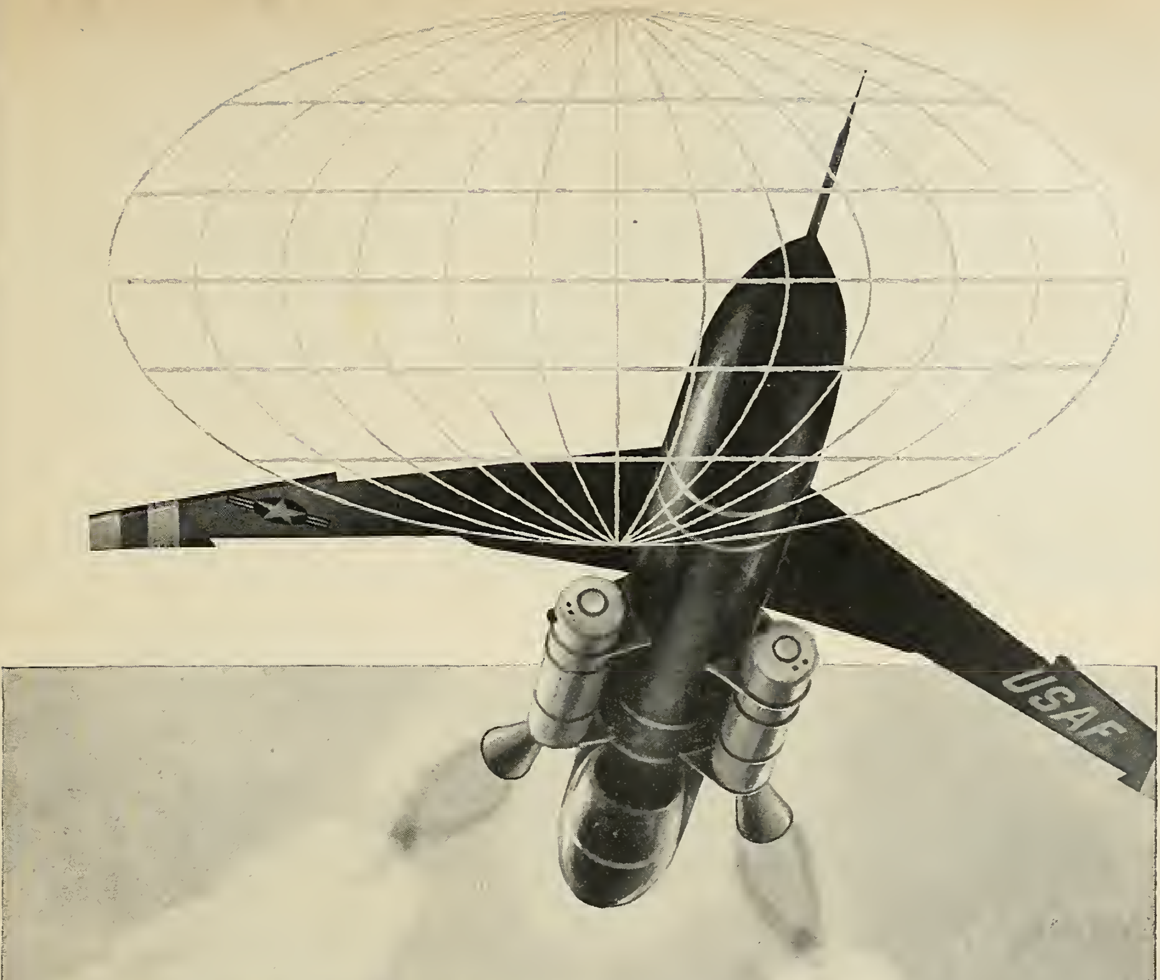
METALS AND MATERIALS

missiles and rockets

INCLUDING MISSILE ELECTRONICS

MAGAZINE OF WORLD ASTRONAUTICS

MARCH 1958



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missiles and rockets

Magazine of World Astronautics

March, 1958 Volume III, No. 3

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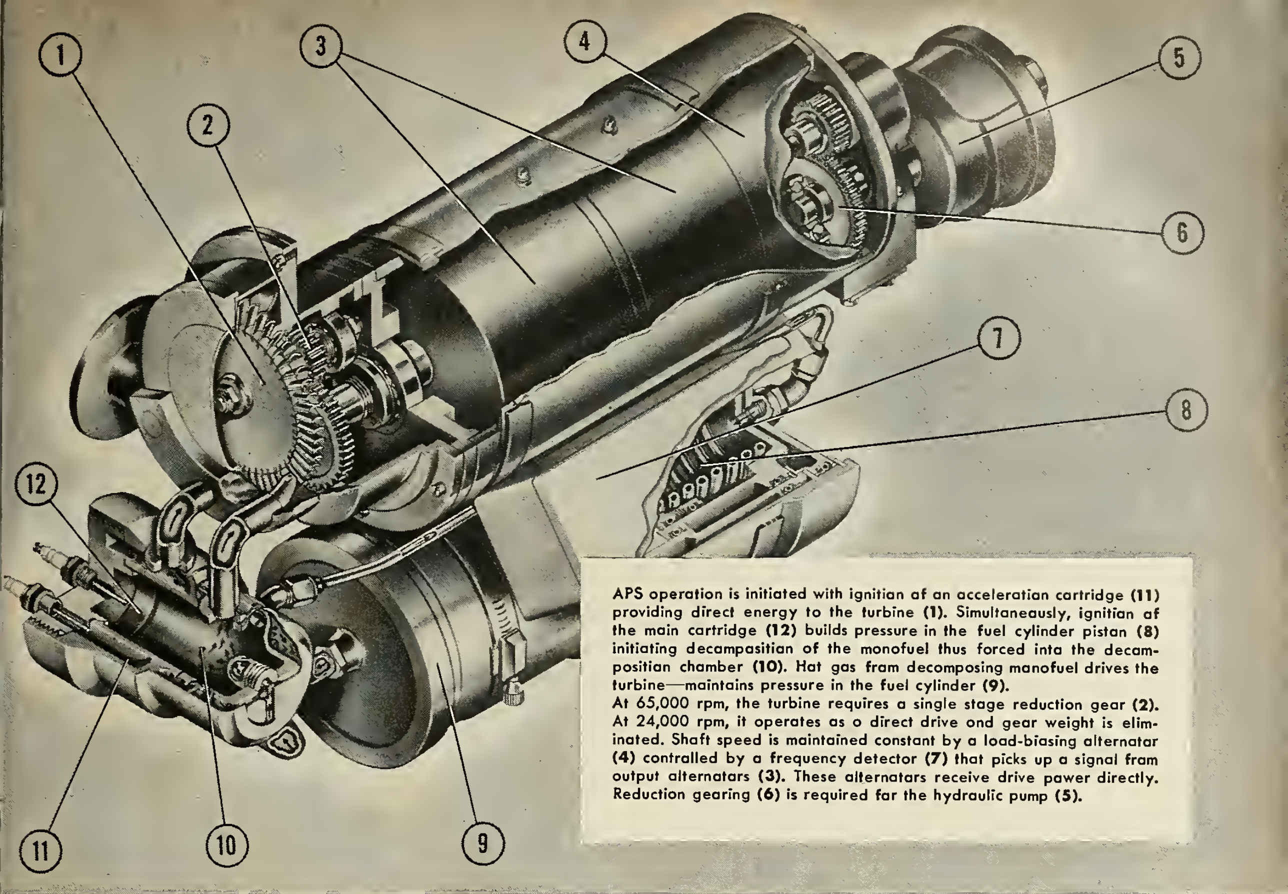

'HIS CUTAWAY SHOWS HOW . . .

Design Simplicity of Missile Accessory Power System Contributes to Light Weight and High Reliability

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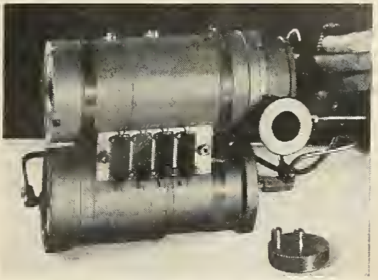

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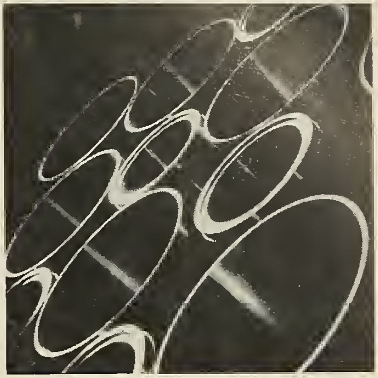


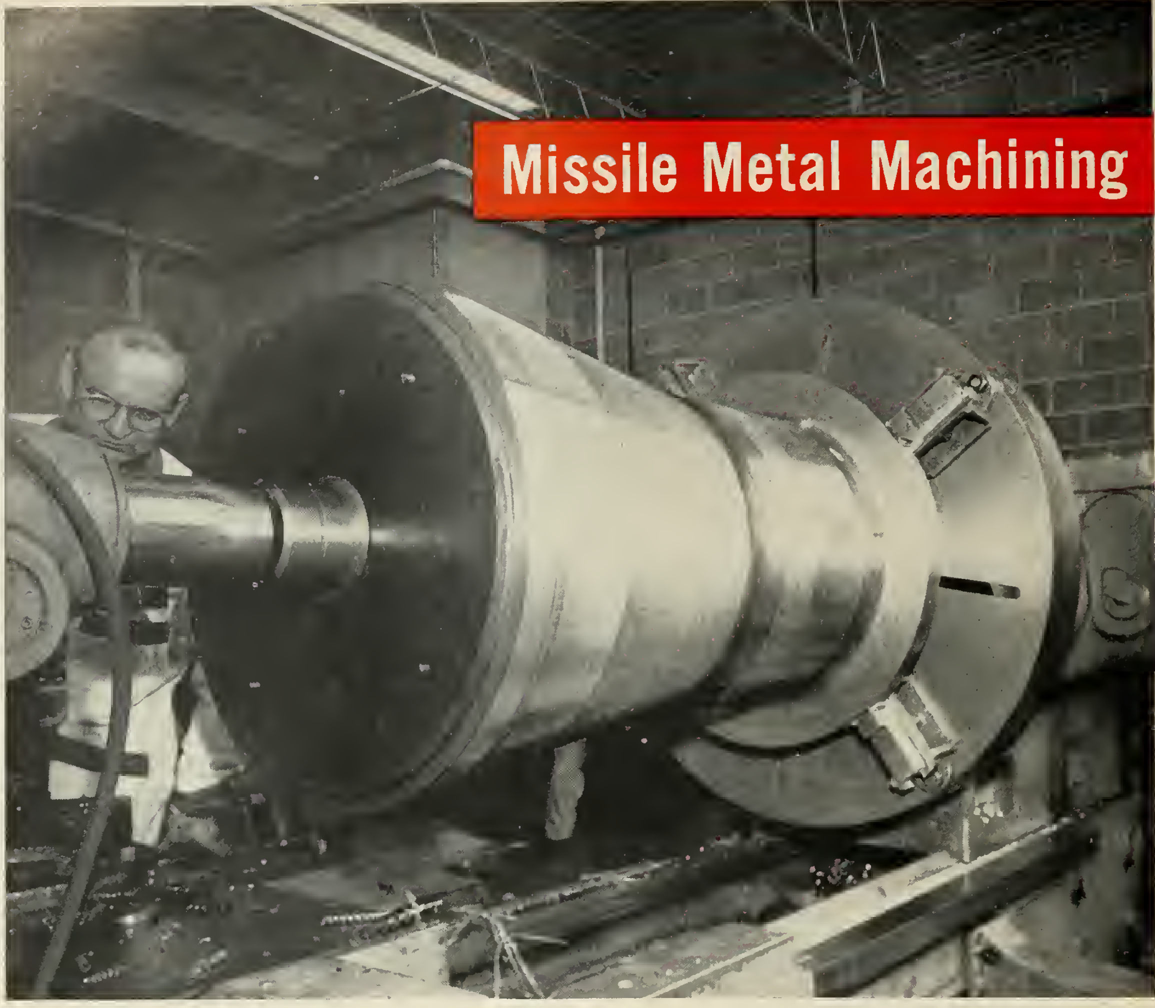
Pattern for tomorrow! Caught in the sunlight, these stacked Nike *nozzles were photographed by m/r Associate Editor Seabrook Hull at Diversey Engineering Co. in Chicago. They symbolize much that is peculiar to missiles. Starting as heavy steel forgings, they have been machined down to less than one-half of their original forged weight in just a few minutes. Other missile metals run the gamut from aluminum and titanium, through the stainless steels and on to nickel-cobalt alloys, columbium and molybdenum. It is missile materials such as these that this issue of m/r emphasizes.*

columns

departments

photo credits:

Air Force, p. 130; Army, pp. 38, 112, 113; Budd Co., pp. 104, 105; Dow Corning, p. 120; Goodyear, pp. 114, 116, 134; Navy, p. 39; Northrop, p. 42; Phillips, p. 138; Reynolds Metals, p. 72; Sperry, p. 188; US Chem. Mill., p. 130; US Steel, pp. 88, 89; Westinghouse, p. 73.



Big Nozzles for Big Rockets

Behind the tailstock you see a Diversey craftsman ready to take a cut that will trace the bottom flange and taper of the O.D. of the nozzle. As nozzles go, this one is big . . . real big. It is the nozzle for one of the large rocket motors.

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missiles and rockets

Magazine of World Astronautics

Why all the Hemming and Hawing?

Five months have passed since *Sputnik* I. Yet the United States still doesn't have a space flight program. Bureaucratic complacency continues to hamper our missile and rocket efforts.

The basic problem appears to be lack of leadership at the top. No high-ranking administration official has spelled out what this country will attempt in the fields of missiles and astronautics.

Perhaps the main problem is that our political leaders cannot yet visualize the implications, the rewards and the value of space flight. Furthermore, they are still arguing whether space flight should be conducted under civilian or military auspices. Undoubtedly, a full-fledged attempt to explore and conquer space must be considered as a joint scientific-military venture.

Numerous space flight proposals from individuals and from industry have been submitted to the three services. Even our Vice President has been pleading with the National Security Council to rush approval of a moon rocket. The Vice President has reviewed such plans with Douglas Aircraft scientists, who are building the *Thor* missile. The Air Force hopes to use the *Thor* as the first stage for a moon rocket. But no one has yet attempted to coordinate all these proposals. No one has been authorized to do so.

Let us keep in mind what the Russians think about astronautics. They are convinced that apart from its purely scientific interest, space travel probably will be of practical value, although at this stage, they say, it is difficult to specify in what way. They point to the fact that the planets and their satellites are an inexhaustible source of mineral wealth which must be studied and utilized for the well-being of mankind.

Red officials say the Soviets will build interplanetary stations and spaceships in order to uncover the secrets of the universe and extend the domain in which human reason reigns over the elements.

We do not recall ever having heard similar remarks from any Administration official in this country. The lack of enthusiasm has been discouraging, not only to the American people, but to the entire Free World. Our efforts have been small, aimless.

Interservice rivalry is worse than ever. It has been thrown wide open again by Missile Czar William Holaday. All three services have been invited by Holaday to submit their missile proposals. This invitation automatically cancels past agreements to divide up missile development.

As a result, the Army has submitted plans to build an intercontinental ballistic missile, in direct competition with the Air Force's 5000-mile *Atlas* and *Titan* missiles. The invitation immediately spurred the Air Force to submit a proposal to build another ICBM—a solid-propellant vehicle to replace the programmed *Atlas* and *Titan*.

The ironic symbol of complacency in our bewildered astronautics efforts is the also-ran success of the Army-launched *Explorer* satellite. This belated achievement was proof that we could have launched a satellite a long time ago. Unquestionably, we have the technological capability to launch other, more sophisticated space vehicles.

What are we waiting for? The Administration must take the blame for the lack of planning and the failure to get a national space flight program off the ground. If we wait much longer the result could be fatal to us as a nation.

ERIK BERGAUST

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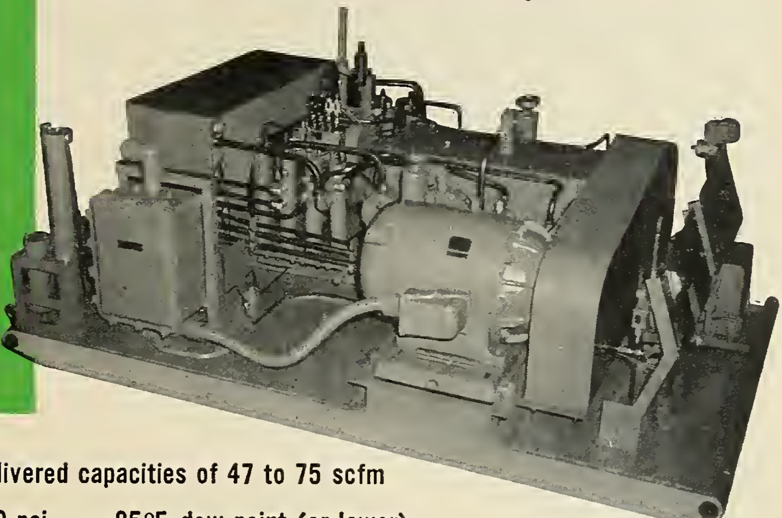

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MARCH

1958 Nuclear Congress and **Atomic Industry Trade Show**, International Amphitheater, Chicago, Ill., March 16-22.

ARS-ASME Joint Aviation Conference, Dallas, Tex., March 17-20.

First Interservice and Industry Symposium on Guided Missiles Training Equipment (limited to those with secret clearance), Naval Ordnance Laboratory, Silver Spring, Md., March 18-19.

USAF Cambridge Research Center, Conference on Extremely High Temperatures (over 30,000°K), L. G. Hanscom Field, Bedford, Mass., March 18-19.

IRE, National Convention and Radio Engineering Show, Waldorf-Astoria Hotel, New York Coliseum, New York, N.Y., March 24-27.

AFOSR 2nd Annual Astronautics Symposium, Shirley Savoy Hotel, Denver, Colo., April 28-30.

APRIL

ASME Division of Instruments and Regulators Conference, University of Delaware, Newark, Del., April 1-3.

Eighth International Symposium, Electronic Wave Guides, sponsored by Microwave Research Institute of Brooklyn Polytechnic Institute, Engineering Societies Building, New York, N.Y., April 8-10.

ASME Maintenance and Plant Engineering Conference, Penn-Sheraton Hotel, Pittsburgh, Pa., April 14-15.

ASME Design Engineering Conference, International Amphitheater, Chicago, Ill., April 14-17.

ASME and AWS Engineering Division Joint Conference, Statler Hotel, St. Louis, Mo., April 15-17.

Institute of Environmental Engineers, Second Annual Technical Meeting, Hotel New Yorker, New York, N.Y., April 17-20.

AIEE, IRE, EIA, WCEMA Electronic Components Conference, Reliable Application of Component Parts, Ambassador Hotel, Los Angeles, Calif., April 22-24.

MAY

American Society of Tool Engineers, Second Annual Technical Meeting, New York, N.Y., May 1-8.

National Flight Test Instrumentation Symposium, Instrument Society of America, Park Sheraton Hotel, New York, N.Y., May 4-7.

Professional Group on Microwave Theory and Techniques, National Symposium, Stanford University, Palo Alto, Calif., May 5-7.

IRE, ACM, AIEE, Western Joint Computer Conference, Los Angeles, May 6-9.

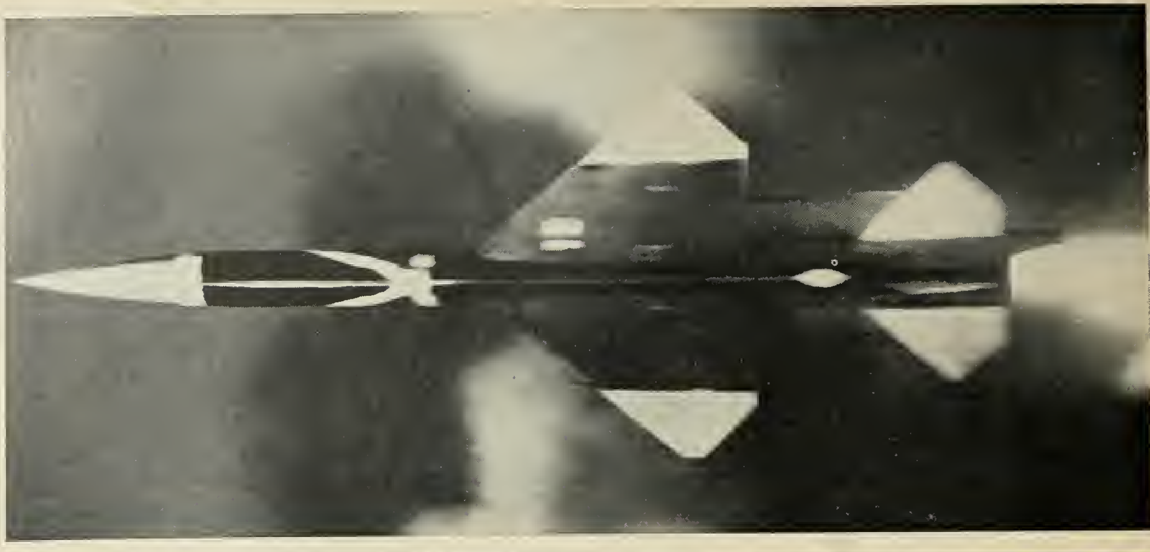
Armed Forces Day "Open House" at most U.S. Military Bases. Observances May 10 thru May 18 in various cities.

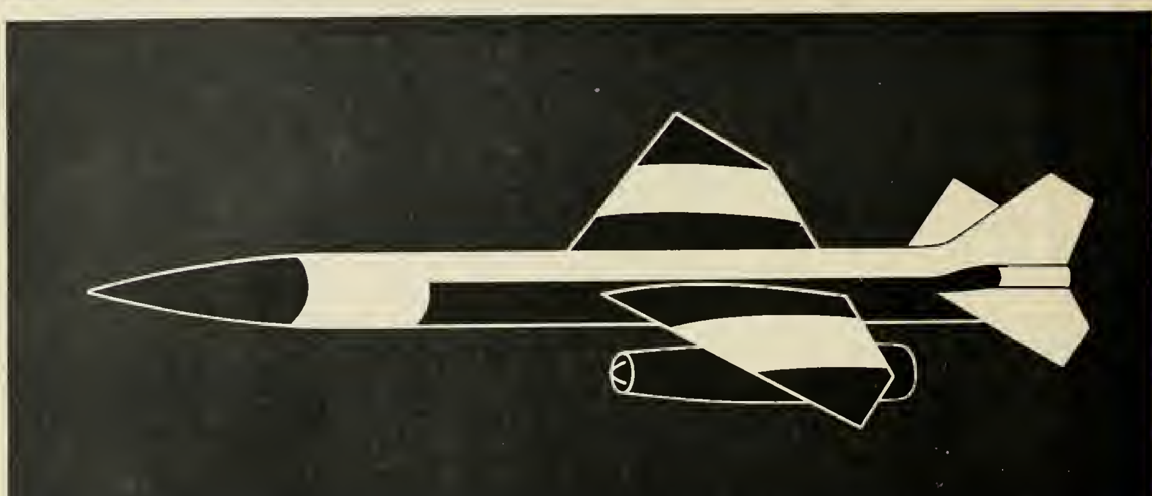
JUNE

IAS, AIEE, ISA, National Telemetering Conference, Lord Baltimore Hotel, Baltimore, Md., June 2-4.

IRE Second National Symposium on Production Techniques, Hotel New Yorker, New York, N.Y., June 5-6.

American Rocket Society, Semiannual Meeting, Hotel Statler, Los Angeles, Calif., June 8-11.





White areas show extensive use of magnesium, (see details below).

HOW ELEVATED-TEMPERATURE MAGNESIUM ALLOYS HELP BOMARC KEEP FIGHTING WEIGHT

Approximately 230 lbs. of magnesium is used in the airframe of the Bomarc, powerful surface-to-air missile. And for good reason: In each case, the specific application called for light weight and retention of strength, rigidity and other properties at elevated temperatures. The logical choice was sheet, extrusions or castings of elevated-temperature magnesium alloys.

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WING, FIN AND TAIL. 111 lbs. of HK31A sheet were used in the wing, elevators and elevator stubs, fin and rudder. All leading and trailing edges of control surfaces for wings and fin are HM31XA extrusions. Here another 8 lbs. were saved by using an elevated-temperature magnesium alloy.

These are but a few instances of how precious weight was saved in the Bomarc. For more information about the use of magnesium alloys in aircraft, rockets and missiles, contact the nearest Dow sales office or write directly to us. THE DOW CHEMICAL COMPANY, Midland, Michigan, Department MA 1407L.

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**For details, contact Greer sales manager, test equipment division.*

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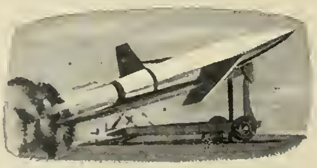

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letters

Credit to ABMA

To the Editor:

We were very pleased with the inclusion of the John Jagy article in your February issue. However, probably due to editorial space you condensed the introduction of the article and thereby made an error which I feel should be corrected.

In the introduction of the article as we sent it to you, we pointed out that the air bearing gyro was developed by the Army Ballistic Missile Agency. In your condensation of the introduction you left this information out and consequently gave the impression that we are claiming to have developed this very unusual instrument.

I feel that it would be only right for you to carry a correction . . . to give full credit to the Army Ballistic Missile Agency for their work and particularly to Dr. Walter Haeusserman, Mr Fritz Mueller, Mr. Henry Rothe and Mr. Wilhelm Angele, who headed up this splendid work.

I am sure that it is your intention to give full credit where credit is due to all who are responsible for making valuable contributions to America's missile effort.

S. H. McAloney
Director of Public Relations
Ford Instrument Co.
Div. Sperry Rand Corp.
31-10 Thomson Ave.
Long Island City 1, N.Y.

Done.—Ed.

Wise Men

To the Editor:

Your editorial in your December issue, "Let's Listen to the Wise Men," stated that: "Reports were written by Dr. Louis Ridenour urging a divorcement of research from engineering management." I would appreciate it very much if your office could send me complete reference to these reports. They should have application in management of R&D on range instrumentation.

Dr. Fred Hanson
Scientific Advisor
Integrated Range Mission Staff
White Sands Proving Ground
P. O. Box 3
Mesilla Park, N.M.

Contact the Command Historian, ARDC, Andrews AFB, for copies of reports by the Ridenour Committee, which led to the establishment of ARDC.—Ed.

Space-for-Peace Plan

To the Editor:

In a recent issue of m/r you mentioned my proposal for an International Astrophysical Decade. Since the date and place of submission of this proposal was not mentioned, I wish to add this information here, together with a few comments.

The proposal was part of a paper entitled "Instrumented Comets—Astronautics of Solar and Planetary Probes." It dealt with the analysis of lunar and heliocentric probes, their flight profiles, characteristics and mission assignments.

The paper was presented at the Eighth International Astronautical Congress in Barcelona, October 1957, and was submitted to the International Papers Committee long before the first Russian satellite appeared in the sky. In studying the practical and organizational problems of inner solar-systems research by artificial comets and its remoteness from immediate military significance, it appears to me that an international effort is the most attractive approach, similar to the IGY in spirit and purpose, but to be extended over a longer period of time in view of the duration of the missions and the cost of the experiments involved.

I also see in such a project a unique opportunity for astronautics to foster international cooperation and gradual development of a planetary perspective in the international public, a feeling which must become the foundation of future space operations if they are to be peaceful and constructive.

In my opinion, the Russian Government—much as it has exploited propagandistically its great achievement—has missed here a historically unique opportunity of genuine service to mankind—namely, to invite international astronautic cooperation of the type of the International Astrophysical Decade or comparable projects, because I am convinced that this is what most people on this earth would really welcome.

Instead, the Russian Government has called for a "race into space." The adjective "peaceful" was used by Mr. Khrushchev. However, the dangerous implication of the "race" concept is that in a race the partners *compete* rather than *cooperate*. Although noble competition is most desirable, it is, in view of

ONE-PIECE WELDED CONE FOR THE HOT SPOT

This is the vital nozzle cone of the Martin Mace guided missile. American Welding was able to form it in one piece from ¾-inch plate (FS-1020) and arc weld the joint to produce a tapered cone with a major diameter of 25 inches and a minor diameter of 15 inches. After heat treating and X-ray testing, it proved to be better and more economical than nozzle cones produced by the previous method of forming in two halves.

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the existing international situation at least, unrealistic to assume that such important competition will stay in the realm of peaceful manifestations only.

Therefore, a call for international cooperation in the coming series of giant cosmic experiments is the only realistic approach if one really aims at peaceful execution of space exploration. We do not want to fire ballistic missiles across space, but forerunners of manned spaceships. Russia's lead will be short-lived—*sub specie aeternitatis*—and their leaders must realize this. Their opportunity for leading the world in astronautics, in a higher sense than purely mechanically, is gone forever. Our great opportunity is still ahead of us. Will we use it? I herewith renew my call—now post-*Sputnik*—for an International Astrophysical Decade.

Krafft A. Ehricke
Convair-Astronautics
San Diego, Calif.

Jupiter Cover

To the Editor:

I have just received my December copy of m/r and I think that the cover showing the *Jupiter* taking off is one of the outstanding photos you have yet published. Do you think it would be possible for me to obtain a copy of this cover for I should very much like to have one for mounting. I have been taking m/r for 12 months now, and I am certain that it is the best publication of its kind available. Keep up the good work.

L. Sykes
Melrose
Staynall Lane
Hambleton, Nr. Blackpool Lanc.
England

In the mail.—Ed.

Definition

To the Editor:

In regard to your article "Roundup of Surface Equipment Contractors" in the January issue of m/r, you give mention to GFE in transport vehicles and fuel equipment. I have been unsuccessful in finding the identification of the letters GFE and would appreciate your definition of them.

Leon S. Trenholm
RFD No. 1
Bangor, Missouri

Government Furnished Equipment.—Ed.

Bids Too Soon

To the Editor:

From Dec. 16, 1957 through Jan. 7, 1958, I worked on one of the new *Bomarc* launching installations, part of a $46,000,000 project recently announced by the Air Force. I was present at the opening of the bids on the first installation, to be located at the McGuire Air Force Base near Wrightstown, N.J., in Philadelphia on Jan. 7, 1958.

When I got back to Houston, the January issue of m/r was lying on my desk. It was devoted to "Ground Support Equipment," including, on page 78 and 108, concise, authentic information on the very problem I had been working on—*Bomarc* missile. Had I had this information one month sooner, it would have been extremely helpful.

As part of my avocation and activities in rocketry, I make numerous illustrated speeches and lectures to engineering, civic and social groups. At these meetings, I am invariably asked, "How can we find out about this business of rockets, missiles and *Sputniks*?"—and I tell them two things: subscribe to MISSILES AND ROCKETS, and join the American Rocket Society.

Lawrence F. Megow
3342 Arbor Ave.
Houston, Texas

Hamilton Standard Engaged in Electronics

To the Editor:

In view of the overall excellence of your magazine, it was quite surprising to find that your listing of companies engaged in electronic and missile activity failed to mention us (page 76, Feb. issue).

Hamilton Standard division of United Aircraft Corp. has been engaged in the design, development, testing and production of electronic controls since 1944. Today, the Electronics Department is established as a virtually autonomous unit at Broad Brook, Conn., to concentrate on the design and development of total weapons systems and airborne electronic systems for both aircraft and missiles. Except for missing us, I think that you have a most excellent magazine, and in this I echo the sentiments of all our technical staff. Keep up the good work.

Roy E. Wendell
Public Relations
Electronics Department
Hamilton Standard Div.
United Aircraft Corp.
Broad Brook, Conn.

Sorry. Hope this takes care of the omission.—Ed.

Standardizing Terms Needed

To the Editor:

First of all, I would like to express appreciation of the fine coverage of the field from A to Z. I am a charter subscriber and have a complete file of m/r, to which I frequently refer.

In a recent issue of m/r, Mr. Arthur F. Joy of Raytheon Manufacturing Co. inquired as to the difference between a ballistic missile and manned and unmanned rockets and missiles, spaceships, and guided and unguided missiles and rockets.

I would like to recommend to Mr. Joy and others interested in these terms, the U.S. Air Force Dictionary published in 1956 by the Air University Press, Woodford Agee Heflin, editor. I am employed as an engineering publications editor, Service Publications, Convair (Fort Worth), home of the B-58 *Hustler*. This dictionary is used as first authority for the words it defines.

A dictionary of aeronautical and astronautical words and terms that is frequently brought up to date will find a very useful place in the industry.

C. Roger Cripliver
4928 Rector Ave.
Fort Worth 15, Tex.

Fine idea. Perhaps this should be undertaken by the IAS or ARS.—Ed.

What's new in TITANIUM alloys:

Advances in aviation technology have happened so swiftly that engineering materials can no longer be selected for their broad use, but rather for the specific tasks they perform.

Today, in the face of tight budgets, the *right* material is the only sound solution to any given problem. Patch-work design, engendered by second-best materials, can only result in second-best aircraft and missiles in uniquely critical times.

To meet the constant tightening of design requirements, Titanium Metals Corporation of America has opened wide new areas of alloy development. This means: heat-treatable bar stock with *guaranteed* capabilities; higher temperature ceilings; broad new strength ranges.

Q. Are the guaranteed heat-treat alloys new?

A. The alloys are not. They have a production history of four years and a wealth of technical data to support them. Recent development of their full heat-treat capabilities has produced such dramatic results that they are considered new.

Q. What are the heat-treat alloys?

A. Ti-155A (5.5% aluminum; 1.5% iron; 1.5% chromium; 1.1% molybdenum) the highest strength bar and forging stock commercially available; and Ti-6A1-4V (6% aluminum; 4% vanadium), which in the annealed condition has already won wide designer confidence. Samples of *guaranteed* minimum heat-treat capabilities show:

Section size: Up to 1"	Ti-155A	Ti-6Al-4V
Ultimate Tensile Strength (psi)	170,000	160,000
0.2% Yield Strength (psi)	155,000	150,000
Elongation, % in 4D (Long)	10	10
(Trans)	8	8
Reduction in Area, % (Long)	20	25
(Trans)	15	20

Detailed information on Ti-155A is presented in a 20-page TMCA Engineering Bulletin. Additional data on Ti-6A1-4V, such as fatigue characteristics and guaranteed heat-treat capability are also available.

Q. Are there other new alloys?

A. The leading alloys nearing commercial volume are Ti-8A1-1Mo-1V, a bar stock offering excellent elevated-temperature creep strength to 1000°F, and Ti-4A1-3Mo-1V. The latter, now being produced and evaluated by the Department of Defense sheet rolling program, is designed to fill the need for high strength sheet alloy which can be formed in solution-treated condition and aged to strengths of 175,000 psi. When compared to other high-strength titanium alloys, Ti-4Al-3Mo-1V combines improved formability with outstanding elevated-temperature strength and stability.

Typical Properties — Ti-4Al-3Mo-1V

Condition	Temp. °F	0.2% YS psi	TS psi	Elong. % in 2"
Solution treated	Room	94,000	135,000	14
Solution treated and aged	Room	163,000	175,000	5
	200	142,000	169,000	8
	400	126,000	152,000	8
	600	111,000	140,000	7
	800	98,000	127,000	9

Q. How will these alloys raise temperature limits?

A. Ti-8Al-1Mo-1V is a good example. Although its short-time elevated temperature tensile properties are similar to Ti-6A1-4V, this new alloy offers as much as a tenfold increase in creep strength between 600°F and 1000°F, as shown:

Creep Comparison Between Ti-8Al-1Mo-1V and Ti-6Al-4V

Alloy	Annealing Treatment	Temp (°F)	Stress (psi)	Time (Hrs.)	Def. (%)
Ti-8Al-1Mo-1V	1400°F (24 hrs) AC	850	50,000	300	0.42
Ti-6Al-4V	1300°F (2 hrs) AC	850	50,000	300	3.6
Ti-8Al-1Mo-1V	1400°F (24 hrs) AC	950	15,000	300	0.16
Ti-6Al-4V	1300°F (2 hrs) AC	950	15,000	300	4.3

Now being evaluated by engine manufacturers, Ti-8A1-1Mo-1V appears to answer the need for light-weight strength at steadily higher temperatures. Data on both Ti-4A1-3Mo-1V and Ti-8A1-1Mo-1V alloy are available from TMCA.

All these excellent new alloys have boosted still higher titanium's major advantages of light weight, great strength, superior temperature characteristics, and outstanding corrosion resistance.

To guarantee ready availability of this important engineering metal, TMCA has opened in Toronto, Ohio, the world's first plant designed and instrumented solely for rolling and forging titanium to aircraft quality standards.

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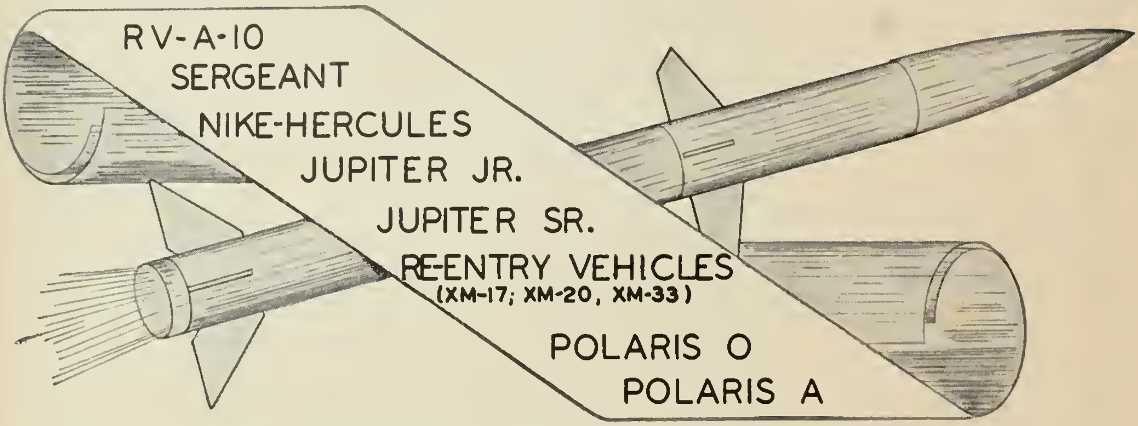

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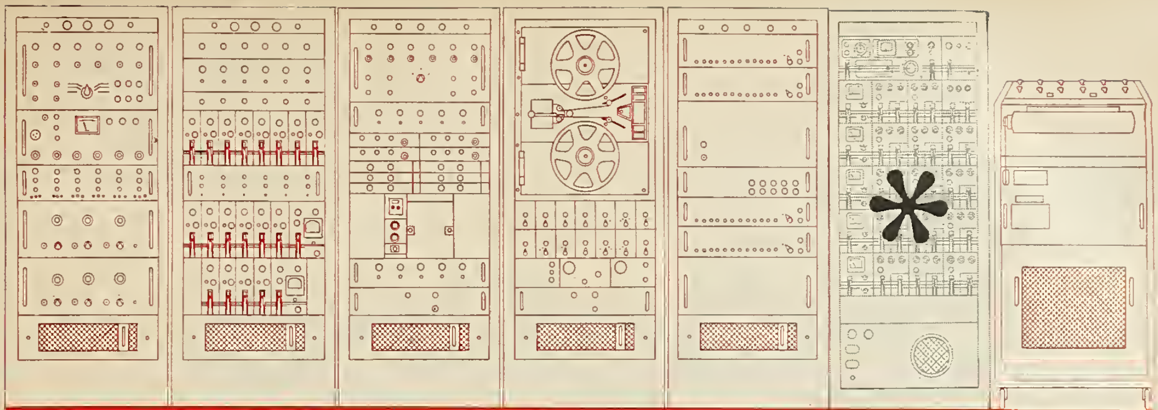

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Range	00.D1 ohms to 10 megohms	D00.01 ohms to 10 megohms
Aotomatic Features	Ranging	Ranging
Controls	Digits gain, manual and automatic ranging, power on-off-standby	Digits gain, manual and automatic ranging, power on-off-standby

For accuracy specifications see Bulletin 180.3

Write for Bulletins 180.1, 180.3

AC RATIOMETERS

Specifications	Model DRA-480	Model DRA-490
Display	5 digits	5 digits
Ratio Range	0.0000-1.0999	0.0000-1.0999
Accuracy*	±2 digits	±2 digits
Controls	Digits gain, power on-off-standby	Digits gain, power on-off-standby, reference selector
External Reference	1 volt rms	Choice of 3

*Calibration at 400 cycles; 60 cycle models also available.

Write for Bulletin 180.9

DC RATIOMETERS

Specifications	Model ORC-400	Model ORC-500	Model DVC-400†
Oisplay	4 digits	5 digits	4 digits, polarity
Ratio Range*	.0000-.9999	.00000-.99999	D0.D1-99.99 volts
Accoracy	±1 digit	±(0.01% and 1 digit)	±1 digit
Controls	Digits gain, power on-off-standby	Digits gain, power on-off-standby	Digits gain, power on-off-standby
External Reference**	1 to 10 volts	10 to 100 volts	±100 volts

*Models ORA-400L and DRA-500L, 10% overscale read out. For higher ratio ranges, see Bulletin 180.7.

†Recommended for computer applications.

**Internal reference supply optional; specify DRA in place of DRC.

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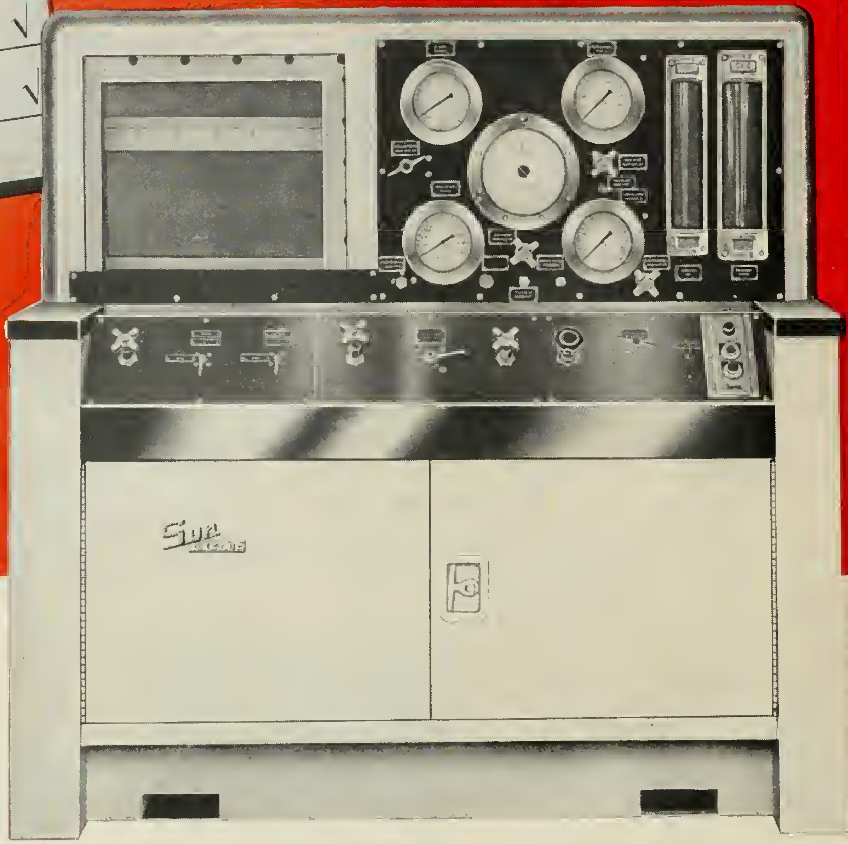

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Purpose	Hydraulic Components Tester
Dynamic Hydraulic System	Remote supply, delivers 5 gpm at 3000 psi
Static Hydraulic System	Remote supply, delivers 1 gpm at 100 psi boosted to 20,000 psi by air-operated boost pump
Pneumatic System	100 psi
Controls and Instrumentation	Circuit controls, pressure gages and flowmeters. Illuminated instrument and Control panel recessed and angled for easy viewing and operation

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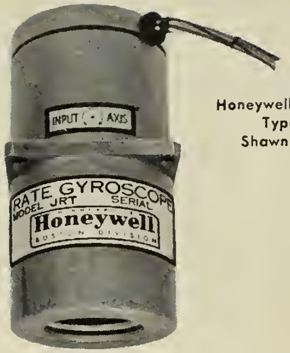

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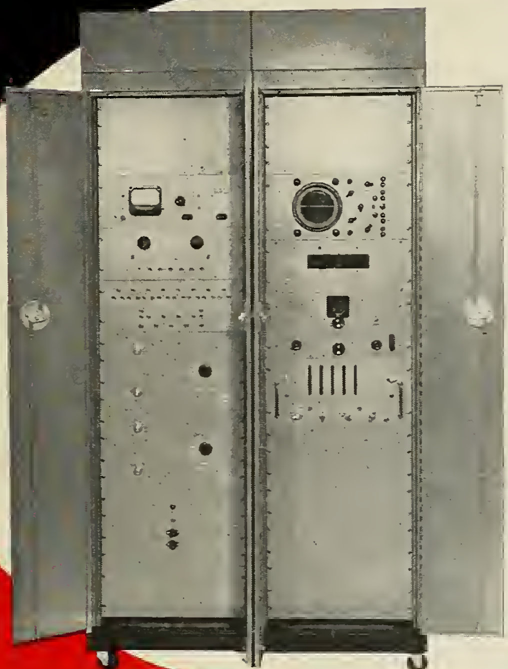

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PAUL D. CASTENHOLZ, Pacific combat veteran, graduated B.Sc. (Eng.), UCLA 1949. From research engineer his grasp of rocket engine work raised him through a supervisory post in experimental development to assistant group leader in combustion devices, and then to group leader of experimental engines. Recently completed requirements for his MSc. Relaxes with hi-fi, fishing and back packing.

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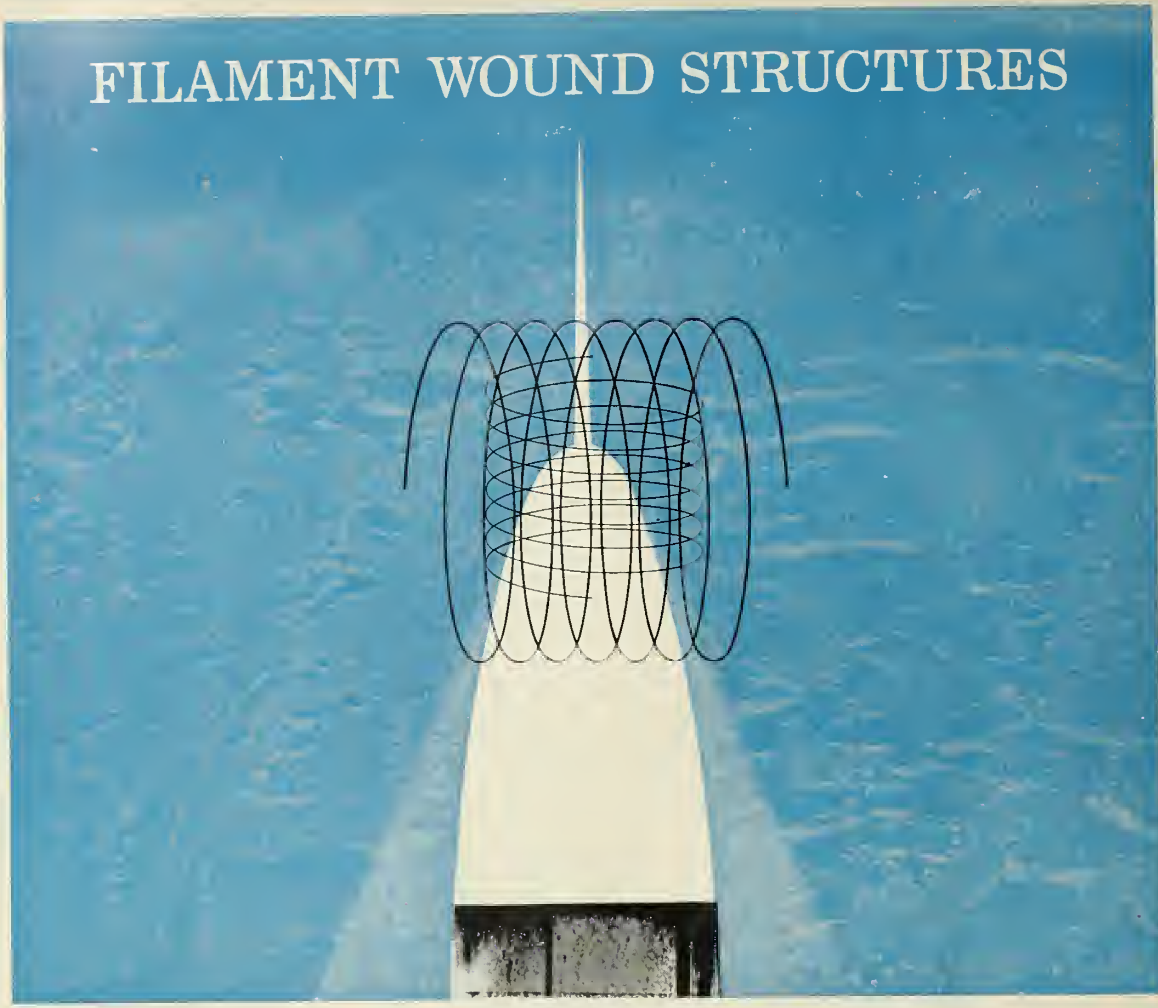

FILAMENT WOUND STRUCTURES

U.S. To Launch Nine Satellites By 1959

Army gets approval for five more *Explorers*; *Vanguard* 'grapefruit' still bogged down

by Erik Bergaust

The Army has been authorized to send aloft another five Explorers, but this venture is not scheduled as part of any national space flight program. At the end of February no steps had been taken in Washington to finalize a space flight agency. MISSILES & ROCKETS questioned a number of the nation's top missile experts as to whether they had been invited or approached by the Defense Department for participation in a national space flight program. The answer was negative in every instance.

Frustrated Washington missile officials have expressed the hope that the United States will launch successfully nine satellites by 1959. Explorer II is scheduled to be fired this month. The Vanguard grapefruit carrier, after having been bogged down in technical complexities, was set for another try as m/r went to press. The International Geophysical Year already is nine months old.

In secret testimony before the House Appropriations Committee last month U.S. satellite officials learned that the United States has gained much information from the two *Sputniks*. In fact, the U.S. IGY Committee appeared to have used this argument as a stepping stone to get more money "to expand their studies." Hugh Odishaw, executive secretary of the U.S. IGY program indicated the American scientists gained information from the *Sputniks* without any aid from the Reds. The request for an additional $2,100,-000 in "emergency funds" was made.

On the other hand the U.S. IGY committee last month stated that none of the information offered by the Russians on the first two *Sputniks* was new. The first official Red report does not contain any of the measurements made by instruments in the satellites. It lists only the type of measurements made, the equipment carried and orbit data from the ground tracking stations.

Data from *Sputnik* I will not be available before June and data from *Sputnik* II not before July.

The report was sent by the USSR on January 27 and received at the IGY headquarters in Brussels on February 11.

Orbit velocities and altitudes corresponded with those reported by tracking stations in the United States.

The five satellites scheduled for launching by the Army this year will be put into orbit by the *Jupiter*-C vehicle.

Explorer II will incorporate a tape recorder, allowing storage of information until it passes over a ground receiving station, at which point the stored data will be transmitted to earth.

As m/r went to press, there were reports in Washington that a 500-pound satellite would soon be launched by the Army, using a *Jupiter* IRBM as the first stage.

Red Moon Rocket on Launching Pad?

European scientists who visited the USSR recently confirmed to m/r that the Reds are pushing hard to launch their first moon rocket. After a relatively "quiet" period with no Sputnik *launchings and very few IGY sounding-rocket firings, the Reds apparently are concentrating their efforts on Project* Boomerang.

As reported in last month's issue of m/r, the Reds' effort to place an instrumented vehicle in an elliptical orbit around the moon (Project Boomerang*), has been placed under the direction of Prof. G. A. Chebotarev. One year ago Chebotarev authored a paper on the method of placing a payload of 110 to 220 pounds in a lunar orbit.*

From reliable sources overseas, m/r has learned that the Russians have conducted several unsuccessful satellite launchings and that they already have tried—unsuccessfully—to reach the moon. Nevertheless, the general feeling is that they will get a moon rocket under way before the United States. However, some Russian scientists have expressed their concern over the difficulties involved in launching a rocket around the moon. Prof. V. Sharonov, writing in IZVESTIA, *says that "the task of orbiting an artificial satellite around the moon is very far from the practical capabilities now available to us." One should remember, however, that Russian scientists less than a year ago also warned about the difficulties of launching satellites such as* Sputnik *II.* eb

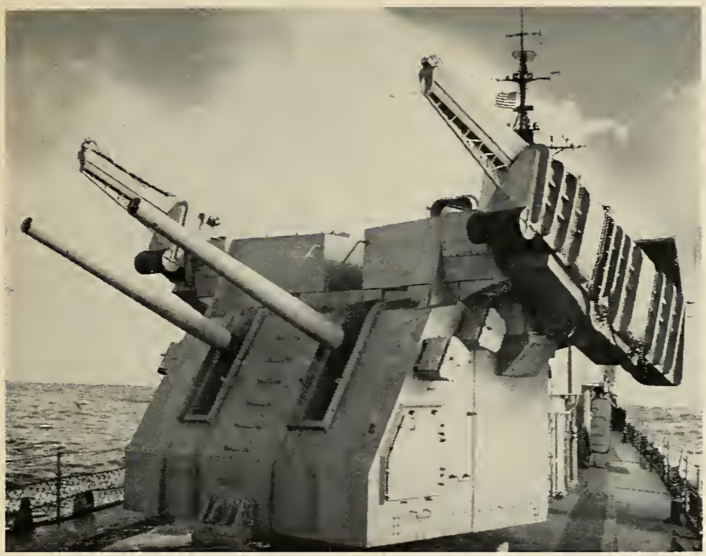
U.S. MISSILES in the NEWS

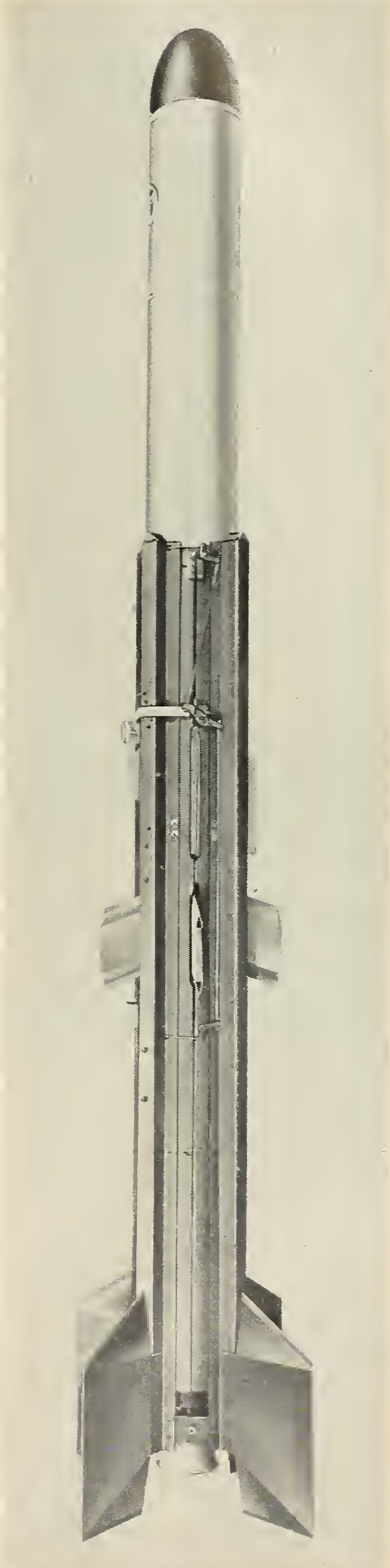
THIS NATION'S largest solid-propellant missile, the *Sergeant*, is now in production for the U.S. Army, with first deliveries to troops expected in the near future.

A second generation missile, the *Sergeant* will succeed the four-year-old *Corporal* missile, with incorporated improvements over the *Corporal*'s thrust and accuracy. The anticipated range of the thirty-foot-long missile will be close to 200 miles compared with the *Corporal*'s 75-100 mile range. An operational battalion for the *Sergeant* is expected to be under 200 men.

All system elements for the missile have been designed for portability and mobility incorporating government-furnished equipment for transportation vehicles. Guidance is achieved by an inertial system requiring only a programmed pitch control for range variation. This makes the weapon extremely ideal for battlefield operation. In contrast, the *Corporal* is controlled by radio signal during its powered flight making it susceptible to enemy countermeasures.

The *Sergeant* is the latest member of a family of Army missile designed and developed by the Jet Propulsion Lab. These include *Private* A, *Private* F, *WAC Corporal*, *Corporal*, and the *Sergeant*. Next in the series will be the *Pershing* 500-mile solid-propellant rocket. The Sperry Gyroscope Co. will be responsible for production of the complete *Sergeant* missile system.





A RAT is the Navy's latest defense against enemy submarine "wolf packs." The new rocket-assisted torpedo, which is launched from destroyers in pursuit of enemy subs, is expected to be in fleet operation by the end of this year.

The weapon system consists of a standard homing torpedo, solid-propellant rocket booster and detachable aerodynamic control surfaces for stability. The missile is 16 feet long and weighs 450 pounds. It was developed by Naval Ordnance Test Station, Pasadena and China Lake, Calif., developers of the *Sidewinder* air-to-air missile..

After the destroyer's sonar searching equipment detects and begins the tracking of the enemy submarine, the ships fire-control system trains and elevates the RAT launcher and sets the range. The rocket motor propels the torpedo along a ballistic flight path and separates along with the airframe after burnout. Two parachutes lower the torpedo to the water where the parachutes and nose cap are discarded. The torpedo then starts a circling search pattern until the homing device makes contact and guides the weapon to the target. The missile may also be air-launched. RAT will not home on the launching ship in the event it misses its target.

Military Rockets Cheaper for Space Exploration?

by Norman L. Baker

In recently published secret testimony, Garrison Norton, assistant Navy secretary for air, was quoted as saying that the use of *Jupiter*-C rockets for launching satellites was "very, very expensive and rather inefficient when compared with the Navy's *Vanguard* launching vehicle."

Army officials questioned on this statement answered that this was the reverse of actuality and that Norton's remarks could be easily repudiated.

Norton said it would be wasteful to divert any military missile hardware for space projects "at this stage of the game.

"These motors and complexes were designed for an entirely different purpose: the sending of large warheads certain distances and the placing of those warheads very accurately on target. This is basically an entirely different problem from trying to put a small-size satellite in orbit. I think if you looked into the economics of the business you would find that using any of our large-scale missile hardware to launch satellites is a costly operation compared to *Vanguard*," he said.

Economies of *Vanguard*

A check into the economies of the *Vanguard* and *Jupiter*-C projects and a comparison of the costs of the two brings to light several interesting facts.

The *Vanguard* program, as originally conceived, required 13 launching vehicles to fulfill its mission during the IGY. The first vehicles were modified *Viking* research rockets left over from an earlier high-altitude research program. The third vehicle was a *Vanguard* configuration with a dummy second and third stage. The remaining nine rockets were destined to launch four four-pound test satellites and six 20-pound full-size satellites.

The first appropriation for the *Vanguard* project totaled $29 million. That figure was soon raised to $110 million, the figure released June 1, 1957. It is believed that this total has been increased in recent months but there has been no official release on *Vanguard* funds since the June 1957 report.

The $110-million appropriation figure would give each *Vanguard* vehicle a price tag of approximately $8.5 million. Assuming a 100 per cent success in the satellite launching attempts, the United States would have 136 lbs. of instrumentated satellites circling the earth at a cost of approximately $800,000 per lb. When the *Vanguard*'s empty third stage rocket is included in the satellite weights (it will weigh about 50 lbs. and orbit with the 'sphere') as is done with the *Explorer*, the cost-per-lb.-of-satellite figure drops to about $160,000. Taking into account the last two failures and assuming complete success on the remaining vehicles this latter figure increases to $200,000 for each pound of maximum satellite weight.

Army officials have disclosed that each of the *Jupiter*-C research rockets have an average cost of $1.5 million for hardware and $2.5 to $3 million for accomplishment of a launching. Twelve *Jupiter*-Cs were fabricated for the Army Ballistic Missile Agency's re-entry test program for the *Jupiter* IRBM. Three of these research rockets were tested successfully—out of three launchings. The last one fired propelled a dummy fourth stage rocket and 5-lb. satellite 3300 miles over the Atlantic in September 1956. Officials point out that this shot could easily have launched the world's first satellite.

The three tests convinced the Army that the nose cone re-entry headache was a problem of the past there by making available nine research rockets with satellite capabilities.

Therefore, if the value of the re-entry tests are ignored, the *Explorer* I cost $390,000 for each pound. If the eight remaining *Jupiter*-C rockets each launch satellites of the same weight as *Explorer* I, each pound of satellite will cost $130,000.

Dr. Wernher von Braun announced that a 50 per cent increase could be made in satellite weight and still place the payload in an orbit with the same vehicle. Cost: $65,000 per pound of satellite.

Army officials have stated that a 300-lb. satellite could be launched with the *Jupiter*-C after further modifications. Depending upon how many of these were launched the lb.-satellite figure would range from $12,000 to $65,000.

The total research and development costs for the workhorse of the *Jupiter*-C, the *Redstone* rocket, would obviously raise the costs of the *Jupiter*-C rockets slightly but the costs of developing the individual systems of the *Vanguard* (*Viking, Aerobee, Hermes* first-stage engine, etc.) must also be considered as above and beyond the *Vanguard* funds.

Based upon the preceding cost figures and anticipated successes versus actual successes *Vanguard* costs would be double to three times those of *Jupiter*-C.

With each launching failure the satellite costs jump sharply and the *Vanguard* still must prove its system capability while *Jupiter*-C continues to pay off.

NAA Hydyne Fuel Boosted *Explorer* I

A Rocketdyne liquid-propellant rocket engine, burning a new high-energy fuel compound and liquid oxygen, provided the first-stage power to lift the Army's *Explorer* I satellite into outer space.

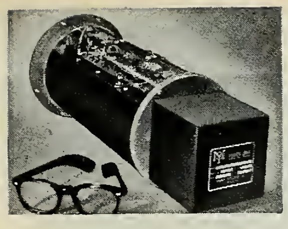
Test-flown more than a year ago, the powerful rocket booster was modified from an engine series in production by North American's aviation division for the Army's *Redstone* medium-range ballistic missile.

The satellite launching fuel was a hydrazine-based compound developed by Rocketdyne engineers. Nicknamed Hydyne, the fuel increased thrust and missile range by 12 per cent over that of a conventional *Redstone* engine.

Dr. Jacob Silverman, supervisor of Rocketdyne's propulsion research thermodynamics unit and a leader in the development of Hydyne, first started work on the new compound early in 1956. The problem faced by Silverman and the company's chemical engineers was that of developing a fuel that would increase performance and could be substituted for the alcohol usually burned in the *Redstone* engine.

Their studies led to two commercially available chemicals that never before had been used at the high-trust levels of rocket engines. By a unique blending of the two, the engineers developed a compound that retained the physical properties of alcohol, required no change in engine hardware or missile tankage, and increased the total burning time and burnout velocity.

The *Redstone* engine series—rated in the 75,000-pound-thrust class—has been in production by Rocketdyne since 1952.



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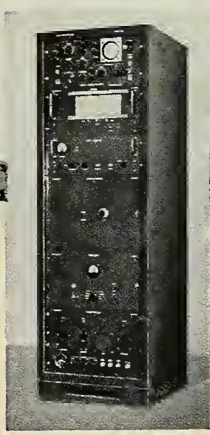

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Snark Disclosures Fit with Carrier-base Plan

by Raymond M. Nolan

WASHINGTON, D.C.—Details disclosed by Northrop Aircraft about the *Snark* missile added new credence to the suggestion that *Snark*s be used as an interim intercontinental striking force launched from aircraft carriers (editorial, February m/r).

Northrop Vice President John Alison stated that the *Snark* needed only a minimal launch area because of its zero-launch feature. This raises the speculation that the missiles could be fired from carriers while positioned in the existing launchers now used for ground-based firings. Since the *Snark* uses conventional jet fuel and solid-propellant rocket boosters, the standard Navy objection about liquid rocket fuels would not be raised.

Sources in Washington recently confirmed that the Navy is presently conducting feasibility studies on the carrier-launched *Snark* and that, because of the relatively low cost and short time involved to make this system operational, prospects look good.

A significant statement by Alison was that the *Snark* is not now used to its full operational capabilities but could, in fact, impact on Moscow from anywhere on the eastern seaboard. He gave the range as more than 5500 nautical (6300 statute) miles. Ward Dennis of Northrop's development planning section added that the *Snark* had inherent qualities equal to any manned aircraft and that dogleg courses to avoid populated areas or for maximum evasive action could be programmed into the *Snark* before launch. Dennis also said that a recall signal or the capability for a recall or destruct signal could be programmed into the *Snark* by the launching commander. However, he added, the destruct or recall capability could be sealed off in the case of anticipated enemy interception or jamming on the recall or destruct channels.

When asked about costs of the *Snark,* Dennis stated that the *Snark* is about one-tenth the size of a B-52 and that costs are in the same area—roughly one-tenth that of a B-52. Since present B-52's cost somewhere around $6 million (after production of about 600), a *Snark* probably costs between $800,000 and $1,000,000 now, but could come down in price to $500,000 when a sufficient quantity has been produced.

Mr. Dennis emphasized that, since over $400 million have been pumped into the research and development program, economy of production can never be realized while these units are in pilot production nor can effective retaliatory measures be possible without great numbers of *Snark*s. Present production contracts total $143 million, but the actual number of *Snark*s ordered was not revealed. He proposed that *Snark* be put on a high production schedule for both these reasons.

His contention is that with any

weapon, superiority in numbers is the major factor in the degradation of a defense system and that combinations of high- and low-altitude *Snark*s coupled with IRBMs and manned bombers could achieve penetration far beyond that of one or more IRBMs or ICBMs.

Throughout his talk, Dennis emphasized the terms "large payload" and "thermonuclear payload." This would seem to indicate that the *Snark*, though only one-tenth the size of a B-52, has a warhead capacity near that of a B-52 and certainly well beyond that of an IRBM or ICBM.

AMF Reveals *Talos* Automation System

The first automatic missile loading and launching equipment for firing *Talos* surface-to-air missiles has been completed and is now undergoing extensive testing by the U.S. Army.

Designed and built by American Machine & Foundry under subcontract from RCA, the prototype automatic loading and launching equipment and associated missile handling equipment is installed at White Sands Proving Ground, N.M. Pending the results of current tests and final contract negotiations, pilot production of the launching equipment would take place in a 200,000-square-foot government plant near Rochester, N.Y.

Each *Talos* defense unit includes a missile handling and assembly area and two automatic launchers, each supported by a circular missile-storage magazine resembling a railroad roadhouse. Capable of handling missiles with high-explosive or nuclear warheads, the launchers can fire either single missiles or salvos to engage a number of different targets simultaneously and can continue to fire at a high rate over an extended period of time.

On command from electronic computers in the control station, the launcher turns toward the cell in the circular storage magazine which contains the desired type of missile for the tactical mission. A cart runs out to the automatically preselected cell, picks up a missile and returns to the launcher.

The missile is then positioned in the launcher where it is elevated and rotated to firing position. When the firing signal is received, the missile is fired automatically and the launcher recycles for the next round.

If it is desirable to unload the launcher, this operation is accomplished automatically making possible the rejection of a missile at any time. Execution of the launching cycle requires no operation personnel whatsoever.

'55 Decision Blocked Army Satellite Try

In the wake of the failure of the Navy's *Vanguard*, Feb. 4, a check of information available in Washington has made it apparent that a little-known committee action in 1955 may have been a root of the trouble. The difference might have been an American satellite in orbit two years ahead of *Sputnik* I—if Army vehicle proponents were right in their claims—but certainly a year earlier.

The decision—by Deputy Defense Secretary Donald Quarles—was announced July 29, 1955, when the U.S. Government ruled out the Army-backed Project *Orbiter* in favor of *Vanguard*. Action was based on a six-to-three vote of the so-called Stewart Committee, which had been given the job of deciding which vehicle the United States would back in its IGY satellite-launching program.

The committee consisted of Dr. Homer J. Stewart, chairman; Dr. Clifford Furnas, Dr. Robert McMath, Dr. Joseph Kaplan, G. H. Clement, Prof. John B. Rossner, Dr. Charles Lauritsen, RADM Paul A. Smith (USCG Ret.), and Dr. Richard Porter—who is now chairman of the U.S. International Geophysical Year Satellite Committee.

No reason for the committee majority's disapproval of the *Orbiter* proposal has ever been given officially, but the three dissenters, Drs. Stewart, Furnas and McMath, wrote a strong dissent.

A comparison of the 1955 proposals shows that *Orbiter* consisted of a *Redstone* first stage with clusters of *Loki* rockets in the succeeding stages; while *Vanguard* was to have some sort of *Viking* configuration with a *Hermes* engine to power it (in the first stage).

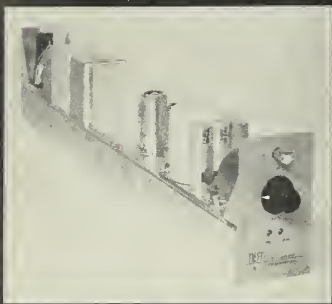
In theory, this was fine. General Electric, at the time, had several *Hermes* engines on the shelf and the idea of the *Vanguard* people was that these could be fitted to vehicles in a hurry—thus first-stage power would be no problem. But, according to one Pentagon source, the *Hermes* engines proved to be, among other things, too rusted for use on the first-stage vehicle. GE had to design a new first-stage engine, although *Orbiter* backers insist that Reaction Motors already had an engine which could have put the *Vanguard* first stage in the air.

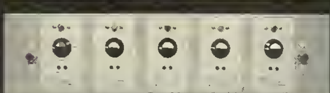
Nevertheless, GE tackled the job of coming up with an entirely new engine and it is this unit which currently powers the *Vanguard* in the first part of its journey. Meanwhile, ABMA was shooting *Redstone*s almost at will, with few failures.

Only under the impetus of the Russian achievements was the Army proposal reactivated—this time under the name of *Jupiter*-C, the designation of the vehicle which had solved the nose-cone re-entry problem for the Army.

The rest is history—America had a satellite put into orbit by a vehicle

Presidential Science Adviser Dr. James R. Killian, Jr., chats with Diversey Engineering Co. President J. H. Kauffmann, at the conference on "America's Human Resources to Meet the Scientific Challenge" Feb. 3-4 at Yale University. A joint project of the President's Committee on Scientists and Engineers and the William Benton Foundation, the conference's object was to explore methods for improving the U.S. supply of scientists and engineers. Those who participated included leading industrialists, educators, scientists, private study groups, interested government officials and members of the national press.





not much different than the one proposed while Project *Orbiter* was still alive.

As for the *Vanguard*, in spite of official reasons released to the public, the general opinion is that it has not flown mainly because of an inadequate first-stage engine.

Sources close to the situation say that failure of the *Vanguard* that attained a 96-inch altitude before burnup was due to engine-wall failure. Unburned fuel used for regenerative cooling prior to ignition caught on fire when the engine wall gave out under excessive temperatures.

The second failure—the one caused by midair breakage—was blamed on a faulty wire in the control system. It is believed that this wire broke because of excessive vibration. Statements in the general press, such as "the *Vanguard* finally struggled into the sky" are the clue: the marginal thrust-to-weight first-stage engine got the *Vanguard* off the ground but components normally able to withstand missile flight could not put up with the vibrations encountered as the missile groaned skyward.

Lockheed Prepares *Polaris* for Ground Test

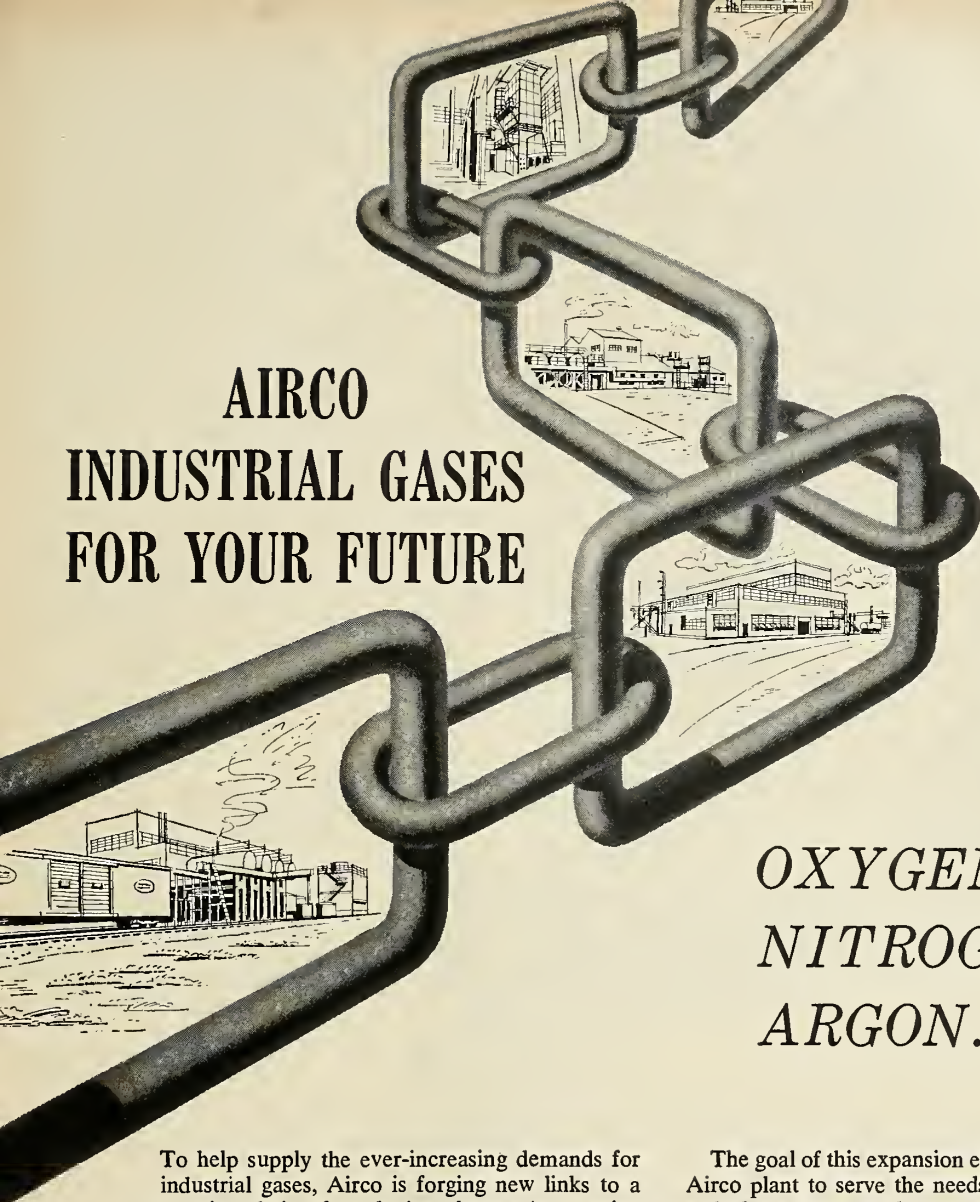
The Navy is accelerating the ground test program for the recently accelerated *Polaris* fleet ballistic missile. First ground test is expected within the next few months. This program is in addition to the *Polaris* test vehicle program which has been underway since last fall.

Construction will begin immediately on a special Navy-owned *Polaris* test facility on 271 acres loaned to the Navy by Lockheed. This multimillion-dollar building project, comprising a complex of huge concrete and steel missile test stands and special related buildings will be located at Lockheed's 4000-acre remote test site in the Santa Cruz mountains south of San Francisco.

L. Eugene Root, general manager of the Lockheed missile organization, said that the recently announced acceleration of the submarine-launched *Polaris*' development places heavy importance on the new ground test station.

"Because we must compress *Polaris* development time, we must speed up our program with as much ground testing as possible of each component or whole missile before we finally expend it in flight test," he said.

Root explained that static or ground testing of parts at the new facility will take place under conditions that



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are closer to actual flight conditions than any other method short of flight. Actual firing of rocket engines, for example, will create flight-like conditions of heat and vibration during the checkout of electronic equipment, guidance systems and other key components.

Goal of the tests will be to increase system reliability, decrease overall test-program costs and speed availability of the operational *Polaris* missile, Root added.

Supporting the Santa Cruz test-stand complex, the Navy *Polaris* test facility will have a control blockhouse with elaborate instrumentation, control and simulation equipment; an assembly building, engineering building and test-stand workshop.

Franklin Institute to Run Astronautics Lecture Series

A series of 10 space travel lectures, "Ten Steps Into Space," will be given at The Franklin Institute, Philadelphia, Pa., on Tuesday evenings at 8 p.m. from March 4 through May 6.

Dr. I. M. Levitt, Director of The Franklin Institute's Astronomy division, announced the lecturers will be the ranking men in the astronautics field in this country. Each authority will speak on his specialty.

Willy Ley, noted historian on space travel, will begin the series on March 4. Dr. Ley's lecture, "The Long History of Space Travel," will provide the foundation for the following talks.

Other lectures are: March 11—Kurt Stehling, "The Rocket and the Reaction Principle;" March 18—S. Fred Singer, "Satellite Instrumentation—Results for the IGY;" March 25—Krafft A. Ehricke, "Space Navigation—The Path to the Planets;" April 8—Ernst Stuhlinger, "Propulsion Systems—Gases, Ions and Photons;" May 6—I. M. Levitt, "Satellites and Travel in the Future."

The series fee will be $10; individual lecture fee, $1.50. Persons may register by mailing the fee to: Astronautics, The Franklin Institute, Phila. 3, Pa.

Univ. of Mich. Offers Automatic Control Course

The University of Michigan College of Engineering has announced a summer Intensive Course in Automatic Control scheduled for June 16-25, 1958, inclusive. The course is intended for engineers who wish to obtain a basic understanding of the field, but who cannot spare more than a few days for this purpose. Its aim is to make the subject matter easy to learn


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- Analog and digital computer systems
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- Plotting equipment
- Nuclear systems and controls
- Gunfire controls
- Drone controls

A special guidance system for the Jupiter C, developed by the Army Ballistic Missile Agency, was used to launch the first U. S. artificial satellite into space.

Many components of this system were provided by Ford Instrument Co., prime contractor for both the "standard" U. S. Army Redstone and Jupiter guidance systems.

The fabulously-equipped, fantastically-clean gyro lab (above) is only a small part of the advanced research and development facilities available at Ford Instrument Co. They're used to create and produce the incredibly accurate control systems called for by modern technology in both government and industry.

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There will be four hours of lecture each morning and three hours of laboratory demonstration in the afternoon. Extensive use will be made of computing, instrumentation and servo laboratories on the campus. The role of analog computing methods will be emphasized. This course has been given summers since 1953.

April 15 is the closing date for registration. Further information may be obtained by writing to Prof. L. L. Rauch, Room 1525 B, East Engineering Building, University of Michigan, Ann Arbor, Mich.

Research Group Sponsors German Ballistics Session

The AGARD Wind Tunnel and Model Testing Panel will sponsor a ballistics meeting in Freiburg, Breisgau, Germany, from April 22 to 25. Subjects will include the historical development of ballistics, high-velocity guns, range techniques and long-range missiles. Some 15 papers will be presented.

Scientific Progress Vital to Survival—Dr. Ramo

"Scientific developments in electronic computers and other synthetic intelligence devices may be more important in our race for survival than space supremacy," Dr. Simon Ramo, chief scientist for the Air Force ballistic missile program, said recently.

"Space conquest, intercontinental ballistic missiles—neither of these new technological advances would be possible without a multitude of instruments that extend man's senses; that observe and remember, compute faster and more efficiently than the human brain under similar circumstances," he added.

Speaking before the American Institute of Electrical Engineers in a special session devoted to "thinking machines" of the future, the president of Space Technology Laboratories said, "Total brain power of a nation in the coming half century is going to be the determining factor in that nation's

until and after man conquers space...

Since time began man has sought to escape the limitations of the body. Though his feet are planted on earth he will climb to the sun. Today's jet pilot probes the upper reaches of the earth's atmosphere . . . tomorrow, manning vastly different craft he will conquer the final frontier — outer space.

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progress. However, that ability is not set just by the number of human brains in each nation, but rather how those brains are used and how they are assisted by synthetic intelligence devices.

"In every phase of our economy—engineering design, factory operations, communications, transportation, and in the military—we are making tremendous strides in the extension of human brains and senses," he said.

"For instance, I think we are ahead of the Russians today in the techniques that extend and make more useful each brain, each pair of eyes in our nation." Space Technology Laboratories is a division of The Ramo-Wooldridge Corp., and has as its primary job engineering direction of the overall missile systems, *Atlas*, *Titan*, and *Thor*, the Air Force's long-range ballistic missiles.

Automatic Test Equipment to be Made Under License

Automatic equipment for production testing of complex fire-control, flight-control and missile systems, developed by Westinghouse, will now be manufactured under license by Mason, Shaver and Rhoades Sales, East McKeesport, Pa.

The four basic automatic units involved in the licensing agreement are: a dc resistance tester, developed for high-volume testing of components such as transformers, which automatically bridge-tests items through a range of 0.001 to 10,000 ohms; a precision potentiometer tester which tests ganged computer-type potentiometers for resistance, terminal linearity, dielectric strength and electrical noise; a turns-ratio tester which tests the electrical relationship between the number of turns in transformers of multiple windings at a test rate of 15 seconds per transformer, and a flux-reset-type core tester for testing all types of magnetic amplifier toroidal cores.

Epsco System Used by General Electric

Makeup of the analog-to-digital subsystem in the GE missile and ordnance systems department's data-processing center has been described by its manufacturer, Epsco Inc., as a major advance in automatic data reduction. The subsystem forms part of the integrated computing facility described in the February issue of m/r.

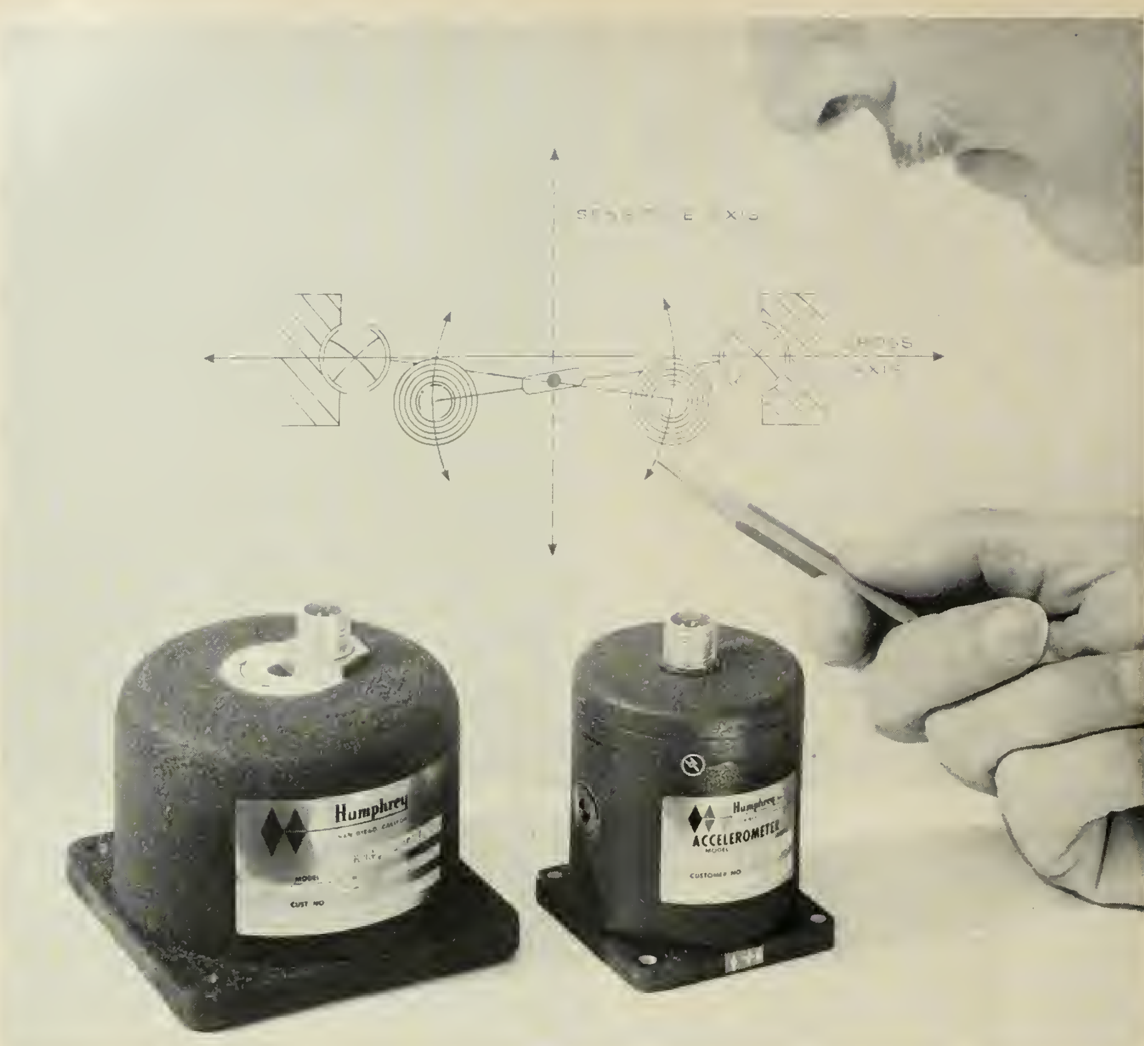
However, Epsco points out, even though this conversion subsystem was designed, built and delivered in less than 10 months through extensive use of modular techniques, new advances are already in the design stage.

The new technique uses Universal System Logic Boards—solid-state printed wiring circuits which may be combined without modification to comprise complete system logic for data-handling applications, from process control to telemetry data reduction. The use of such pre-engineered modules is, Epsco feels, the answer to improving electronic system reliability even in the face of increasing system complexity.

'Most Accurate' Radars Track *Explorer* Launching

When the Army's *Explorer* rose into its history-making orbit, its flight was followed by two of the most accurate tracking radars in the world, it was disclosed today by the Radio Corporation of America.

A number of these instruments, RCA vice president, A. L. Malcarney said, are currently being produced in



CONTRA-ROTATING WEIGHTS ELIMINATE CROSS TALK IN HUMPHREY ACCELEROMETERS

When an accelerometer used to measure motion of a body in one direction is influenced by motion in another direction, the resulting "cross talk" leads to inaccuracies. Humphrey licks this problem by building accelerometers that cancel out cross talk.

The diagram illustrates the principle. There are two contra-rotating weights on arms that are flexure mounted so they are free to move. Where the arms cross, they are pinned together with a slot and pin that allows them to move. Assume the accelerometer is measuring vertical motion as shown by the arrows. Lateral motion can't produce error in vertical measurement because "up" error of one weight is cancelled out by "down" error of the other. Flexibility of this design permits covering a wide range of operating characteristics. Low natural frequencies can be furnished to filter out mechanical vibrations. Let us work with you on your linear or angular accelerometer requirements. Write today.

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quantity for installation on Army, Navy and Air Force missile ranges throughout the country. They are the first specifically designed for guided-missile range instrumentation, and are the result of a ten-year program of research and development carried out by RCA in conjunction with the applied physics laboratory of Johns Hopkins University, the Navy Bureau of Ordnance and the Navy Bureau of Aeronautics.

"The radars, located on the Florida coast and on Grand Bahama Island, 165 miles away, provided information vitally necessary for the successful orbiting of the satellite," Mr. Malcarney said.

"The AN/FPS-16 is also used for tracking in the Army's *Talos* defense unit missile system, and is adaptable to most of the U.S. missile systems."

According to Malcarney, the radar development "was accelerated by the large-scale testing of guided missiles and the resultant need for providing fast, accurate, tracking data. The AN/FPS-16 tracks in total darkness, through clouds and at long range. Tracking data is almost immediately reduced to their final form. Previously, weeks were required to translate tracking data to intelligible form."

"Still another feature of this highly accurate radar" Malcarney said, "is its ease of control with only a single operator needed for each unit. It is also reliable, functional under all weather conditions, flexible and highly standardized for use by all three services, thus eliminating duplication of effort.

"Along with the more glamorous missiles that soar majestically into the sky every day, this precision radar is playing a tremendously important supporting role in the drama of national defense."

Market Guide, Directory Publication Set in April

The first annual edition of the Missile Market Guide & Directory will be published by American Aviation Publications, Inc., publishers of Missiles & Rockets, in mid-April 1958. This book, the only complete marketing directory of the missile industry, has been over a year in preparation and will cover all phases of this rapidly growing industry.

Included in the Missile Market Guide & Directory will be a marketing section outlining the procurement policies of the Department of Defense and the various services; an alphabetical listing by company of over 2500 prime contractors, subcontractors and equipment manufacturers showing plant location, purchasing & sales personnel, and products; and a completely cross-indexed missile catalog of over 4500 items that go into a missile and the companies that manufacture them.

Questionnaires have been sent to some 10,000 companies in the missile industry and the editors have advised that companies who have replied by March 8 can be included in the directory.

Copies of the MISSILE MARKET GUIDE & DIRECTORY will be distributed to all subscribers of MISSILES & ROCKETS as part of their subscription. Additional copies, at $5.00 each, can be reserved by writing to the Circulation Director, MISSILE MARKET GUIDE & DIRECTORY, American Aviation Publications, Inc., 1001 Vermont Ave., N.W., Washington, D.C.

Rocketdyne Awarded Nuclear Rocket Contract

Rocketdyne, under an Air Force contract, is conducting studies and research activities directed toward a nuclear rocket engine. The contract is administered by Wright Air Development Center and is in coordination with previously announced work of the Atomic Energy Commission.

The present contract extends pioneering work by North American in the nuclear rocket field. The nation's first studies and experimental research were carried out by the company as early as 1946.

Rocketdyne project engineer for the nuclear rocket studies and research activities is Dr. S. V. Gunn, a graduate of Purdue University who joined the North American division in 1953.

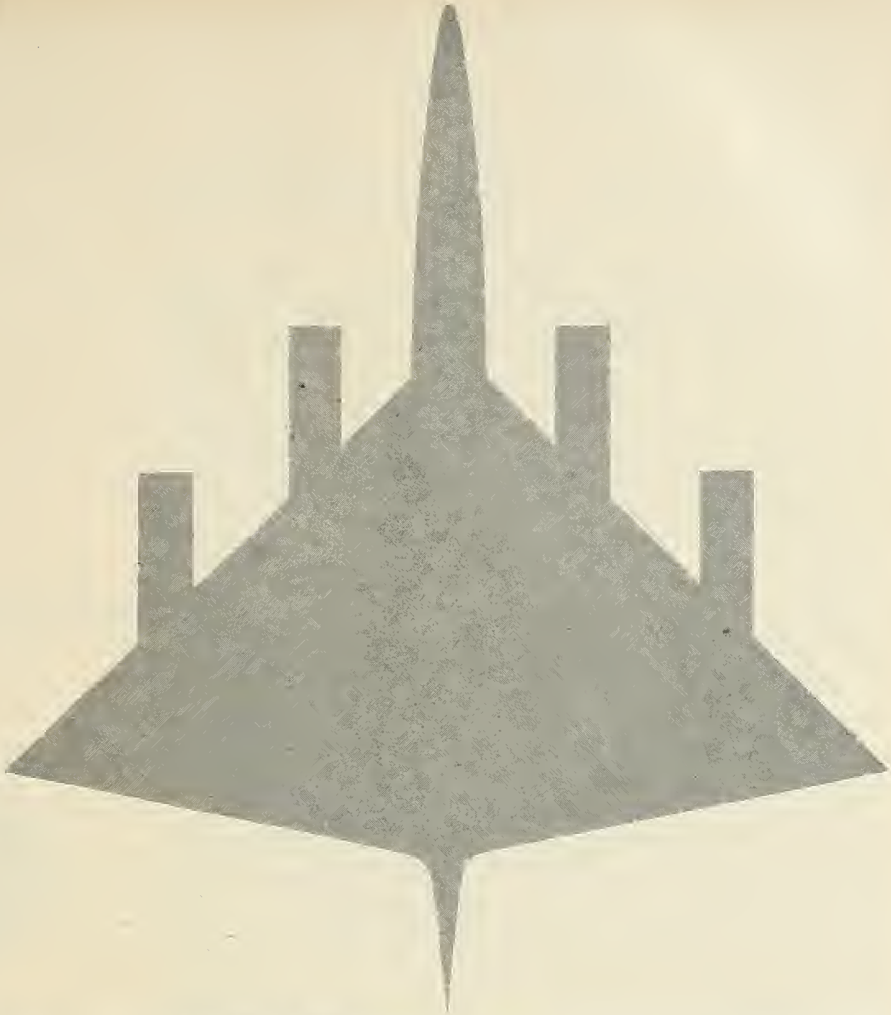
AF High-altitude Chamber Due for Midyear Operation

ALAMAGORDO, N. Mex.—Finishing touches are being placed on a new high-altitude chamber here at the Air Force Missile Development Center.

This test and research facility—two years abuilding—is expected to go operational around midyear. Under the high-altitude division of the Directorate of Ballistic Missile Test, the new facility is slated to further extend the frontiers of men and missiles into space. Altitudes of 140,000 feet can be simulated but the capacity can be pushed to 250,000 feet.

Function of the chamber is to check out large components of vertically launched rockets, high-altitude balloon chambers, and other packages, under simulated and reproducible conditions for periods of as long as 60 days.

Unique feature of the chamber



is the automatic programming capability of simulating pressure, temperature, humidity and solar radiation environmental characteristics encountered in flight of rocket missiles and high-altitude balloons. With an eye to space biology, infrared radiation production and control has received special attention.

Inside-chamber work space is 8 feet wide by 8 feet high by 11 feet deep. Main access door—monorail hung—is 8 feet by 8 feet and opens one entire side of the chamber. Chamber lighting, designed for near-vacuum conditions, gives an intensity of 30 foot candles. The floor can take loads of up to 450 psf while 1,200 pounds can be hung from the ceiling. An anteroom provides an air-lock method of entering or leaving the main chamber without test cycle abortion.

Various utility penetrations are provided—including three window ports. Four oxygen outlets are located in the chamber itself with another outlet in the anteroom. An intercom and electrical patch system are also provided.

Instrumentation includes recorders for dry bulb temperatures, wet bulb temperature, dew point temperature, and two altitude recorders. All of the instruments are made up of two prime components: a programmer strip-chart instrument, and a recording strip-chart. The programmers are the curve-following type, utilizing a photronic cell and light-beam principle.

Curves are plotted on a strip chart to program any cycle or series of cycles within the capacity and ranges of the chamber machinery. Automatic digitized logging equipment is associated with the chamber instruments and will type out a readout and punch IBM type.

Housing for the chamber is a concrete masonry structure. The main test-chamber space is 44 feet by 40 feet with 16 feet (clear) of ceiling. Evacuation system consists of three 900 cfm pumps. Refrigeration system (cold wall) uses Freon-22. High stage is 40 hp while the two lower stages are 25 hp each. Heating space is electrical. The normal complement of persons regularly assigned to operate the facility are an Air Force officer, a civilian mechanical engineer, an instrumentation specialist, a refrigeration mechanic, four operators and a secretary.

Performance capability of the chamber is:

TEMPERATURE. –100°F to 200°F. With a one-ton workload, the air temperature can be lowered from 80°F to –100°F in four hours at ambient altitude pressure or raised to 200°F in 20 minutes. Cold wall temperatures of –100°F can be obtained in one hour at altitudes of up to 140,000 feet. Some 8 kw of electrical energy can be dissipated at −100°F. Dry bulb temperature accuracy is to ±0.75°F.

HUMIDITY. Relative humidity can be increased from 5%-100% at 33°F to 200°F. Humidity can be increased or decreased 5%-95% at 200°F in two hours. Overall humidity accuracy is ±3% RH.

ALTITUDE. Range is from location (4100 feet) to 140,000 feet. With ideal conditions it may be possible to obtain 250,000 feet. Rate of ascent is 4100 to 140,000 feet in three minutes and 23 seconds. Maximum descent is 50,000 fpm with the controller or emergency descent from 140,000 feet to ambient in 30 seconds. Altitude accuracy is ±1% from 0 to 100,000 feet or ±2% from 100,000 feet to 140,000 feet.

The chamber is available for use by any Defense Department agency or private industry engaged in defense contracts. Normal users will be Air Force groups engaged in upper-atmosphere research and Air Force guided missile contractors.

Reliability Films Sponsored by U.S. Navy

The Bureau of Ordnance, U.S. Navy (ReS1) is currently soliciting suggestions to illustrate given points or principles in a series of sponsored films on the aspects of reliability. The series will consist of nine films and work has already begun on the first two. The films will be unclassified and will be available for use by universities as well as industry and the military. The Navy hopes that scholastic use will be a means of reaching the graduates who enter the government and industry each year, providing them with some advance consciousness and awareness of the importance of reliability.

Basic concept of this series is that, to achieve high reliability, it is necessary to start with the people who constitute the maker-user team and to inform and educate in a manner that will develop mental attitudes and approaches focused toward high reliability.

Titles for the films planned range from: "Why So Much Concern," "Basic Steps and Procedures in Planning," "Design Approaches," on through to the final title, "The Maintenance Factor."

Mr. P. R. Wheeler, BuOrd, states that suggestions will be welcome so that the films will have maximum appeal and effectiveness. All correspondence should be addressed to the Bureau of Ordnance, ReS1, Department of the Navy, Washington 25, D.C.

only

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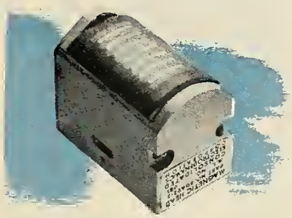
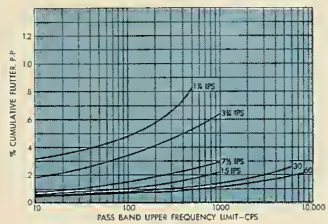
offers

all-metal-surface magnetic heads



No more drop-outs or loss of high-frequency response because of oxide build-up on heads. All-metal-surface...rather than conventional metal-plastic combinations...promotes a self-cleaning action and minimizes head wear.

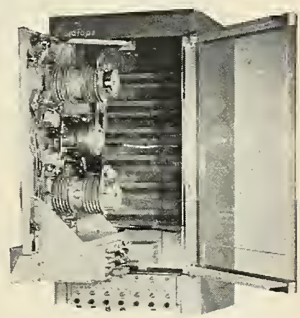
lower flutter even at low tape speeds

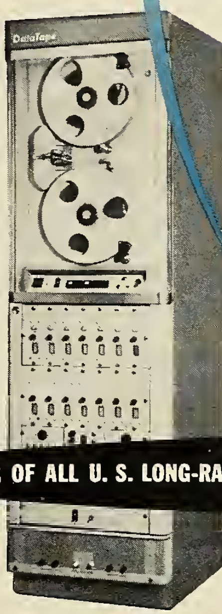


Cumulative flutter at 1⅞ and 3¾ ips is approximately one-half that found in other tape equipment. CEC is first to achieve the low-speed flutter characteristics shown at left. Chart shows flutter recorded at 30 ips and played back at speeds indicated.

complete front access

The 5-752 is the only recorder/reproducer offering complete front access to all incoming and outgoing signal, control, and power interconnections. Access to internal amplifier circuits is through standard connectors on front of unit. All electronics are mounted on drawer slides.





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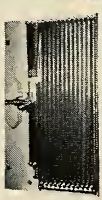
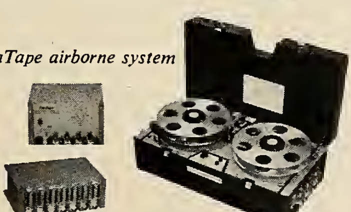


Continuous loop transport



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Soviet Affairs

by Dr. Albert Parry

Impressions gathered on my recent lecture tours of the Northeast and the Middle West, both in the United States and Canada, include a curious popular misconception on the subject of the German role in the Soviet rocket effort.

Many Americans and Canadians are sincerely convinced that the Soviet successes in rockets and missiles are due predominantly, if not entirely, to the work of German experts captured or contracted by the Soviet Union at the end of World War II.

On one occasion in Cleveland, I had carefully explained that only a small portion of the Soviet achievements in the space race can rightfully be credited to German help when a listener ventured this interesting psychological explanation of the misconception:

"We Americans remember so well that we licked the Germans twice—in World War I and World War II. Now, consciously or not, we tell ourselves that it isn't really the Soviet Russians but the very same Germans who are again trying to challenge us. The same Germans, but in the guise of Red Russians! And we reassure ourselves that just as we licked the Germans in the two World Wars, we will lick them a third time, if there is a third time."

This popular American picture of Germans-in-the-guise-of-Soviets has already reached Khrushchev. Outraged, he found it necessary to deny the charge in his recent Minsk speech. Nikita pointed out that while Germans had indeed been used by his government in rocketry and other scientific and engineering fields, it was only "a small group of Germans," and that "on the termination of their contracts they have either returned or are now returning to Germany."

Moreover, Khrushchev emphasized the role of Germans in the U.S. rocket field. Following his lead, the Soviet press at once began to stress the number and importance of such German experts in American service as Dr. Wernher von Braun and his associates.

•

The successful launching of our *Explorer*, under von Braun's guidance, is now being used by the Soviets in their own version of America's post-*Sputnik* game: "It is Germans, not Americans, who produce whatever rockets, missiles and earth satellites the capitalist world has!"

To use the psychological explanation of the man in my Cleveland audience, by this time the Soviet Russians may also be guilty of the same attempt at self-assurance and saying in effect: "We Russians licked those Germans in World War II (if not in World War I). We will lick those Germans again even though they assume the guise of Americans on that Cape Canaveral base!"

Another self-consoling illusion I found among my American and Canadian audiences appeared in the form of a question I was frequently asked: "Isn't it true that most Russian scientists in the rocket and atomic field are men in their fifties, sixties and even seventies? Doesn't this mean that younger Soviet scientists and engineers are not as good as they are often described—that they cannot continue the successes of their elders and therefore are of no real competition to the West?"

My answer, of course, was that there is plenty of young blood among Soviet rocketeers and nuclear physicists—that under no circumstances must we lull ourselves into any false sense of security on this score.

Moscow Briefs

From October 4 to January 18, a total of 91,569 letters and wires, addressed "Moscow—*Sputnik*," was received by the Soviet Academy of Sciences. This number includes letters, postcards and wires from 58 foreign countries. In addition, more than 300 packages arrived containing photographs, tapes and records registering both *Sputniks* in picture and sound. Nearly 1300 persons, from both Russia and abroad, wrote volunteering as passengers on the first Soviet flights of the future into outer space, particularly to the Moon.

•

Radio Moscow has begun making space flight programs a regular part of its diet served to North America. The broadcasts give general descriptions of a wonderful era ahead, in which there seems to be a complete absence of any ideological or other conflicts.

•

The initial claim of "Soviet military and scientific superiority" because of their ICBM and *Sputniks* has been played down in the Russian press. The fact that these events jolted the United States into beefing up its defenses has led the Soviets to change their line and claim that our reaction is due to U.S. "failure to understand the real aims of Soviet science."

•

The Soviet Union expects to "hold the first place in the world in the peaceful use of atomic energy by 1960." This is one of the chief points made in the book THE YEAR 1960 by L. V. Zhigarev, just issued in Moscow by the State Political Literature Publishing House. Atomic-energy stations will dot the entire country, says the author, but in the south of the Soviet Union there will in addition be a network of solar powerhouses, creating "a veritable revolution in industrial energy."

•

The Moscow Mint is preparing a special miniature emblem in honor of *Sputnik* I, to be worn in coat lapels, apparently by those Soviet scientists, engineers, and officials who contributed to the satellite's creation and launching. The emblem shows a globe ringed by a fine strip of gold representing *Sputnik* I's orbit. The satellite itself is marked by a small red spot on the gold strip.

•

"Sovetskaya Aviatsia," the official newspaper of the Soviet Air Force, has been paying respectful attention to American ideas and research that tends to discard the sharp nose cone of a

rocket or ICBM in favor of blunter shapes for re-entry purposes. These blunt shapes, the article notes, have a much better chance of surviving the plunge through the atmosphere at re-entry velocities. A recent article in the publication was accompanied by the above illustration and gave approving treatment to blunt-nose rocket projects.

•

A vicious attack on Dr. Wernher von Braun was published by the Moscow *Komsomolskaya Pravda,* the official organ of the Communist Youth League, on January 26, or five days before the *Explorer* went up into its orbit.

Entitled "Father of V-2, Servant of Hitler and the Pentagon," the prominently featured article included two photographs, one showing Dr. von Braun in the early 1940s present at a tour of inspection by some Nazi generals, the other—a recent photo—showing him at a conference with American generals and officials at Huntsville.

The article, signed by I. B. Biryukov, charges that just as Dr. von Braun used to answer Nazi greetings by exclaiming "Germany Above All!", so now he shouts "Wall Street Above All!" The Soviet writer declares that Dr. von Braun tries to be "a faithful Columbus" with his discoveries for American rocketry, but that "he is no prophet" and is therefore wrong in predicting victory for the United States over the Soviet Union "and the world."

Dr. von Braun is invited by the *Komsomolskaya Pravda* journalist to "remember his defeat of 1945" as a lasting lesson for his part in the American race against Soviet rockets and missiles.

•

The death of Dr. Sergei V. Orlov, one of Russia's oldest and most famous astronomers and astrophysicists, has been reported in Moscow. A professor at Moscow University, Orlov was the author of many works on comets and other subjects. Director of the Shternberg Astronomical Institute attached to Moscow University, he was known not only for his scientific achievements but also for his training of numerous young Russian astronomers and astrophysicists now serving all over the USSR. Dr. Orlov was 77 at his death.

•

The Moscow "Literaturnaya Gazeta" castigates Professor S. F. Singer of the Physics Department at the University of Maryland in a special unsigned article entitled "Atom Warmongers in Outer Space."

While recognizing Professor Singer "for his works in the field of astronautics," the Russian article attacks his "report at the International Congress of Astronauts in Barcelona of last October wherein he advocated moving H-bomb tests from Nevada to the Moon."

The Soviet writer sees in this project "an opportunity for an unlimited increase of the might of nuclear arms, which is a fond dream of the gentlemen of Washington."

Precision Instruments Are Core of Rocket Test Track

ALAMAGORDO, N. Mex.—The new 35,000-foot rocket track at the Air Force Missile Development Center will make extensive use of precision and versatile electronic instrumentation in its test program.

The purpose of the track is to collect data on the performance of missile and aircraft components, but because the average run will take only a few seconds, and because it will involve thousands of dollars in components, propulsion, and engineering man-hours, the collecting and recording data has to be of the highest quality. A vast net of ground lines, coax cables and radio links joins the blockhouses (3), firing pads, and instrumentation sites to the control and central data-collection building.

Each run requires the measurement of velocity and position of the rocket sled as a function of time. Standard equipment measures velocity with an error of not over one part in 1000 while position can be determined to ±0.1 inch.

Most tests use a permanent space-time system which consists of a small light source and a light-sensitive element carried on the sled. When the light beam is interrupted (by accurately spaced knife edges as the sled passes) a signal is telemetered to the data center where it is correlated and recorded.

For more accurate measurements, a sled-mounted accelerometer in conjunction with space-time data are fed into a computer. The computer processes the data and calculates velocity and position automatically, allowing for the changing travel time of the signal as the sled changes position relative to the data center.

Because of the more extensive data needed during a sled run, telemetry is required. Two telemetry signals are used:

The frequency modulation (FM/FM) system receives and presents transducer data in continuous form with a frequency response up to 3 kc on the upper channels; overall accuracy is over 94 per cent. Accuracy can be increased to 98 per cent with automatic calibration.

The other system, PCM, can hit an accuracy of 99.8 per cent. Here, the analog transducer output is sampled by sled-mounted equipment and converted into digital form for transmission over the PCM system to the data center for recording.

Missile Business

by Seabrook Hull

First there was the sound barrier; then, the heat barrier. Now, in the business of missiles, rockets and space flight another barrier rises: the dollar barrier. Simply put, the question of mounting concern in Washington is "Can we afford it?" And that's a dilemma that may well explain the delay in getting the country off top dead center in its efforts to catch and leapfrog Russia in advanced weaponry and modern technology.

The inescapable fact is: If you take all the programs and projects now pushed as essential and their costs, you come up with a total that gets frighteningly close to the $1-trillion mark. It would not be hard to budget "essential" projects requiring an annual expenditure equivalent to our entire national debt of some $275 billion.

Politically, the public would not stand for the taxes necessary to a pay-as-you-go approach, even assuming we had the scientific and engineering manpower to go around—which we don't. Economically, the country would collapse under any effort to finance it with massive deficit spending. It means that from the point of view of economics spending must be kept down to within "reasonable" levels—say, to $1 billion or less (corrected for inflation) for the whole national budget for some years to come. Politically, the practical total is probably closer to $75 billion—unless and until Russia does something else to scare us.

In terms of programs, it is therefore inevitable that many will be put on the shelf or dropped entirely. It should also mean that duplicate-but-competitive approaches (like *Thor* vs. *Jupiter*, *Wizard* vs. *Nike-Zeus*, etc.) will probably be rationalized down to a single survivor. It could even mean, for example, the cancellation of *Titan*, on the theory that *Atlas* will fill the gap until the solid-propellant ICBM comes along and that we simply can't afford the interim-though-sophisticated liquid-propellant *Titan*. Conversely, of course, it might mean dropping *Atlas*, should *Titan* suddenly show great troublefree promise in flight test.

It takes only simple arithmetic to see the reasoning involved. Though a comprehensive listing of missile-age prices is still a closely guard military secret—on the theory that contracts divided by unit prices give numbers ordered—enough has been released and/or surmised to demonstrate the present costliness of missile and rocket weapon systems.

One military estimate of the number of *Bomarc*s and their sites needed to fully protect this country rounds out at around the $10-billion mark; a single operational ICBM squadron, at about $1 billion. *Polaris*-launching submarines cost, in production, $80 million each without missiles, according to preliminary estimates. And, there's serious talk of building 100. The anti-missile missile will cost at least $1 billion just to develop, much less place in operational status. Ordered-in-volume air-to-air missiles range in price from $1200 to over $50,000 each, not including those with nuclear warheads. And, we haven't even begun to price a progressive space flight program! Nor have we included maintenance costs, pay and allowances for troops, industrial mobilization, education, etc.

A sharp thinking-through of our current and future military and space flight program is dictated not only by the limited dollars available, but also by limited, specific industrial capacity (forging and heat-treating, for example), and by the short supply of technical manpower.

In a word, the United States is forced to abandon the shotgun approach. Instead it must be highly selective—a new experience. This will have a profound affect on the missile business and should help provide an explanation for some of the "rather odd" decisions that may come out of Washington.

washington trends

by Elizabeth Oswald

A NEW STEP IN THE PLAN to develop an orbital bomber is expected "pretty soon." In Air Force parlance "pretty soon" means from two to three weeks, up to possibly six months.

Study is being made of proposals submitted by major aircraft companies, one from Bell Aircraft, first in the field to study under AF contract the possibility of using powerful rocket engines to boost an aircraft into space, at which point the pilot would take control. The vehicle would be capable of bombing any place on earth from outer space under pilot control, reentering the earth's atmosphere by use of a skip-glide technique.

ARDC officials are not convinced the project is feasible after studying proposals from Douglas Aircraft, Bell, North American Aviation, Northrop Aviation and Republic Aircraft. What could come next is a phase I design competition. Boeing Airplane Co. also has made a study of an unmanned ballistic rocket bomber for televised reconnaissance work.

ARMY-AIR FORCE BATTLES over the roles they will play in the development and operation of air defenses aren't over. Air Force wants a new look taken at the Defense Department decision which calls anti-missiles a "point defense" function, and gives the Army the job of developing *Nike-Zeus* as an anti-missile missile. AF claims that the missile can't properly be separated from its radar command and tracking equipment or its detection equipment. As of now split responsibility exists with AF responsible for the development of the detection equipment. It will also argue that a "point defense" weapon would require astronomical numbers of men and locations to protect such cities as New York or Los Angeles.

USE OF THE FIRST AIR-LAUNCHED solid-propellant ballistic missile may come with the production of the WS-110A, now known as the B-70. Chances are that the missile will not be a "sawed-off *Polaris*." Current thinking is that the WS-110A will carry both air-to-ground missiles and an intermediate-range ballistic missile. The air-to-ground missiles would be slung under the wings, with the ballistic missile carried in the bomb bay. This way, the Strategic Air Command expects to be able to pick off more than one target on each mission.

UPPER AIR RESEARCH conducted by the AF's Cambridge Research Laboratory is responsible for a big, and expensive project which is scheduled to continue until February 1, 1960. The balloons start at the Navy auxiliary field at Vernalis, Calif., and are scheduled to float east. Some of the bigger balloons reportedly will stay up for about 10 days. Details of the program are classified.

NEW PUSH FOR CONSTRUCTION of 100 submarines to carry the *Polaris* will run afoul of the limited submarine construction capability which now exists in the United States. Lead yard for such construction is that of the General Dynamics Electric Boat Co. at Groton, Conn., which will build two of the first three *Polaris* submarines. Other yards with a submarine capability are Mare Island which will build the third *Polaris* sub, the Naval Shipyard at Portsmouth, N.H., Newport News Shipbuilding Co., Newport News, Va., and Ingalls Shipbuilding Co., Pascagoula, Miss. The accelerated submarine construction program will take just under two years to produce its first submarine.

ROY W. JOHNSON, CHIEF of the newly created Advanced Research Projects Agency, won't have any fix on what the new organization will be until after April 1, when he comes to Washington full time. As of now his only certain needs are a top-notch scientist who, he says, won't come from General Electric Co., and a military assistant.

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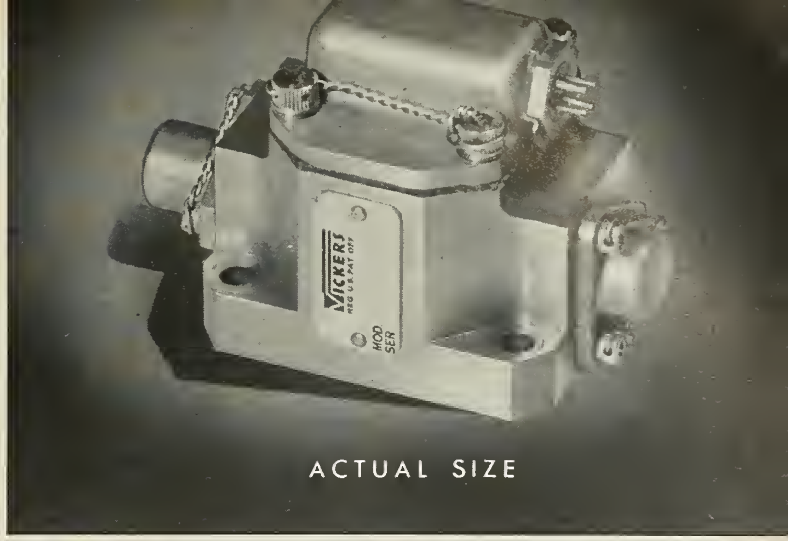

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2. Jet Engine Vane — Titanium — 27 lbs. — 15 inches.
3. Aircraft Support — Aluminum — 20 lbs. — 49 inches.
4. Aircraft Fitting — Aluminum — 282 lbs. — 86 inches.
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6. Missile Ring Splice — Aluminum — 54 lbs. — 20 inches.
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VOL. 3 NO. 3

MARCH, 1958

missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS

1958 Missile Materials Review

a report on industry use and development of present and future materials

by Alfred J. Zaehringer and Raymond M. Nolan.

TODAY THE AMERICAN missile industry has available a myriad of missile materials, many of which existed only on paper 10 years ago. Others, specifically developed for missiles, are, in some cases, only a few years old. Newcomers in the missile business expect this wide variety of materials, but oldtimers are prone to overlook some of the amazing properties available.

Day by day, new products are rapidly being added to this materials spectrum. These materials developments, coming at a critical time in our race with the USSR, now offer us two choices: we can take advantage of the ready availability of the new materials to offer superior missiles, or we can let these new materials fall by the wayside and thus fall even farther behind the Soviets, who are exploiting every conceivable new material and technique.

The key materials categories reviewed in this issue will be the old standby metals, the newer missile-age metals, the fast-moving plastics, ceramics, nuclear shield materials, and materials for lubricants and hydraulics.

Missile Metals

In the early days of rocketry, the fabricator was likely to make his rocket from any old chunk of steel or aluminum lying in the bare stockbin or in the scrap heap. Pre-World War II philosophy (and to a lesser extent during the war) seemed to be that the

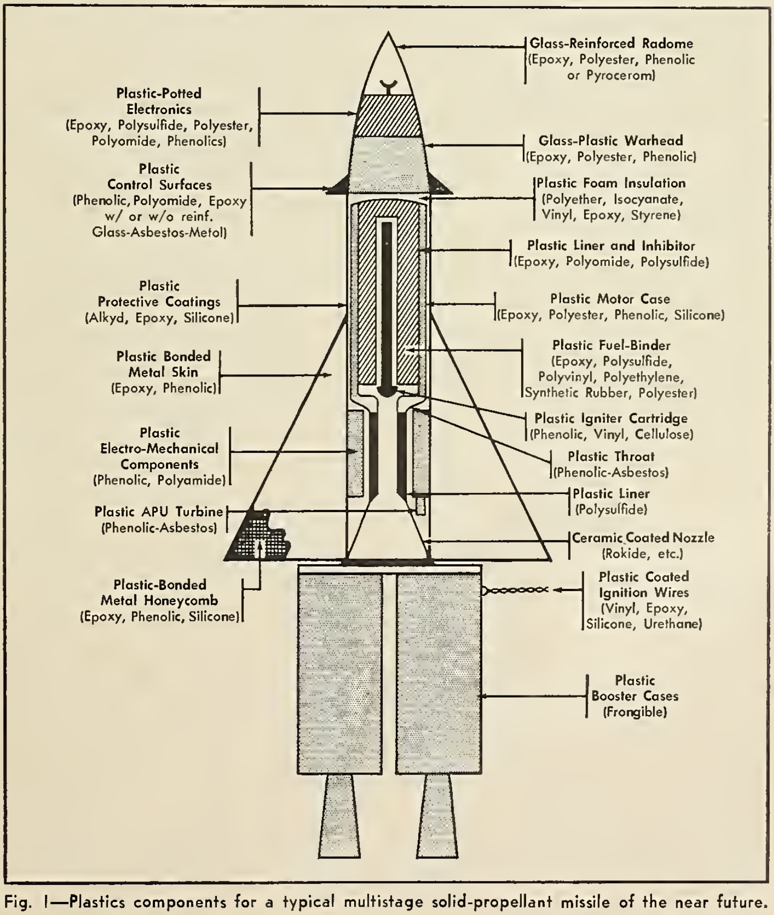


Fig. 1—Plastics components for a typical multistage solid-propellant missile of the near future.

Table I: Workhorse Metals

Metal	Melting Point (°C)	Boiling Point (°C)	Specific Gravity	Use
Aluminum	670	2057	2.7	Standard lightweight alloys
Chromium	1615	2200	7.1	Plating, stainless steel, high strength and corrosion resistance at high temps.
Cobalt	1495	3000	8.9	High-strength, hi-temp. alloys, supermagnets
Copper	1083	2300	8.9	Electrical conductor, alloys
Gold	1063	2600	19.3	Alloys, plating, solders
Iron	1535	3000	7.8	Steel, metal standard
Lead	327	1620	11.5	Solders, radiation shields
Magnesium	651	1110	1.7	Low-weight metals and alloys
Manganese	1260	1900	7.2	Alloy steels, Al, Cu
Nickel	1455	2900	8.9	Stainless steels, corrosion-resistant alloys (Monel, Inconel, etc.)
Silicon	1420	2600	2.4	Rectifiers, solar battery, iron alloys, silicones
Silver	960	1950	10.5	Brazing alloys
Tin	232	2260	7.3	Plating, solder
Zinc	420	907	7.1	Alloys, plating

rocket missile could only be justified if it could be made from the remnants of other weapons. Gradually, however, there evolved specific metals and fabrication techniques (many of them borrowed from the aircraft industry) which apparently reached their zenith during the critical shortages of World War II and the Korean conflict. Much to the chagrin of postwar missilemen, who had finally mastered the available materials, metals did not revert to the old standards. New propulsion systems, higher temperatures, higher flight speeds and newer materials again made the metal masters hop.

Aluminum, and to some extent the magnesium alloys, have gained somewhat in overall structural application, but the trend toward higher operating temperatures and high-Mach-number flight regimes has forced the swing back again to the steels.

Specifically, the stainless steels are now in the spotlight. Table I lists some of the workhorse metal elements. Steel is still our number one metal. However, the more exotic missile metals (Table II) are beginning to take shape and will find increased application, particularly in the nuclear field.

Here is a review of the metals scene as reflected over the past year:

Aluminum. High-Mach-number flight has dulled aluminum structural applications but newer alloys are coming up. According to Alcoa, the U.S. will consume three million tons of this metal by 1958. Typical of the new alloys is 5086, introduced by Kaiser Aluminum & Chemical (4% Mg, 0.45% Mn, 0.1% Cu), which is not affected by welding and whose tensile is 38,000-47,000 psi. North American Aviation's cast aluminum alloy, called Tens-50, which is slated for missile use, is being poured by Rayson Foundry in Los Angeles.

Beryllium. NACA Ames Aeronautical Laboratory believes that this metal has promise for ballistic-missile nose cones. It finds beryllium six times better than copper on thermal and weight bases. Beryllium is considerably better than graphite but has problems with brittleness and difficult fabrication techniques for large sections.

Chromium. This is still a vital component of most modern stainless steels.

Cobalt. Metal is commonly used in high-temperature superalloys.

Copper. Copper alloys such as bronze are getting a new, close look for missile applications. Ampco Metals of Milwaukee has introduced Superstan 40, an aluminum bronze, iron-manganese superbronze. Castings give tensiles of 98,000 psi while the wrought metal is 135,000 psi.

Hafnium. Hopes are that the reactor grade will drop from the present $50/lb. to $20/lb. AEC, Bureau of Mines and Westinghouse are optimistic about hafnium in reactor controls.

Iron. In the form of steel, iron is still the backbone of the entire metals industry. However, pure crystals of iron show exceptional properties. Westinghouse Research Labs has measured tensile strengths of 500,000 psi for thin hairs of pure iron.

In 1957, actual production of steel in the U.S. was 120 million tons; capacity, 133 million tons. Presently 15 million tons of added capacity are under construction. The quality of steel has never been higher. Ore reduction is underway with United States Steel and Bethlehem experimenting with a direct iron ore reduction process. Stainless steel is the iron leader, with $75 million going into aircraft and missiles in 1956, by 1960 up to $200 million per year. Currently, stainless steel runs about $2/lb. in common fabrications.

A new steel for Mach-4 flight—PH 15-7 MO by Armco Steel—will take temperatures of 1000°F. Ultimate strength at 1000°F is 129,000 psi. Composition is 15% chromium, 7% nickel, and 2.5% molybdenum.

Lithium. Present lithium cost is about $10/lb. Newest alloy is X2020, an Alcoa lithium-aluminum metal. It has high strength up to 400°F and is 3% lighter than conventional aluminum aircraft alloys. This Li-Al alloy could raise the flight cruise level from Mach 2 to 2.5.

Magnesium. Of the 61,000 tons of primary magnesium produced in the United States in 1955, 36,000 tons were used in structural applications. Alloyed with aluminum, it gives corrosion-resistant and heat-treatable metals. It is used in canning uranium fuel elements and is most vital in the production of titanium. Ten thousand tons of magnesium were used in titanium reduction processes in 1955.

The B-58 uses a magnesium-thorium alloy 33% lighter than aluminum that has good rigidity and is heat-resistant. Hot forming has aided sheet bending but machining is still a problem with this slightly radioactive alloy. Dow Chemical is now extruding large-diameter magnesium missile fuselages for the Air Force at Madison, Ill. In addition, Dow's presses can make 20-inch widths, 24-inch OD tubing and large "I" beams. Dow has also introduced its HM21XA-T8 magnesium sheet. Containing 1.5-2.5% thorium and 0.35-0.80% manganese, the magnesium alloy has a tensile strength of 20,000 psi at 600°F.

Brooks and Perkins of Detroit have delivered magnesium spheres for the *Vanguard* satellite project.

Manganese. Now going into stainless steel, this element is usually alloyed with small amounts of nickel. Types 201 and 202 manganese steel are comparable in properties to the standard 18-8 stainless.

Molybdenum. "Moly" is finding increased missile applications. The Naval Ordnance Laboratory (Silver Spring, Md.) has developed "Thermenol," a nonstrategic moly steel. It contains 3-4% Mo and 15-16% Al and has better strength over 450°F than RC 130A titanium alloy. "Thermenol" is 17% lighter than 17-7PH stainless and can be used for compressor blades, heating elements, and missile skins.

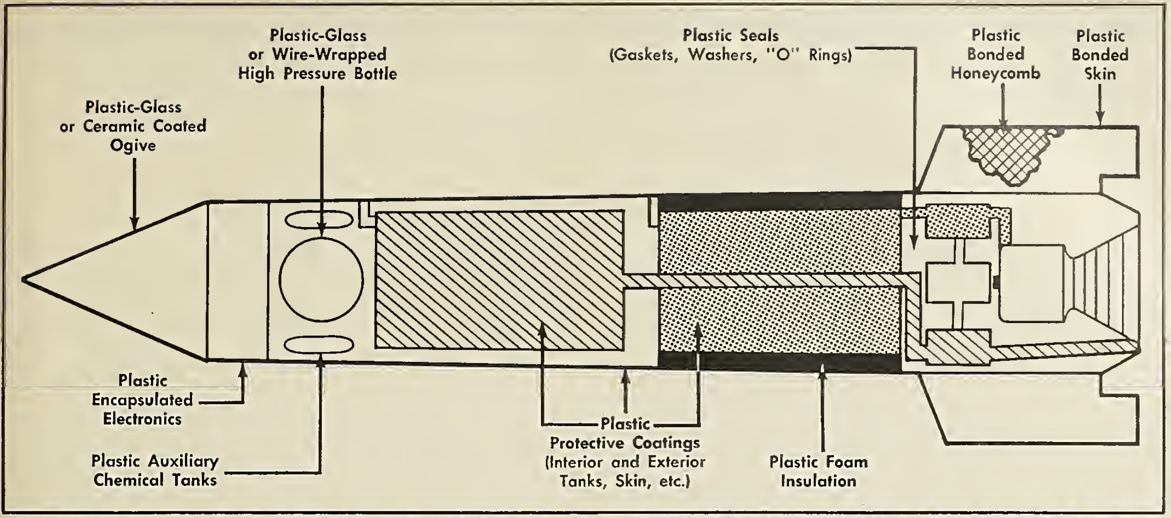


Fig. 2—Plastics components for a typical large liquid-fueled rocket. Some specialized missiles may be 85 per cent plastic in a few years.

Climax Molybdenum has come up with a 99.5% Mo, 0.5% Ti alloy which has high strength above 1600°F. (Tensile is 132,000 psi at room temperature and 88,300 at 1600°F.) The metal has also shown considerable promise as a slipper for rocket sleds and its performance may be related to the formation of molten molybdenum oxide, which has a low coefficient of friction.

Climax has been working for some time on a contract with WADC to develop oxidation-resistant coatings for moly. Several coatings (aluminum-chromium-silicon up to 2600°F, nickel base up to 2200°F) have proven satisfactory, but no coating has been developed which combines ballistic and thermal impact with good erosion- and oxidation-resistance.

Nickel. U.S. consumption of this high-temperature alloying ingredient was about 300 million pounds in 1957; by 1960 it will be 450 million pounds. It is widely used in turbine blade alloys and in stainless steel for missile skins. Haynes Stellite Co. (Kokomo, Ind.) developed a high nickel alloy (with chromium, moly, silicon, manganese, titanium and aluminum) which has a tensile of 90,000 psi at 1500°F and 22,000 psi at 1800°F. Meanwhile, International Nickel Co. predicts a nickel steel (possibly with vanadium, moly, silicon, titanium and carbon) with a tensile strength of 300,000 psi.

Niobium. Also known as columbium, this missile metal is a fast mover and many firms are scrambling to produce the element which might permit engine-temperature operating increases on the order of 500°-1000°F. Its immediate use would be for turbines, where it might make 2000°F operation possible. (Present level is about 1650°F.)

Use in nuclear reactors as well as rocket engines is seen. For example, the USSR already is said to be applying niobium for rocket engines. Kennecott Copper Co. is one producer of niobium ore with zirconium and hafnium as byproducts.

Westinghouse Research Labs is using a zone refining process to produce pure niobium. DuPont and Thompson Products are teaming up to develop fabrication techniques for high-strength niobium alloys. Also in the niobium race are the Bureau of Mines (now studying niobium separation methods) and a host of producers in various

Table II: Missile-age Metals

Metal	Melting Point (°C)	Boiling Point (°C)	Specific Gravity	Use
Beryllium	1350	1500	1.8	Cu and Al alloys, neutron moderator
Boron	2300		3.3	Hardening steels, boron carbide, delay action fuzes
Cesium	29	670	1.9	Ion rockets
Gallium	30	1600	5.9	Heat transfer for atomic rockets
Germanium	958	2700	5.4	Rectifiers and transistors
Hafnium	1700	3200	13.3	Nuclear reactors
Indium	155	2000	7.3	Seals, alloys, solders, neutron indicators for atomic rockets
Iridium	2350	4800	22.4	Electrical contacts, electrodes
Lithium	186	1220	0.5	Li-6 for H-bomb, heat transfer, alloys
Molybdenum	2620	3700	10.2	High-temp. metals and alloys
Niobium	2500	3300	8.4	High-temp. alloys
Osmium	2700	5300	22.5	Hardener for platinum
Palladium	1553	2200	12.6	Contacts, spark plugs
Platinum	1773	4300	21.4	Thermocouples, contacts, electrodes
Rhenium	3000		20.5	Thermocouples, contacts, electrodes, corrosion-resistant alloys
Rhodium	1985	2500	12.5	Thermocouples
Ruthenium	2450	2700	12.2	Contacts
Tantalum	2996	4100	16.6	Resistors, high-temp. alloys
Thorium	1845	3000	11.3	Nuclear fuel, alloys
Titanium	1800	3000	4.5	Alloys
Tungsten	3370	5900	19.3	Tool steels, filaments, high-temp. alloys
Uranium	1150		18.7	Nuclear fuel
Vanadium	1710	3000	5.96	Alloys
Zirconium	1900	2900	6.4	Corrosion-resistant alloys, low neutron absorber

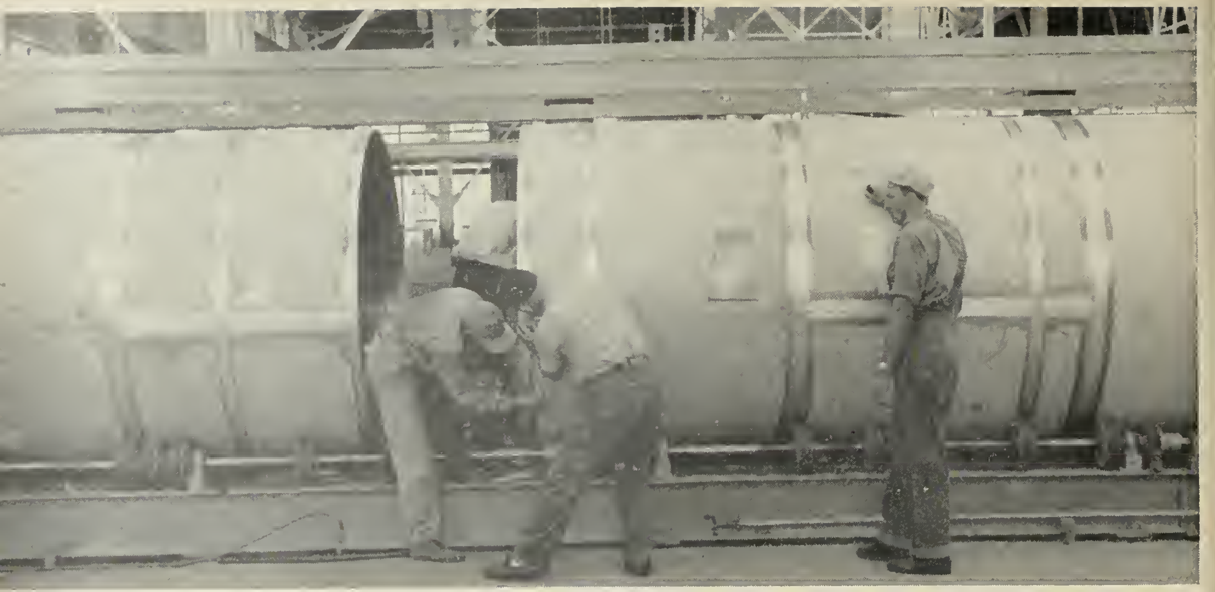


Fig. 3—Workmen welding sections of the JUPITER-C. New techniques have contributed many diverse uses of both old and new metals.

stages of production readiness (Kawecki, Electro Metallurgical, Horizons Titanium and National Research). Kawecki and Fansteel are said to be in actual production. Fansteel is supplying niobium to AEC, as is Shieldalloy.

Kennametal has supplied 7500 pounds of niobium to AEC; a like amount was delivered by the Wah Chang Corp. Biggest niobium aggregate shaping up will be the team-up of National Distillers & Chemical, Mallory & Co., and Sharon Steel Corp. to develop and manufacture niobium as well as titanium, zirconium, hafnium, and tantalum.

Rhodium. Sel-Rex Precious Metals of Belleville, N.J., has a new rhodium electroplating process which eliminates cracking and peeling. The Albany Plating Co. of Chicago uses rhodium for durable plates over brass.

Silicon. In addition to silicon going into steels and silicones, the purer forms have valuable nonstructural applications. Westinghouse Electric Co. is producing superpure silicon for resistors. The Raytheon Mfg. Co. produces silicon for infrared detectors. DuPont's facilities in North Carolina last year produced 50,000 pounds of semiconductor-grade silicon and 20,000 pounds of solar-battery grade.

Bell Telephone Labs has produced high-purity silicon by zone refining. This process uses commercial silicon at half the cost of the purer semiconductor grade. Bell uses the silicon for rectifiers and transistors.

Thorium. Used in nuclear reactors and for fuel elements, thorium is now produced at a 1,000-ton/year rate. AEC sells reactor-grade thorium for $20/lb. Metal Hydrides has produced pure thorium in a new iodide crystal process and forecasts a tonnage cost of $10-15/lb.

Titanium. Though its cost is still high in fabricators' hands (about $20/lb.), its high-temperature characteristics and lower density are making it standard for many missile applications. Titanium sponge is now at the $2.25/lb. level and hopes are to bring it to under $2/lb. soon.

Two new plating processes have been evolved which show considerable promise for missile hardware. The Missouri School of Mines, working under WADC contract, has a process for plating titanium on low carbon steel. The National Bureau of Standards and Springfield Armory have chrome-plated

Table III: Comparison of Metals and Plastics

Material	Density (lb./in.^{3})	Strength (psi)	Strength/Density Ratio
Mild steel	0.283	65,000	230,000
Aluminum (75ST)	0.10	85,000	850,000
Titanium alloy	0.16	90,000	560,000
Heat-treated steel alloy	0.283	180,000	635,000
Strongest steel alloy	0.283	225,000	795,000
Present glass-plastic	0.06	55,000	915,000
Future glass-plastic	0.065	75,000	1,150,000

Table IV: Thermosetting Plastics for Missiles

Resin	Estimated U.S. 1957 Production (million lb.)	Missile Uses
Alkyd	490	Coatings
Epoxy	36	Coatings, laminates, bonding, tooling, potting
Phenolic	580	Coatings, laminates, bonding, shell molding, tooling
Polyester	100	Laminates, radomes, potting, tooling
Silicone		Laminates, seals
Urea & melamine	340	Parts & moldings

Thermoplastic resin uses include films (cellulosics), windows (acrylics), mechanical parts (nylon), fixtures (high-impact styrene), paints & seals (vinyl), foams (urethanes), piping (polyethylene), seals (Teflon), etc.

titanium to give an oxidation-resistant, nongalling bearing surface.

Zirconium. Sponge production in 1957 was about 2.7 million pounds; by 1958, will be 5.7 million pounds. A partial list of 1958 producers includes United States Industrial Chemicals (2 million pounds), Columbia-National (0.8 million pounds) and Carborundum Chemicals (1.5 million pounds). USI has made available a non hygroscopic and nonpyrophoric zirconium in plate form, hafnium-free, in diameters up to one inch.

Plastics Push

Some twenty years ago plastics emerged big-scale on the materials scene. They have grown to a 4.5-billion-pound production item in the U.S. during 1957. By 1960, U.S. production will jump to 5.7 billion pounds per year. Yet plastics have had a difficult time breaking into the missile market. During World War II, the most that plastics contributed to rockets were igniter cases that vaporized in a few milliseconds.

Then reinforced thermosets came along. But how could a plastic be used at rocket temperatures when it "fell apart" at one-tenth that temperature? The early Chinese powder rockets gave us a clue. Black powder was burned at 5000°F in ordinary paper tubes. Some paper burned away, but the charring produced carbon, which prevented fast burning. This opened the door to plastic motors, nose cones, radomes, fins and fuselages. The key was the lower thermal conductivity of the plastic, coupled with charring or burning in parallel layers.

Thompson Fiberglass Co. of Los Angeles reports the following achievements for plastics in rockets:

a. Nose cones that can withstand 750°F for 30 minutes.

b. Fin units on high-Mach-number boosters that handle 2400°F for one minute.

c. Phenolic laminate rocket-motor guide vanes that withstand 4500°F for two minutes.

Also, Raybestos-Manhattan has developed an asbestos-phenolic turbine wheel which operates by direct impingement of solid-propellant exhaust gases (2000°F) for 45 seconds and meets spin tests at 100,000 rpm.

Table III compares plastics with metals, while Table IV lists some of the plastics now being used for missiles. Fig. 1 shows plastics components for a typical multistaged solid-propellant missile of the near future. In Fig. 2 we see that plastics are also making definite inroads on large liquid rockets. Some specialized missiles may be 85% plastic within a few years.

The "big four" in high-temperature plastic applications include:

a. Epoxy for 500°F and short time to 3000°F (4000° to 4500°F with phenolic).

b. Polyester to 400°F, with short time exposure to 3000°F.

c. Phenolic to 500°F, with short durations to 4500°F.

d. Silicone, 500°-700°F and short time to 5000°F.

Typical reinforcing materials used with these plastics are glass fibers ("Fiberglas") and asbestos and quartz fibers. Metal reinforcements have also been used.

The Materials Committee of the Defense Department is looking for the following improvements in plastics for missiles:

a. Reinforced plastics with greater rigidity and hot strength.

b. Cheaper fabrication costs.

c. More uniformity in properties.

d. Better design for reinforced plastics structures.

e. Introduction of more machine methods for high production rates.

Plastics are still expensive (steel $0.10/lb.; aluminum, $0.25/lb.; plastics $0.50-1.00/lb.), but costs can be expected to come down with higher production rates. However, in high-cost items such as missiles, properties are expected to play a dominant role. For example, a current supersonic missile fuselage is being laid out entirely with plastic and will weigh only half as much as a comparable metal unit. Glass-reinforced plastic missile radomes have already proven superior to just about all other materials up to 400°-500°F.

Some of the roles that plastics

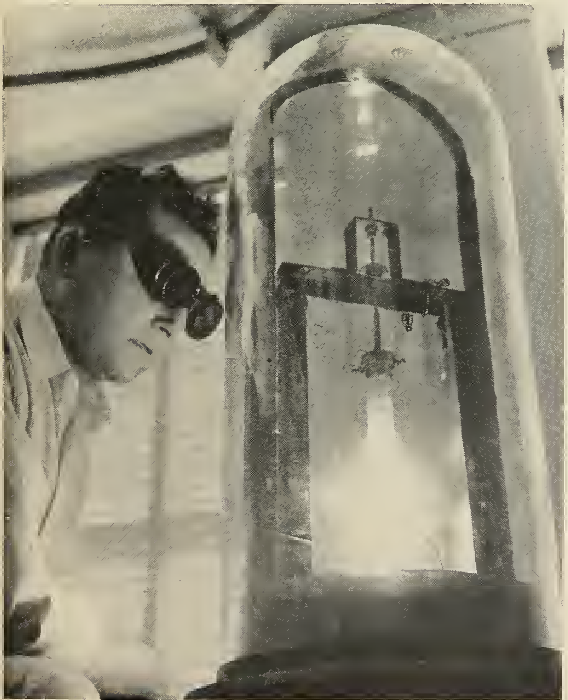


Fig. 4—Testing tensile strength of metals and ceramics.

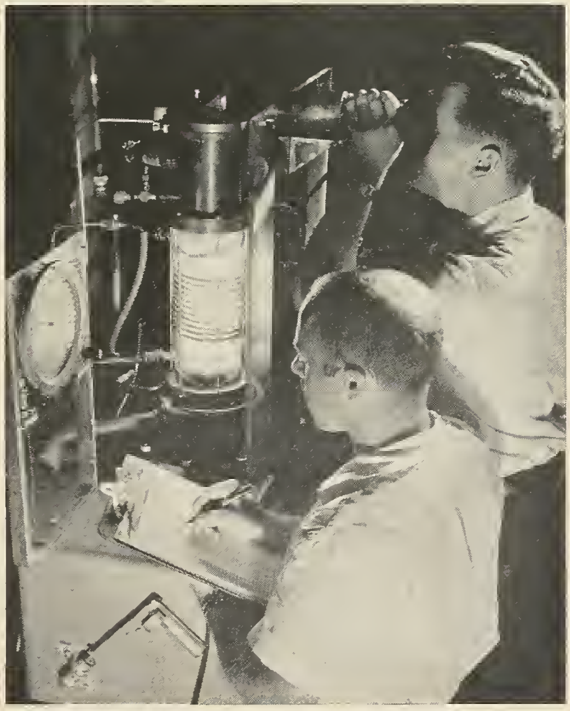


Fig. 5—Purifying niobium by the "cage zone melting" process.

already are playing are outlined below:

Aerojet-General Corp. The warhead on the *Nike-Hercules* will be glass-plastic, produced under a $1.8-million contract.

Bureau of Ships. This U.S. Navy group has put out the call for plastic dielectrics and potting compounds that can take 250°C. Soon it will need materials to sustain 500 hours at 350°C and later 3,000 hours at 500°C.

Carpenter Steel Co., Union, N.J. is turning to the production of chemical polyethylene pipe in one-half to four-inch-diameter sizes. Its PR-150 can take 150 psi at 75°F. The United States produced 55 million pounds of plastic pipe in 1956.

Continental-Diamond Fibre, Newark, Del., has plastic nose cones which can take sustained temperatures of 400°F, and also glass-base, metal-clad laminates of Teflon and epoxy for printed circuits.

Corwin Polymer Products, New Haven, Conn., is developing heat-resistant urethane foams in the 500°-600°F range. These foams can now withstand up to 400°F with only 2% volume change.

Dow Chemical Co. Silicone-glass laminates now used on the B-58 are being considered for *Jupiter* nose cones made of seven to ten layers. Tests show that four to five layers burn but the remainder maintain structural integrity.

Mic-Lin Co., Maple Shade, N.J. A Teflon plastic hose encased by a stainless steel braid can take 4000 psi at 500°F. It is flexible down to −100°F and comes in diameters of 3/16 to 1 1/8 inch.

M. W. Kellogg Co., in cooperation with BuOrd and Allegany Ballistics Lab, has developed entire motors (case, nozzle, heads) for solid-propellant RATO and booster rockets.

NACA and Forest Products Lab have done considerable work with metal-bonding plastics. They find epoxies give good strengths to 250°-300°F. Phenolic-cured epoxies have good resistance to thermal softening to 600°F and good resistance to thermal degradation for 200 hours at 550°F. Glass-cloth-plastic honeycomb cores have proven out at 500°-700°F.

Naugatuck Chemical. Polyesters with 10-25% maleimide result in glass fiber laminates with flex strengths of 36,000 psi while maintained at 500°F for one week.

Pastushin Aviation Corp. produces centrifuge-spun moldings of glass-plastics for radomes, missile containers and drop tanks. Present techniques permit production of sections 10 feet long of four-and-one-half-foot diameter. Wall thickness, up to one-half inch, can be controlled to ± 10% thickness. Typical properties of spun parts are tensile, 17,200 psi; flex, 30,700; specific gravity, 1.77. Twelve parts per week can be produced. Tooling leadtime is 45 days.

Raybestos-Manhattan. A six-and-one-half-foot-long (30-inch-diameter base) nose cone of asbestos-plastic that can stand temperatures of 1000°F is being produced for the *Vanguard* vehicle. Other plastic parts for *Titan, Tartar, Terrier, Sidewinder* and *Polaris* are in work.

Shell Chemical Corp. Its Epon 422 tape (epoxy-phenolic) is used to bond metal to core on B-58 panels and has operating temperature ranges of −70° to 500°F.

St. Louis University. Borazine (boron-nitrogen polymers) point to newer high-temperature plastics.

University of Tokyo. Prof. Hideo Itakawa reports the successful firing of

Table VI: High-temperature Coatings

Name	Company	Temp. Limit (°F)	Coating	Base	Uses
Flame Alumina A	Armour Research Foundation (Chicago, Ill.)	3650	99% Al_2O_3		Rocket nozzles, storage tanks
Flame Alumina D		3650	97% Al_2O_3		Pump housings
Flame Ceramic IA		>2500	Fe-Al-Ti	Al	
Flame Zirconia		4750	98% zirconia	Carbon	High-temp. impact
Flame Ceramics	Continental Coating Corp. (Chicago, Ill.)	3500	98.6% Al_2O_3 98% zirconia	Mg, Al, Steel	Rocket nozzles, combustion chambers, ducts, burners
		4500	TiO_2		
		3270	Cermets		
Flame Plating	Linde Air Prod. (NY., N.Y.)	1800	99% Al_2O_3	Steel, Al, Ti	Turbine seals
			92% WC, 8% Co	Mg, Mo, Cu	
Flame-rock Ceramics	Montzine Corp. (Chicago, Ill.)	3500	97% Al_2O_3		
Metallizing	Metalweld, Inc. (Philadelphia, Pa.)	1800	Nichrome	Iron, steel	Heat corrosion w/o S
			Nichrome + Al		Heat corrosion w/S
Rokide A	Norton Co. (Worcester, Mass.)	3600	98.6% Al_2O_3	Iron, steel, nickel alloys, copper, alum., Mo, C, Mg, Ti, etc.	Rocket nozzles, chamber liners, tailpipes, etc.
Rokide Z		4500	98% Zirconia		
Rokide ZS		3000	65% Zirconia 34% Silica		
Sprayweld	Wall Colmony Corp. (Detroit, Mich.)	1900-2225	A-B-Ni	Low alloy & mild steel; heat-treated stainless	Bearings
Thermospray	Metallizing Eng. Co. (Westburg, N.Y.)	3700	Al_2O_3	Metals & plastics	
		4600	Zirconia		
	Ryan Aero Co. (San Diego, Calif.)	3500	Ni-MgO	Stainless Steel, Inconel	Afterburners, combustion chambers

a plastic-glass solid-propellant rocket motor. Later rockets will be fired from balloons in IGY tests.

Ceramics Click

Age-old ceramics were known to have proper temperature-resisting properties needed for rockets. Rocketeers, realizing the shortcomings of metals and plastics, turned to the nonmetals (Table V) and found a wealth of high-temperature materials. However, most ceramics lacked the strength and the thermal shock-resisting characteristics of metals. Various techniques, however, were evolved for metal coatings (Table VI). Marriage of metals and ceramics has begun and large-scale rocket applications may not be far off. For example, NACA has mixed aluminum oxide in nickel to obtain good strength without extreme brittleness. The University of California and NACA have studied ductile ceramics such as magnesium oxide. Russia, too, is studying "alloys" of lattices of ceramics and metals and doing much basic research in flexible ceramics.

Some highlights of ceramic missile development include:

Air Force Cambridge Research Center points to silicon carbide transistors operating at 1400°C and frequencies of over 100 mc. Westinghouse and Armour Research are working on this project.

Buffalo Forge has developed ceramic filters in the 1500°-2300°F range which possibly could go up to 3000°F. Good shock resistance and pressures to 225 psi have been successful in submicron particle removal.

Climax Molybdenum Co. has developed a molybdenum disilicide coating for graphite rocket nozzles which gives protection against high-velocity oxidation up to 3500°F. The moly compound is mixed with a phenolic resin, applied to graphite, and heated to 4000°F, leaving a glazed coating.

Fairchild Camera & Instrument Co. has vacuum-evaporated ceramic films for coating camera potentiometers rated at 225°C, with special ones operating at 400°C.

General Electric Co. Borazon is GE's diamond substitute. Boron nitride made in a press at one million psi pressure and a temperature of 3000°F, the material is as hard as natural diamonds and will find use in industrial cutting tools. Borazon, unlike natural diamonds, has good high-temperature oxidation resistance.

Gladding, McBear & Co. Ceramics for radomes can now be produced at tolerances of ±0.001 inch. Aluminum oxide is sprayed on a chrome-plated mandrel, subjected to 30,000 psi and fired at 2200°F. Finally it is machined on a lathe with diamond tools. and then given a finish firing at over 3000°F.

Table V: High-temperature Nonmetals

Material	Density (g/cm³)	Melting Point (°C)
Hafnium carbide	—	4160
Tantalum carbide	—	4150
*Carbon	1.8-3.5	3500
Tantalum nitride	—	3360
Titanium nitride	—	3220
*Titanium carbide	4.3	3140
*Zirconium oxide	5.7	2900
Tungsten boride	—	2880
*Tungsten carbide	16.0	2820
Hafnium oxide	9.7	2812
Vanadium carbide	5.4	2810
*Thorium oxide	9.7	2800
Thorium carbide	8.9	2773
*Boron nitride	2.2	2730
*Silicon carbide	3.2	2700
*Beryllium oxide	3.0	2570
Molybdenum carbide	8.4	2570
*Magnesium oxide	3.7	2540
*Aluminum carbide	—	2200
*Aluminum oxide	4.0	2050

*Now being used or considered for use as a high-temperature material.

Gulton Industries, Metuchen, N. J. Aluminum (24-S and 75-S) can be up-graded to operating temperatures of 1000°F by a new ceramic coating of lithium borosilicate, lithium chromate, and lithium fluoride.

Kraus Research Lab., Cockeysville, Md. Porcelax is an aluminum silicate coating that is baked on at 350°-400°F. It is more resistant to mechanical shock than porcelain and can withstand 1000°F.

Linde Air Products Co. Synthetic sapphires up to three inches in diameter will prove valuable for IR transmitter applications and other infrared missile uses.

Servomechanisms, Inc. Potentiometers and capacitors are vacuum-deposited with ceramics such as aluminum oxide, making them good for 500°C temperatures.

Radiation Shielding

Already of growing importance in reactors, radioisotope handling and irradiation processes, radiation shielding materials for manned aircraft and rockets are receiving considerable attention. Two of the most effective shielding techniques employ distance and mass. Since distance is impractical in flight installations, the search has been for more effective shielding materials, particularly from neutrons and gamma rays.

Hydrogen is one of the best attenuators and captors of neutrons. Boron, lithium, silver, gold, mercury, iridium, and cadmium, among others, are all excellent neutron captors. Unfortunately, only the heavy elements such as uranium, thorium, lead, gold, tungsten, or tantalum have proven good gamma attenuators.

During the past year, three radiation shielding materials have been introduced:

Boral. Alcoa has dispersed boron carbide in aluminum-clad sheets. Neutron shielding power equivalent to 25 inches of concrete is provided by ¼-inch-thick sheets. The material will not stop gamma rays.

Boron stainless steel. Superior Steel Co., Carnegie, Pa. has developed this alloy (18% Cr, 10% Ni, 1% B), with tensile strength of 90,000 psi, which is 15 times more effective in stopping neutrons than ordinary stainless steel. It has been suggested that substitution of boron-10 might increase the neutron-stopping power. Again, this alloy is not a gamma-ray shield.

Leadolene. Produced by Telectro Industries Corp., Long Island, N.Y., this gamma shield consists of 95% lead dispersed in 5% polyethylene. Recent experiments with epoxy resins under gamma radiation up to 10^8 roentgens indicate that there is little change in heat distortion and compressive properties. Highly hydrogenated plastics may provide a breakthrough for lightweight gamma shielding.

Lubes

Present lubricants must operate over a temperature range of −65° to 165°F. According to the Wright Air Development Center, the operating temperature will soon be up to 500°F —a temperature at which conventional hydrocarbon lubricants and hydraulic fluids break down and cause a multitude of operational troubles. And, says WADC, in 5 years we will need lubes operating at 1000°F.

Organics are now getting temperature stability from compounds of boron, phosphorous, fluorine and silicon. Here are some of the materials being investigated for high-temperature lubes:

American Potash & Chemical: phosphinoborine (phosphorous-boron compounds).

Ethyl Corp.: stannoliloxane (tin-silicon).

General Electric: "Versilubes" (silicones) for use above 450°F (575°-700°F); being studied for use on chemical bomber WS-110A.

WADC: tetra substituted alkylsilanes (now in the advance testing stage as a hydraulic fluid); fluoroalkylsilanes; ferrocene.

Beyond these, liquid metals are being suggested as ultratemperature lubes and hydraulic fluids.★

Market Analysis for the Missile Industry

an analytic approach to planning

by **Douglas S. Evered**

FOR EACH of the past six years United States defense expenditures have been between 35 and 43 billion dollars. This has made the Federal Government the largest single customer available to U.S. industry. During 1957 an economy-minded Congress and seemingly earnest disarmament talks made the future of this annual expenditure seem uncertain. Cutbacks, stretch-outs and layoffs became common as belts were tightened. The advent of the *Sputniks* and Soviet ICBM threats did much to dispell the belief that sudden death from precipitous disarmament was in store for defense industries. However, their presence did little to halt one trend in defense procurement —the shrinking market for military aircraft that has accompanied the swing towards missiles.

Competition in the Missile Industry

Automobile Companies	
Ford	Aeronutronic Systems—parent company allocated $10,000,000 for *Far Side* project
Chrysler	Production contract for *Redstone* and *Jupiter* missiles for U.S. Army
General Motors	Powerplant production for Martin *Matador* and Chance Vought *Regulus* missiles—AC Division—guidance equipment for *Thor* IRBM, *Matador* and *Regulus*
Studebaker-Packard Corp.	Aerophysics Development—*Dart* missile for U.S. Army—high-altitude sounding rockets
Rubber Companies	
Firestone	Prime contractor for *Corporal* missile for U.S. Army—missile development by J.P.L.
General Tire	Aerojet-General Corp.—rocket engines for Martin *Titan*—high-altitude research rockets
Goodyear	Goodyear Aircraft Co.—Akron—guidance for Martin *Matador* missile
Unclassified Competitors	
Kaiser Industries	Contracts for guidance systems development at Toledo—contracts for missile electronics at Richmond, Va.
Bendix Aviation	*Talos* prime contractor for U.S. Navy. Also *Talos* L for USAF
Minneapolis-Honeywell	Inertial guidance systems
Thompson Products	40% control of Ramo-Wooldridge Corp. (responsible for Convair *Atlas* and Martin *Titan* ICBMs and *Thor* IRBM)
American Machine & Foundry	Ground support equipment
American Bosch	Arma Co.—guidance systems
Avco	ICBM nose cone research
General Electric	*Vanguard* first stage—production of rocket motors and ICBM nose cone
General Mills	Inertial guidance systems

Electronic Companies with Missile Contracts

Sperry RCA Motorola Western Electric Philco-Raytheon

Aircraft Companies with Missile Departments

Beech	Bell	Boeing	Chance Vought	Convair
Douglas	Fairchild	Hughes	Lockheed	Martin
Northrop	North American	Republic	Ryan	

Recent events undoubtedly mean that more money will be forthcoming for defense. Much of the money Congress is being asked for will go into missiles but it will have to be spent in what has become a highly competitive market.

Over the last few years a steady stream of competitors has been attracted by the missile bonanza. What was formerly the exclusive domain of the aircraft manufacturer is now inhabited by automobile companies building complete missile systems, food companies developing guidance equipment and tire companies manufacturing rocket engines. The result is a healthy competitive situation in the missile business. Putting the Departments of the Army, Navy and Air Force into a buyer's market for missiles is unquestionably good for the country. It means more defense per dollar of the taxpayer's money. It also means that realistic companies have had to seek ways to strengthen their techniques for getting their share of new missile business.

Next to maintaining a first-rate scientific and engineering capability, a specialized form of market analysis is the most useful device for bolstering the business-getting capability of a missile manufacturer. By providing management with reliable predictions of future missile markets, it can play a significant role in coping with the competitive situation which has developed. Take for example that important question of company-financed studies of new system requirements. No missile company can afford to study them all, and missile market analysis can ensure that funds set aside for this purpose are spent most wisely.

Generally speaking, new missile projects must represent a substantial advance over existing systems or meet some new operational requirement before they are funded. To achieve such advances means being aware of technological development and incorporating the findings of research into new designs. Indeed, many missile manufacturers spend sizeable amounts of their own money on the basic research which brings about technological advances. This directed effort can be pointed by missile-market analysis.

The diverse nature of the specialized activities which make up missile-market analysis explains why, in many missile companies, no formal market-analysis function is defined. Instead, the various studies made in a complete search for new business have their findings synthesized and used by departments with a wide variety of titles—Military Requirements Section, Long-Range Planning Section, Development Planning Section, Military Liaison Section, Military Contracts Section, Proposals Section, Customer Relations Section—to name some of the more familiar titles. In any one of these organizations, aspects of market analysis are likely to be going on in perhaps an unrecognized, or at least ill-defined, manner. Only where the possibilities of market analysis have been *recognized* and *defined* can the device function with the best results.

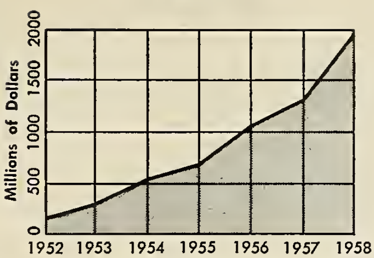
What then are the steps in effective market analysis for the missile business?

They begin with the close monitoring and evaluating of the technological developments being made by industry, universities and governmental scientific organizations such as the National Advisory Committee on Aeronautics. As already indicated, this step is often enhanced by basic research activity within the company. The application of technological development to future missile systems is the purpose of this type of analysis.

A second step consists of becoming aware of military planning through close association with those agencies which directly or indirectly determine future requirements. This is a liaison aspect of market analysis. Both in a formal and an informal manner, relationships must be established and strengthened with agencies such as ARDC, AMC, ABMA, TAC, SAC, ADC, WSEG, AFDAP, AFMLP, ONR, OSR, RAND and OEG.

The market analysis process also must include the study of pertinent economic factors. Federal fiscal policies, defense appropriations and the funding

Missile Funds



expectations of existing and planned systems must be projected and measured against the background of a general economic forecast. In this way the potential volume of future missile business and that share the company should expect to get can be determined.

Although the foreign political situation is cloudy much of the time, attention must be paid to this subject for the rather obvious reason that missile procurement is undoubtedly influenced by international tensions. Insincere smiles or bravado statements by Soviet leaders profoundly, though perhaps indirectly, affect the future of missile procurement. Insight into basic political motives and the immediate and eventual outcome of pursuing them must be obtained and injected into the analysis.

The desires, capabilities and limitations of the missile manufacturer to become associated with new projects must certainly be taken into account in market analysis for missile business, as must the equally important factor of the customer's view of the missile manufacturer's availability to take on new work.

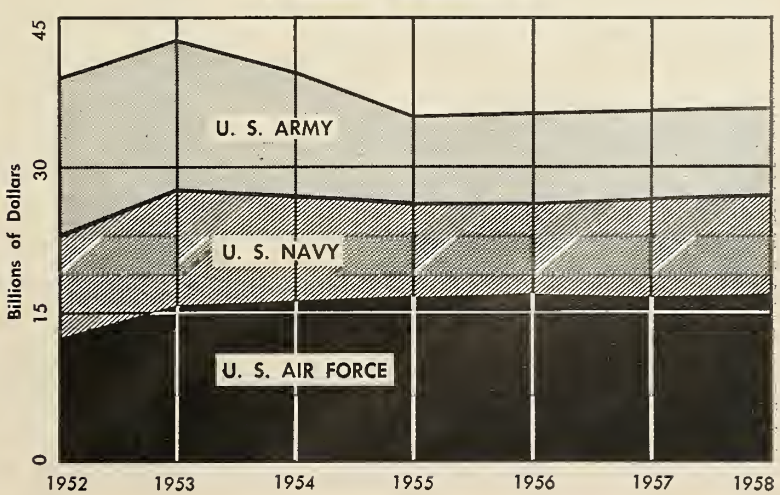
Finally, the activities of competitors must be monitored to determine their effects on the likelihood of obtaining future contracts.

It must be obvious from this review of the ingredients of missile market analysis that a team approach has to be used. The team must include physical scientists to compile and evaluate technological developments, social scientists to investigate economic and political factors and military experts to interpret military planning. The team must be attached to the policy-making level of the company so that it will be both intimately aware of the basic philosophy of the enterprise and able to present its findings and recommendations to the policy-makers.

Equally obvious is the fact that not all companies will conduct missile market analysis in great depth. Some companies may lack the resources for basic research or may not see the wisdom of preparing themselves to take on advanced projects through obtaining a full understanding of the total missile market. Other companies attempt to achieve a sufficient degree of understanding by reliance on the work of their liaison staff. However, unless all of the influencing factors are taken into account, the results of missile market analysis are likely to be disappointing. When the additional usefulness of the market analysis team for exploring diversification opportunities is recognized and used, their presence in well-managed missile companies can readily be understood.

Comprehensive market analysis for the missile business begins with the collection of quantitative and qualitative data and proceeds through analysis and the application of seasoned value judgment to arrive at findings and recommendations for management. It is a process which does not displace the intuition which has largely shaped the growth of American competitive free enterprise.★

U.S. Military Expenditures



How Good Are Free Radicals?

laboratory device or new propulsion system?

by **Erik Bergaust**

RIGHT NOW, free radicals do not offer the hope of a practical, high-energy, high-density rocket propulsion system. They are becoming an important research tool in the laboratory but propulsion systems are a long way off. A big breakthrough has to be made in stabilization and, possibly, in production. Production techniques are just being discovered, while techniques for stabilizing these energetic chemical fragments are very few.

Rocket engineers have long looked to free radicals for performances of two to five times greater than conventional redox (reduction-oxidation) or combustion systems. However, laboratory preparative techniques have been slow in coming.

The famous German chemist, Justus von Liebig, offered the concept of the radical as a group of atoms that acted as a unit in a chemical reaction. Liebig and Wöhler worked on the benzoyl radical. (In 1828 Wöhler made the first lab synthesis of an organic compound.) In 1900, at the University of Michigan, Moses Gomberg prepared an organic free radical—triphenyl methyl—a giant fragment that can live for days. By 1929, Paneth and Hofeditz broke down tetramethyl lead into lead metal and free methyl radicals.

Free radicals are fragments of ordinary, stable chemical molecules (Fig. 1). These molecules can be "cracked" by applying energy—heat, electric discharges or radiation. Free radicals (unlike ions) are electrically neutral and are usually characterized by an odd number of electrons in the outer shell. Free hydrogen would have one electron, methyl nine, hydroxyl nine and chlorine 17.

Free oxygen, however, has two unpaired electrons—leading to extreme reactivity. The radical with an odd unpaired electron seeks a more stable level and also accounts for extreme

A. H_2 + Energy (92,910 Btu/lb) → 2H → H_2 + Energy (92,910 Btu/lb)
Breaking molecular hydrogen into free or atomic hydrogen required energy. This energy is released when the molecule is reformed. Without combustion this technique would allow tremendous concentration of energy for rockets.

B. H_2O (HOH) + Energy → H + OH (Hydroxyl)

C. CH_3OH + Energy → CH_3 (Methyl) + OH

D. O_2 + Energy → O + O

E. NH_3 + Energy → NH (imine) + H + H

Fig. 1—Examples of free radicals: A illustrates most energetic systems. Others are B, water; C, alcohol; D, oxygen; E, ammonia.

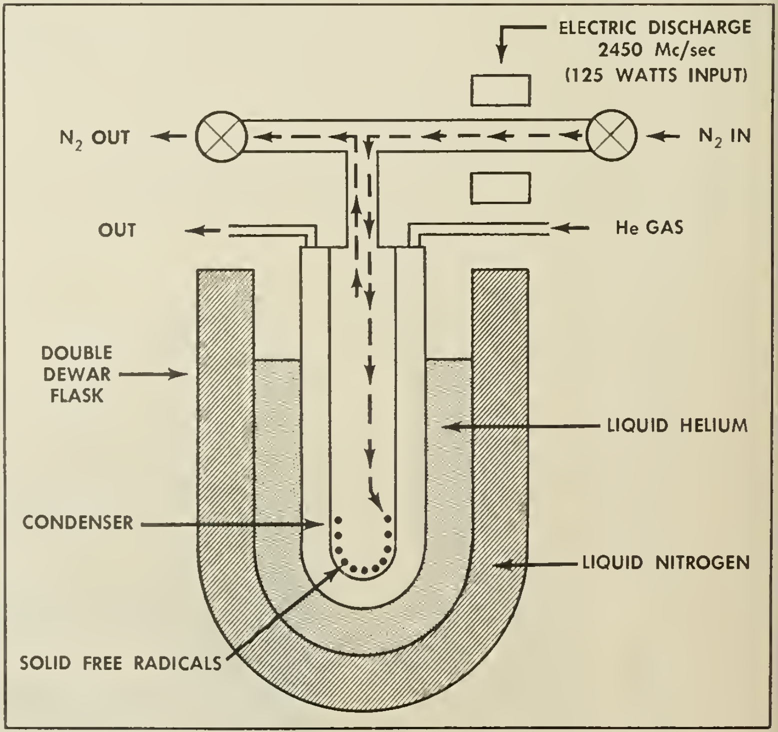


Fig. 2—NBS free radical technique. (Note: Liebig, advocate of the free radical, has also made the present lab prep possible. Condenser above is an adaption of the Liebig Condenser.)

reactivity. The energy residing in the free radical systems seeking the more stable parent molecule is very great (Table I) and is considerably greater than ordinary redox reactions.

Typical theoretical performances (based on recombination alone) are presented in Table II. After recombination into molecules, additional performance increases can be effected by the use of standard combustion techniques.

In 1948 at Catholic University, a free radical research technique, now standard, was accidentally discovered. There Francis Rice used heat to decompose hydrazoic acid (HN_3) into nitrogen and the imine (NH) radical. At liquid-nitrogen temperatures (77°K) or at approximately −320°F blue imine radicals were frozen out. Absolute zero (0°K) is −273°C (−459°F), or that temperature at which molecular motion ceases.

In 1954 Herbert Broida and John Pelham of the National Bureau of Standards sent an electric discharge through nitrogen gas and condensed out a solid at 4.2°K. Visible radiation from this solid has been interpreted as coming from atomic and molecular nitrogen. Fig. 2 shows the NBS Dewar collection system for free radicals.

The electric discharge breaks down the molecular nitrogen into atomic nitrogen. Free nitrogen is condensed as a solid at the bottom of the apparatus. With flow rates of 10 to 200cc/min, the solid glows green but turns yellow at the higher rates. Local warming causes brilliant blue flashes from the surface as the nitrogen goes back into its normal state and releases large amounts of energy. NBS has also prepared atomic oxygen and hydrogen.

From this early work, free-radical research projects have branched out to include the following:

National Bureau of Standards has underway a three-year program supported by the Department of Defense for the formation and stabilization of free radicals. The NBS project is unclassified and is a center for university and industry free-radical research. Several large firms have stationed scientists at NBS to aid research.

Air Force Office of Scientific Research is sponsoring free-radical research.

Army Office of Ordnance Research is also sponsoring such research.

Applied Physics Laboratory is working on the stabilization of hydrogen atoms trapped in solid hydrogen at 4°K.

Aerojet-General Corp. has been working on a free-radical AFOSR project since 1954. The firm is aiming for production of ammonium azide via hydrazoic acid and the imine radical.

General Electric Co. Rocket Engine Section at Cincinnati has been calculating performance of free radicals for Army Ordnance.

Naval Radiological Defense Laboratory has undertaken irradiation of ethyl and methyl alcohol with high-intensity sources at liquid-nitrogen temperatures.

Office of Naval Research is also supporting free-radical research.

Other free-radical research work includes:

Atomic Energy Commission at Oak Ridge has irradiated frozen sulfuric acid with cobalt 60.

Caltech scientists are depositing molecules at 20°K and irradiating them to study possible new reactions.

Monsanto Chemical Co. has worked at NBS in blending gases to react with free radicals.

Olin Mathieson is studying the reaction of free radicals at NBS on various surfaces such as tungsten.

University of Lyon is working on the prism spectroscopy of free radicals at NBS.

Washington University suggests free radicals as an important energy step in the process of photosynthesis.

The USSR has been very active in the free-radical area. The Reds have reported production of atomic oxygen, nitrogen and hydrogen. Organic free radicals have been studied along with free-radical boron compounds.

The Soviets are especially interested in combining small amounts of free-radical fuels in conventional solvents, thus producing a two-step propulsion system. Considerable work has been evidenced in the OH and the HO_2

Table I: System Energies

Fuel	System	Heat Content (Btu/lb)
Atomic hydrogen	Nonredox	92,910
Molecular hydrogen	Redox	52,000
Diborane	Redox	32,000
JP-4	Redox	18,000

Table II: Free Radical Performances*

Radical (mol)	Diluent (mol)	Molecule	Specific Impulse (sec)
1 NH	2.8 H_2	NH_3	410
1 CH	5.0 H_2	CH_4	510
1 H	1.7 H_2	H_2	775
H	H	H_2	2160

*Nonredox systems

Table III: Concentration Versus Performance*

Free Radical Concentration in Diluent (mol %)	Nonredox Specific Impulse (sec)		
	O in O_2	He* in He	H in H_2
5	60		200
10	100	300	400
20	140	360	580
40	190	500	800
60	225	625	950
80	250	730	1040
100	265	800	1210

*Frozen equilibrium as calculated by GE

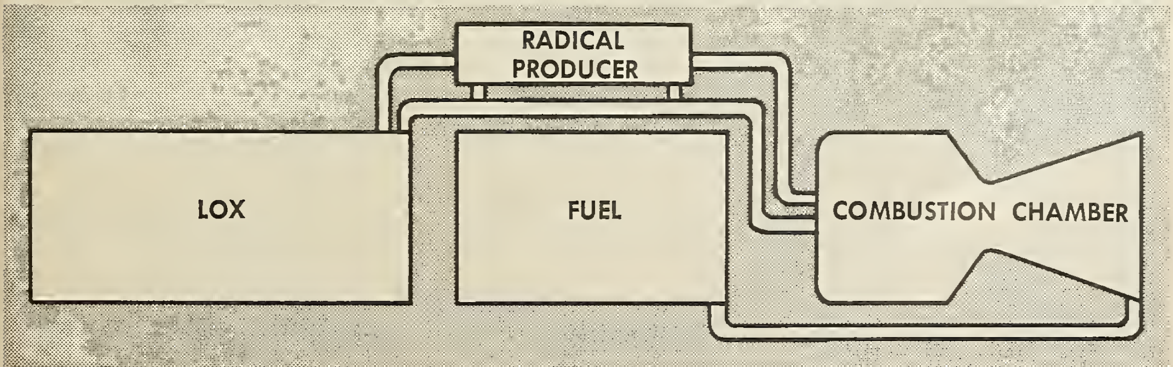


Fig. 3—Example of two-step propulsion system. Relatively small amounts of oxygen gas are fed into a jacketed free-radical producer. Atomic oxygen is fed into combustion chambers where conventional oxidant-fuel (redox) system is also operating. Such a system might offer immediate increases of about 50 seconds until more is learned about stabilizing high concentrations of free radicals.

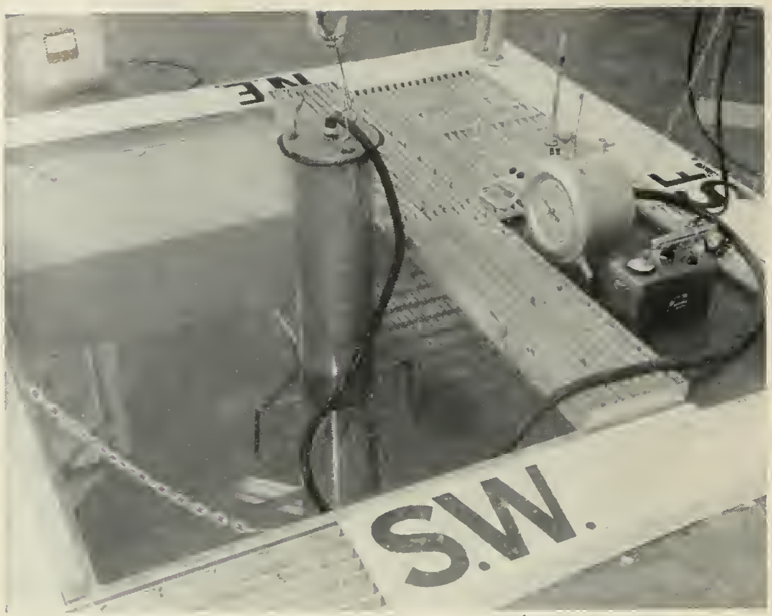


Fig. 4—Production of free radicals by gamma ray bombardment in a cobalt 60 source.

radical. Russian work with hydrogen superperoxide synthesis, possibly a polymer of the HO_2 radical, has been under way for several years. Several research teams in the free-radical scene have been in operation at least since 1950.

Almost all free-radical work employs cryogenics (ultralow temperatures) at low pressures. The theory is simple. At very low temperatures kinetic movement is very slow. If the pressure is kept down, the fragments do not bombard one another and hence lose energy.

This theory may make practical application difficult if not impossible. For example, a jump of a few degrees Kelvin for free radicals is like thousands of degrees for ordinary chemical systems. Warming a free radical from 4°K to 25°K is equivalent to a jump from room temperature to that of an acetylene flame. And performance drops with increasing radical size.

The large, stable fragments do not offer good performance as such (Table III). Hydrogen is better than helium or oxygen. However, after free radicals revert back to ordinary molecules and release energy, the recombined molecules are still available for further energy release via combustion reactions. Almost any conventional propellant system could be improved performance-wise by a free radical "spike" (Fig. 3).

In addition to the critical stability, concentration is also important. Present free-radical concentration estimates are about 0.1 per cent by electron spin resonance methods and up to one or 10 per cent by chemical or calorimetric methods. Thus, say, incorporation of about 1 per cent atomic oxygen in liquid oxygen might jack up rocket impulse by about 50 seconds.

Present lifetimes of free radicals leave much to be desired. At pressures of about 1 mm Hg, NBS figures a lifetime of about 15 seconds for free radicals. With decreasing temperature, the lifetime increases. GE figures that metastable neon has a half-life of about 25 seconds at 10°K, many years at 5°K.

Because of these facts and because of lack of sophistication in the field, Dr. Broida said recently that the odds do not now favor free radicals as practical, high-density, normal-temperature propellants. Perhaps this grim picture could change if better stabilization techniques were evolved. Such stabilization might result from new solvent systems, protective colloids, or occluded solids. It might even take the form of free radicals trapped in a solid propellant, as recently suggested by H. W. Ritchie of Thiokol. However, before we can use free radicals in a rocket we must learn much more about them. This takes years.★

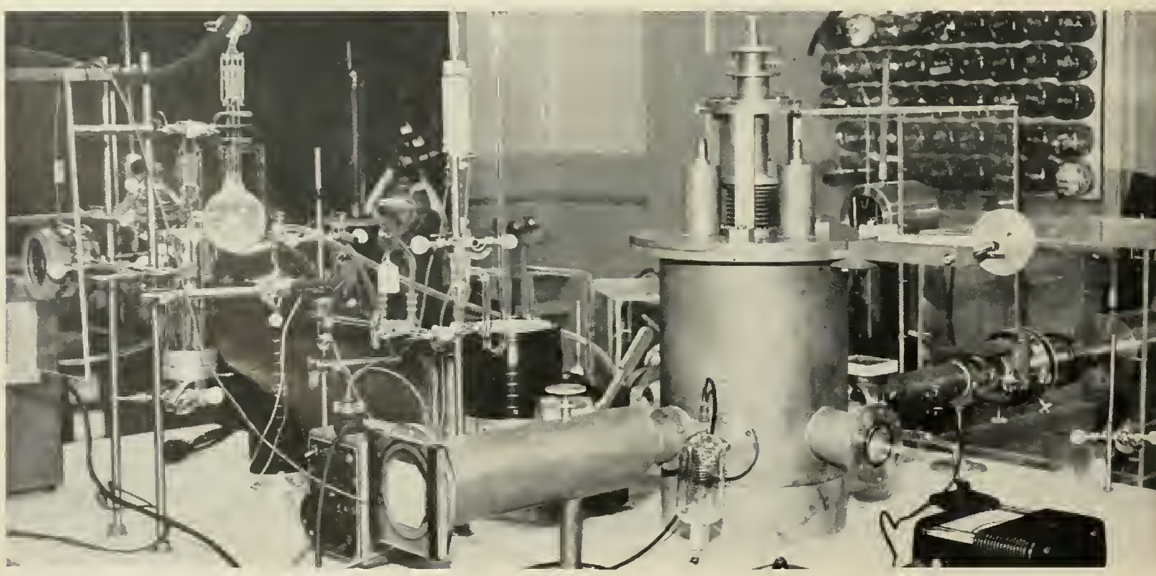


Fig. 5—Electron diffraction apparatus for studying and producing free radicals.

SELLING MISSILES

by Seabrook Hull

The scramble in the missile marketplace is getting louder and rougher. Everyone wants to get into the act. Some answers to "how to get in the missile business" involve some pretty extreme answers—even to the point of buying one's way in. However, one conclusion is general: the missile business is big already and getting bigger all the time. It's also a profitable one in more ways than one.

Some companies have been in the missile business from the beginning. Airframe-makers, for example, were some of the first, because it appeared at the time that they were a likely place from which to buy missiles. "After all, like airplanes, they fly too, don't they?" However, it was soon apparent that it wasn't all that simple, and others were brought in. Forging, machining, welding and heat-treating, for example, to a large extent took the place of casting, sheet-metalworking and riveting. Since then some of the "unlikeliest" kinds of companies have emerged playing a major role in the burgeoning industry. Now the pull of the swelling dollar sign is drawing them in by the hundreds. Competition gets tougher daily.

There are a few basic across-the-board rules for getting into the missile business. First, and most obviously, study the market. Find out what's wanted; who's already in the business; who is doing the subcontracting; who are the vendors; how much money is involved; and which agencies have it to spend.

Next, compare the requirements with your facilities, both human and capital. Have you the equipment for supplying any of the market's needs? These are elementary approaches to any business. They apply just as much to rockets and missiles as they do to anything else.

If you find your capabilities fit the market's needs, get out and sell. Sell! This again is just as vital in missiles as it is in, say, plastic combs, automobiles or ladies' underwear. And in selling, there's no real substitute for being on the spot in person.

If you're just starting out, you'll probably have better luck breaking into the business if you content yourself with first becoming a subcontractor or vendor. This means getting in touch with the purchasing officers and/or project managers of those companies with prime or large subcontracts. You can get a list of these from the Department of Defense.

In making this contact, remember that the man you're trying to sell is busy, may not be all that bright, talks to dozens of other people trying to sell precisely the same services or products that you offer. In other words, make your proposal clear, concise and to the point. Offer a specific product at a good price and with confident guarantees of top quality and on-time delivery. These points should be obvious, but the number of people who wander vaguely in with bland statements about "I've got so and so facilities. What can I do?" is appalling.

Now maybe, your capabilities don't exactly fit the missile market requirements. This doesn't necessarily mean you're out of luck. For example, most missile metals require a density not attainable in normal casting processes. But casting is a valuable mass-production technique. Thus, one possibility here—to start—is to get a research contract to determine (a) just where casting can and cannot be used and (b) develop more suitable casting methods.

In other words, if your processes seem in danger of being bypassed by the missile age, get the Government to pay you to find out how it can be kept in the industrial complex. However, be specific in your proposal and don't be too ambitious (greedy) on the first go-'round. Figure a program that will bring solid results quickly and inexpensively—and will provide a reason for a bigger, more costly program to follow.

Government contracts below, say, $25,000 can be approved by a division chief. As the sums get higher, the redtape they encounter mounts rapidly. It may not be much money, but it's a toe in the door and often a very good way to start.

Another technique that works is to bid on a job that you know you will lose money on—bid so low you know you're bound to get the contract. Perform well, and it will be a lot easier to sell the next time—at an equitable (profitable) price. This is really buying your way in.

Some companies are getting into the missile business by buying or merging with other companies that are already in the business. There's been a lot of this sort of thing lately. Still others get together in groupings where, between them, they offer a comprehensive ability. This is a device for those who already know the missile business but who want to improve their competitive position. A recent action involving both of these devices is the merger of Thiokol Chemical Corp. and Reaction Motors Inc., on the one hand, and Thiokol's agreement with Callery Chemical on the other. The merger gives Thiokol both solid- and liquid-rocket capabilities; the agreement gives both rockets high-energy boron fuels.

The business of studying the market carefully can't be overemphasized. So many peculiar problems plague missile development and production, there is no way of forecasting just where a better solution will come from.

For example, take solid-propellant rockets. There are two real posers which beg solution. Most solid-propellant grains (the actual charge) are bonded with a rubber-base material. Below certain temperatures, these get brittle and crack and instead of a rocket you get an explosion when you fire it. This means that solid rockets have to be heated when transported through cold climates. This is costly and a nuisance in the field.

One company, however, has come up with a rubber polymer that retains its characteristics (including flexibility) down to –120°F. This could be a valuable answer to a tough, costly problem. It could also mean profits to the developing company. First step, get a contract from the Government to see how it works as a binder.

These are just two examples of what researching the market can bring up. There are thousands of such problems plaguing the missile industry. Helping to solve them is one way to break into the business. But again, be specific in stating exactly what it is you propose to do and how you plan to set about doing it. There's a place for you in missiles, if you just go after it the right way.★

SPUTNIK NOT SO SECRET

by Dr. Victor P. Petrov

The first Soviet Sputnik *surprised us on October 4, 1957, when it was successfully launched by Soviet scientists and went into orbit around the earth. In addition to the initial surprise of the launching of this satellite, we were shocked to learn that they had managed to put into orbit a vehicle more than eight times heavier than the one we expect to launch in March. Then, another surprise—the launching of the second* Sputnik *on November 3, 1957, weighing (according to Soviet sources) more than a half ton and containing a live dog, as Soviet Academician Sedov had predicted (m/r, Nov. 1957). This time the satellite weighed almost 50 times as much as ours, which was still on the ground.*

We know very well that the Soviets are secretive, and the officials of the International Geophysical Year program probably were peeved at the Soviets' inability to supply the organization with particulars on the scientific instruments aboard *Sputnik* I. American Minitrack stations had to make hurried changes *post factum*, after *Sputnik* I was already in its orbit. However, knowing this tendency of the Soviets, we should have been more alert. A diligent and painstaking study of Soviet periodicals, and especially technical and scientific magazines, could have given us some valuable information.

For example, we were indignant at the Soviet scientists' failure to inform us beforehand of the frequencies on which the radio transmitters of *Sputnik* I were to send their messages back to earth. However, even with all this secrecy, we could still have learned about their plans to use frequencies of about 20 and 40 megacycles. The June 1957 issue of the magazine Radio, published for the benefit of Soviet radio amateurs, specifically mentioned that the first earth satellite would have two radio sets operating on these frequencies with about one watt strength. Furthermore, four months before the launching we could have learned that the radio messages from the satellite were to be of 0.05- to 0.7-second duration and spaced in such a way that the messages on one wave length would emanate during the pauses on the other.

This same article also explained that changes in the physical conditions during flight would cause a consequent change in the form of the transmitted radio signals, but that these changes would be discernible even to amateur radio operators. To assist the amateurs in recognizing the possible forms of transmission and changes in them, a chart was provided. This chart, resembling an oscilloscope image of the signal, would have been of great help to our scientists if available to them at the time. The article even alerted the amateurs to watch for the radio signals transmitted by the satellite.

Another article in the same issue of the magazine impressed on the radio listeners the importance of recording the *Sputnik* signals on a magnetic tape and synchronizing it with the exact time. The length of dots and pauses thus registered would give valuable information about certain processes on the *Sputnik* itself.

Sputnik II, of course is more interesting, if only for the fact that it is of greater dimensions and weight and carried a live dog. The greater space within this satellite allowed for more instrumentation. It should be noted that the dog was not sealed in the satellite without preliminary and extensive experimentation. We had, of course, known that the Soviet scientists were experimenting with dogs in rockets but information was fragmentary. In June, 1957, detailed information on these experiments could have been obtained from the annals of the Soviet Academy of Sciences. The Soviet rocket specialist Academician Blagonravov stated in an article that experiments had been conducted with animals since 1951.

Originally, rockets were sent up to a height of 62 miles at a speed of 3850 feet per second. At the top of its trajectory, the cabin with the animals was detached from the rocket and was in free fall until it reached an altitude of two to two-and-one-half miles. Then its parachute system automatically came into action.

In later experiments, the animals were placed in sections of rockets which were not hermetically sealed. Special helmets, through which they received oxygen, were placed on their heads. They were then harnessed to special "carriages" which had all the necessary apparatus as well as parachutes. A supply of 550 cubic inches was provided—enough for two hours. At the top of its trajectory—a height of 60 to 70 miles—the rocket separated from the nose section containing the animals. The nose section then was in free fall to a height of about 55 miles, at which altitude a carriage containing one dog was catapulted from the section at a speed of 2300 feet per second. Three minutes later, the parachute opened. The second dog remained in the falling rocket nose until it reached an altitude of 25 to 30 miles, where the carriage was catapulted at a speed of 360 feet per second, and continued in free fall to a height of two-and-one-half miles, when its parachute opened.

The movies taken automatically during the entire experiment indicate that the animals were very calm during the flight, and only a few of them were disturbed at times of excessive vibration. In several cases the dogs just slept. No significant changes in the behavior or basic functions of the animals or their systems were observed.

Even before their first *Sputnik* was in orbit, Soviet scientists freely discussed the possibilities of observation of plants and animals aboard future *Sputniks*. The fact that the first *Sputnik* would be heavier than the *Vanguard* satellite was indicated in Izvestia two weeks before the *Sputnik* was launched. It was also divulged a year ago that experiments with various animals—mice, rabbits and monkeys—would be conducted in three-stage rockets. While the monkeys were in the upper atmosphere, scientists continuously observed their pulse, blood pressure in arteries and veins and made electrocardiographs. These observations, it was claimed, would be very "important for setting up future interplanetary flights with the participation of men." ★

Dr. Petrov, who has authored articles in England and Germany, is a professor in the U.S. Naval Postgraduate System.

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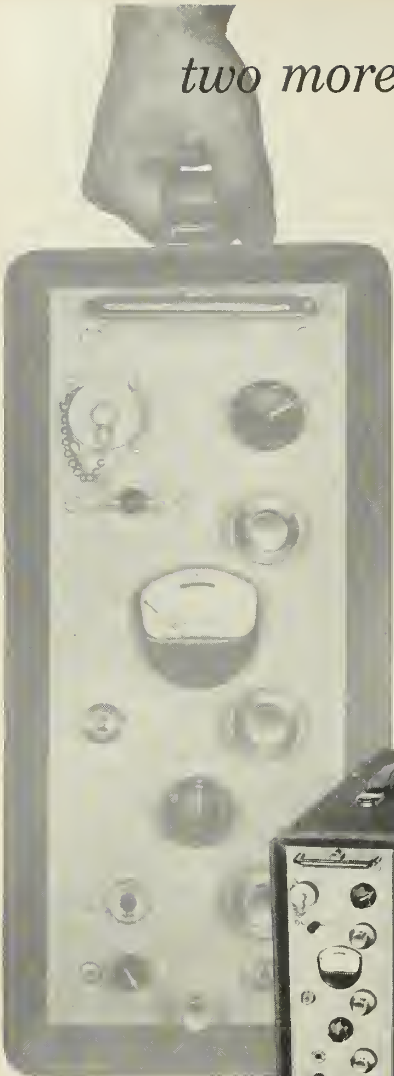
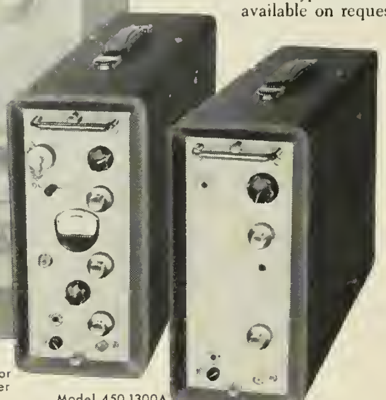
two more **UNIT PREAMPLIFIERS**

in the new

SANBORN "450" SERIES





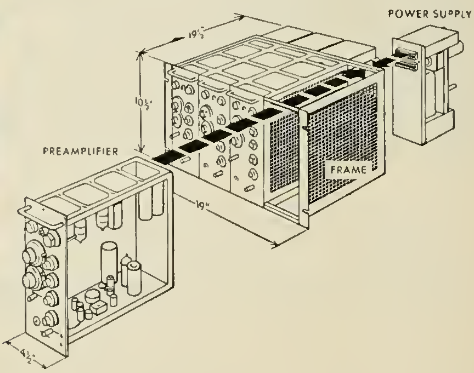
Model 450-1200 Servo Monitor (Demodulator) Preamplifier

Model 450-1300A DC Coupling Preamplifier

Here are the newest of the recently introduced Sanborn "450" Series Unit Preamplifiers—compact, lightweight, self-contained instruments for use with optical and tape recorders, wide band 'scopes, panel meters, computers, etc. (For use with high speed optical galvanometers at frequencies above 500 cps, requiring larger current swings, a transistor output amplifier is built into the 450-1800A True Differential DC type and available as optional equipment on other 450's.) As with all 450 Unit Preamplifiers, the new Servo Monitor and DC Coupling models mount in either individual portable cases or in the four-unit 19" module frame (#354-1100-C2) shown. The *450* designation refers to *unit packaging* of Sanborn 350 Preamplifiers and Power Supplies in individual 450 cases. Loosening two front panel thumbscrews allows quick, simple interchangeability. Since *all* "450" Preamps use the 350-500 Power Supply (which remains in place at the rear of the frame or case), new requirements necessitate only additional *Preamplifier* units, permitting sizable savings in equipment investment.

The Model 450-1200 is a phase-sensitive demodulator, whose DC output voltage is proportional to the in-phase (or 180° out-of-phase) component of an AC signal with respect to a reference. Precision measurement is realized by such characteristics as negligible quadrature signal error, provision for floating signal and reference inputs, front panel VTVM for accurate calibration signals. The 450-1200 accepts the outputs of resolvers, synchros, differential transformers and other transducers. The 450-1300A is a moderate gain, balanced input—balanced output DC amplifier. Its input circuit performs equally well with single-ended or balanced signals.

The "450" Series Unit Preamplifiers presently include the Model 450-1100 Carrier, 450-1200 Servo Monitor, 450-1300A DC Coupling and 450-1800A True Differential DC types. Following these will be "450" Series Logarithmic and Low Level types. Further data and application information on present models is available on request.



MAJOR SPECIFICATIONS

MODEL 450-1200 SERVO MONITOR PREAMPLIFIER

Sensitivity: 5 mv (in phase) produces 1 volt at output jack under maximum output load conditions
Input Impedance: Signal 100k
Reference 12.5k for 15 volts, 55k for 120 volts
Frequency Response: 3db down at 20% of carrier frequency filter position
Carrier Frequency Filter: Selected by a switch (three positions)
Low 60 cycles
Med 400 cycles
Hi 1000 cycles (5000 cycles optional)
Reference Voltage: Internal selection accepts voltages from 15 to 120 volts
Quadrature Rejection: Ratio better than 100:1
Maximum permissible quadrature before overload indicator lights is twice full scale (in phase)
Calibrate Voltage: 10 millivolts internal (set by meter on panel)
Drift: Less than 0.1% of full scale per hour
Preamplifier Output Jack: ±3 volts available into 2.2k minimum load resistance. Output appears across two cathodes at approximately ground potential
Rear inputs and overload indicator lights are included
Output Impedance: 1k
Overall Linearity: ±¼%
Power Requirements: 115 volts, 50-400 cycles, approximately 35 watts

MODEL 450-1300A DC COUPLING PREAMPLIFIER

Sensitivity: 50 mv produces 1 volt at output jack under maximum output load conditions

Input Impedance: 5 megohms each input side to ground

Input: Single-ended or push-pull

Preamplifier Output Jack: ±3 volts into 2.2k minimum load resistance. Output is balanced and appears across 2 cathodes at approx. ground potential

Output Impedance: 1k

Drift: Referred to input 2 mv/hr. line voltages change less than 10%

Frequency Response: 0-20kc

Calibration: 100 millivolts internal

Linearity: ±¼%

Rear inputs included

See the new "450's" and other Sanborn equipment at Booth 3601-3603 I. R. E. Show

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aluminum:

For Missiles in Production

by Don Fabun

SO MUCH has been published about the use of rare or lesser known materials in missile design that the fact often is overlooked that the "workhorse metal of the air age"—aluminum—is playing an integral part in missile programs from *Atlas* to *Zuni.*

Several months ago, a comprehensive survey was undertaken in Kaiser Aluminum & Chemical Corp. to determine just where and how aluminum is being used in current missile programs and what its future market potential might be.

In some cases, security restrictions on missile details made the search difficult; many of the prime contractors were already in the aircraft business and already buying aluminum, so that there was no easy way to tell whether the metal was going into aircraft or into missiles; and, finally, the entire missile industry is so complicated that tracing the progress of a single order of metal through the network of contractors and subcontractors was often impossible.

Nevertheless, from the information gathered so far, some interesting points can be developed:

Aluminum is being used in significant quantities or in critical areas in more than half of all the missiles that have reached the production stage today. The percentage would undoubtedly be higher if information was available on all missiles.

A composite rocket that would be reasonably complete could be built from parts of rockets now being made of aluminum. Such a composite would include aluminum airframe, skin, wings, wing spars, nose cone, tail, fins, brackets, wiring systems, fuel tanks, motor heads, rocket motor tubes, solid-propellant core molds and electronic components in the guidance system.

Substantial quantities of aluminum also are being used in the ground fueling apparatus for liquid fuel rockets (as for the external skin for *Thor* LOX storage tanks), in missile weapon carriers, launching ramps and launchers. ground guidance systems, tracking and control systems, reusable containers for shipment and storage, and in attachment pads and devices for all types of airborne missiles.

Just about every major form in which aluminum is available is used in the missile programs: sheet, plate, castings, extrusions, forgings, rod, bar and wire, electrical conductors, insulated wire and foil.

There are good reasons for this across-the-board aluminum usage: lightweight (one-third that of the same volume of steel); versatility; some 26,000 firms with the know-how and equipment to work with aluminum; low maintenance factor; and, finally, its economy as a structural metal.

These considerations have led to the so-far-revealed uses of aluminum in current production or operational missiles shown in the accompanying table. The figures in the table were secured through direct contact with the public information officers of each of the appropriate services, or by direct inquiry to the prime or airframe contractors.

There is additional usage of aluminum in most of the missiles which have built-in guidance systems, but the weight for any specific unit would not materially affect the total aluminum in each missile.

Knowledge of this market's potential is of particular interest to the aluminum industry at the present time because it has been engaged for the last several years in a major expansion of primary aluminum producing facilities. One reason for the aluminum industry's expansion, to begin with, was to create such aluminum producing capacity throughout the nation that there would be enough aluminum to satisfy the needs of even the very largest potential users (automobiles, building trades, cans, etc.) without jeopardizing a reserve capacity for meeting military requirements.

When and if missiles move into

Known Uses of Aluminum in Current Production Missile Programs

Missile	Gross Firing Weight Per Unit	% or Pounds of Aluminum Per Unit
Corporal	12,000 lbs.	4,000 lbs.
Dart	100 lbs.	5%
Falcon	110 lbs.	11 lbs.
Hawk	1,200 lbs.	120 lbs.
Honest John	6,000 lbs.	960 lbs.
Jupiter	100,000 lbs.	17,500 lbs.
Lacrosse	500 lbs.	50 to 50%
Matador	13,800 lbs.	3,200 lbs.
Mighty Mouse	19 lbs.	2 lbs.
Nike-Ajax	20,000 lbs.	2,000 lbs.
Nike-Hercules	20,000 lbs.	2,000 lbs.
Rascal	13,000 lbs.	3,200 lbs.
Redstone	40,000 lbs.	4,500 lbs.
Sergeant	22,000 lbs.	1,320 lbs.
Snark	36,000 lbs.	1,300 lbs.
Sparrow I	300 lbs.	95 lbs.
Sparrow III	350 lbs.	280 lbs.
Talos	3,000 lbs.	500 lbs.
Titan	200,000 lbs.	(skin, hull—wt. not available)
Zuni	107 lbs.	(rocket tubes—wt. not available)

The author is editor, Kaiser Aluminum News, *at the Kaiser Aluminum & Chemical Corp., Oakland, Calif.*

the mass-production "hardware" stage, there will be ample capacity to meet all the normal peacetime aluminum requirements without an allocation program for nonmilitary users of aluminum.

Just how big a market for aluminum will missiles be? Obviously, the exact number of missiles being produced or about to be produced is kept secret, but it is possible to make some sort of a guess in some directions. When the guesses are put together, they indicate that the missile field may well be a large user of aluminum within the next few years.

Something like two pounds of aluminum are consumed every time a *Mighty Mouse* missile is fired. Armament on a fighter-attack plane is 104 rockets (although as many as 196 have been carried by a fighter craft). A full load of 104 rockets can be fired in ripple salvos, electronically, in three seconds. A group of 100 fully armed fighter craft firing continuously, assuming such a feat were possible, would use up one million pounds of aluminum in two and a half minutes.

Such a mass firing is unlikely, but the figures do make an important point. It is highly improbable that the big IRBMs and ICBMs, considering the nature of their payload and mission, will ever be used except in an allout global war. The number of units produced will be relatively limited, and their high per-unit cost will keep the number of test and training firings to a minimum.

The smaller missiles, which more and more are replacing conventional artillery, both on land and sea, are likely to be used up at a brisk rate in training maneuvers and limited-scale actions. The use of aluminum in these missiles is therefore of particular interest to the aluminum industry as a potentially large tonnage market.

How much? There is good backing for coming up with a figure of something like eight million pounds of aluminum in the *Nike-Ajax/Nike-Hercules* programs alone. Just how many of these have been built is classified, but in June 1957, the Army asked the House Appropriation Subcommittee for funds to rebuild 4000 *Nike* missiles in 1958. Since the money was for reconditioning 4000, it must be assumed that 4000 already existed, and, as pointed out in the table of aluminum usage, there are 2000 pounds of aluminum used in each *Nike* booster assembly.

Getting back to the *Mighty Mouse*, in October 1957, a West Coast contractor received a contract for the components for two million of these rockets. At the two pound per-unit rate, that's four million pounds of aluminum in the *Mighty Mouse* program alone.

Matador uses 3200 pounds of aluminum per unit. Although the figure has never been officially confirmed, a newspaper in October 1957, reported that 1000 *Matadors* had been built by that date. There's another 3.2 million pounds.

Adding together just the interpolated figures from these three programs —*Mighty Mouse, Matador* and *Nike-Ajax*—there's a total of 15 million pounds of aluminum accounted for, a figure of considerable interest to the aluminum industry, considering that the missile programs may be said to be just entering the mass-production hardware stage.

Even so, considering the metal's natural advantages for missile construction, it may seem surprising that more aluminum is not being used in missile programming. There are a number of pertinent factors here. For one, until quite recently, missiles have not been a mass production business, where aluminum's low cost and easy workability would recommend its use. In prototype stages, a missile is practically hand-crafted and the time and labor involved far outshadow materials cost. Missile designers have been absorbed in solving problems any way they could, and the materials they chose have not necessarily been picked for economy.

As a missile moves into full-scale production, time and labor drop, relatively, and the proportion of materials cost to the overall cost goes up. Unit figures on production missiles give some idea of what is involved. *Nike* I is said to have cost $20,000 per unit; *Sparrow* III is said to cost about $40,000; the *Falcon* costs $9000 to $10,000; the *Terrier* about $40,000 each; *Bull Pup* $10,000 and *Redstone*, $1 million per unit.

If the United States is to have these relatively short range, artillery-replacing missiles in quantities sufficient for adequate defense, price per unit is going to be an increasingly important factor. Aluminum's low basic price, easy machinability and light weight will recommend its use wherever possible to cut unit costs.

Perhaps another reason aluminum has not appeared to play the role in missile construction for which its characteristics fit it, is the "heat barrier" controversy, which has served to create in the minds of some designers and engineers a mental barrier against aluminum "because it can't stand the heat."

The basic premise here is that aluminum begins to suffer measurable loss of strength above 400°F. Since the surface heat of a missile during prolonged periods of exposure to air friction may rise to several times that figure, the argument goes, some better high-temperature metals (like titanium, molybdenum, zirconium, thorium, etc.) are needed.

Valid as the original premise may be, the argument overlooks two significant points. The first is that the practical limit for structural use of any metal is of the order of 2000°F. Since, at very high Mach numbers in the atmosphere, the surface temperature of missiles will exceed that, finding new materials is not going to be the answer. Instead, the heat barrier may be bypassed through redesigning flight paths and through skin-cooling devices.

A few weeks ago, a missile engineer at a major missile contractor's said, unequivocally, "Aluminum is back in the picture (for missiles). Since we can't solve the heat problem just by substituting high-cost materials, we're going to have to go back to aluminum and solve it with new designs and flight paths."

Since the greatest problem occurs during the period of traversing the dense atmosphere during blastoffs, some suggestions have been made for firing missiles at an altitude where air friction is not a problem.

Another consideration in the "heat barrier" argument is the length of time of exposure to elevated temperatures. Artillery-type missiles attain top speeds of Mach 2.5 to 5.0, at critical portions of the flight path. At these portions, friction of the atmosphere will develop high skin temperatures. However, the time of sustained high skin temperature is very short.

At Mach 3, for a missile intercepting at a 30- to 50-mile range, the actual exposure to high temperature is a matter of only several seconds, and most of this in the nose area. For high trajectory ICBMs or IRBMs, the time of sustained high temperatures is limited to the few seconds it takes for the missile to leave the atmosphere. Skin friction is not too critical at very high altitudes, in the rarified air found there. The short time (up to 60 seconds) of high temperature may not be as detrimental to aluminum as the standard physical test data developed for aircraft may indicate.

The aluminum industry is now working to develop complete information on the effects of high temperatures for short periods on aluminum.

All these factors: aluminum's already important role in missile design, its low cost, wide availability, workability, and the promise of even improved qualities to come through research, argue for a greater part for aluminum in missile development as the programs shift into high gear.★

Sandwich Rolling for Wide Steel Sheets

US Steel uses new method to fabricate thin-gauge metal

THE US STEEL CORP. recently announced that a major breakthrough in metal fabrication has been attained at its Homestead Works.

Experimental "sandwiches" of stainless-steel plates inside and carbon-steel plates outside are sealed by machine welding to hold the plates together. A special separating compound is applied to each of the plates before assembly to prevent fusing during the rolling process.

At the outset, the "sandwich" is three inches thick, but is reduced to about 10 per cent of its original width after being hot-rolled. After rolling, the ends and sides of the "sandwich" are sheared off and the carbon-steel covers removed to free the wide sheets inside.

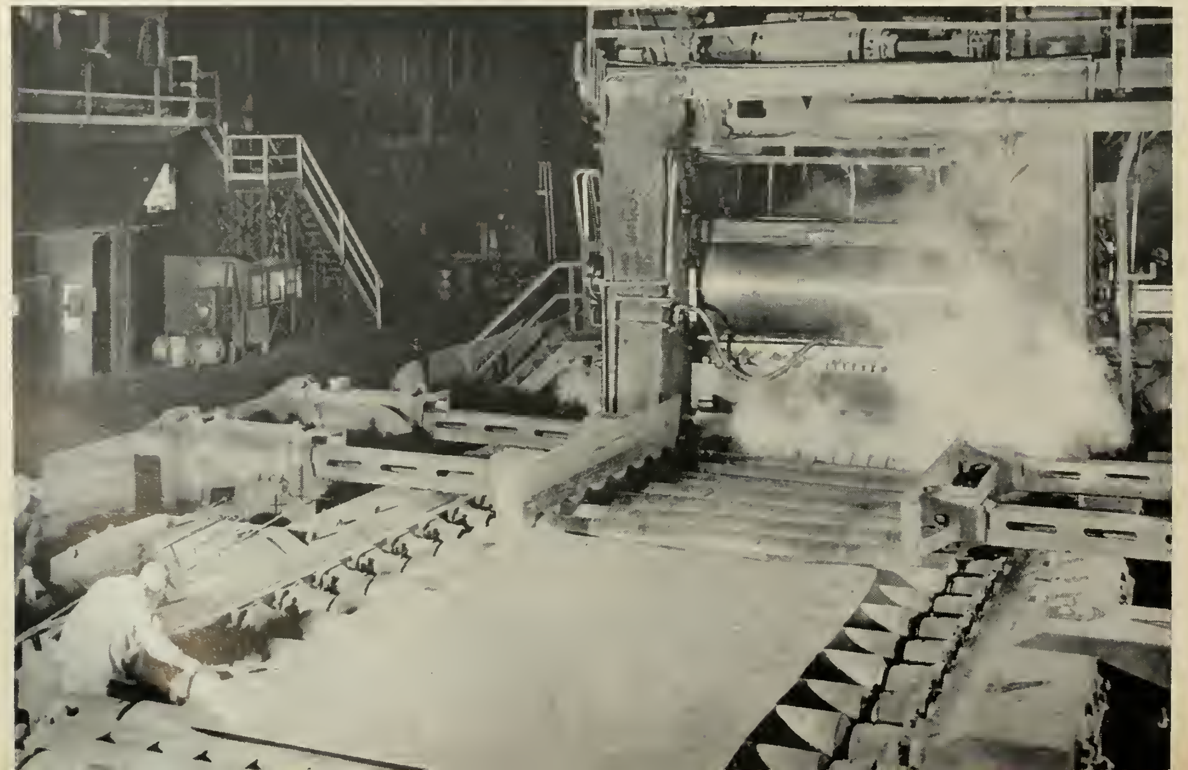
This new technique was developed under a research and development program designed to find means of producing wide thin-gauge stainless- and alloy-steel sheets for missiles.

Experimental runs with this technique have produced sheets 90 inches wide and 230 inches long—about twice as wide as sheets produced by ordinary production methods.

The real key to the process is the carbon-steel covers which insulate the stainless and alloy plates they enclose and keep the material at favorable rolling temperatures. This has allowed US Steel to produce the wide sheets on existing mill equipment.

This new process holds promise of better mill-produced materials for planes and missiles. Further studies to produce even wider and longer sheets of quality equal to the present ones are currently in progress.

Below—After heating and rolling, the "sandwich" resembles an ordinary mill product as its thickness is measured by a workman.



Near right—Fully assembled group of carbon-steel and stainless-steel plates are tack-welded prior to machine welding, which will seal all four sides. Far right—Comparison of conventional-rolled, 48-inch sheet and sheet being produced by experimental process at US Steel. Larger sheet is 90 inches wide and 230 inches long, nearly double the width of regular sheet. Below—Workmen at Homestead District Works lower carbon-steel cover plate onto "sandwich" filled with stainless-steel plates. Hot-rolling will reduce thickness to 10 per cent of original. Several groups of plates have been rolled during this research and development program.

Above—Workman at Homestead Works coating stainless-steel plate with a special separating compound during the assembly of carbon-steel and stainless-steel "sandwich." Use of this compound prevents fusing of the metal plates during the hot-rolling process. After rolling, ends and sides of the carbon plates are sheared away; the resulting stainless plates are the widest ever produced on existing mill equipment. Left—Inspector examines finished stainless sheets after rolling.

CASE HISTORY SERIES: Number ②

ENGINEERING REPORT

A Case History of Environmental Control

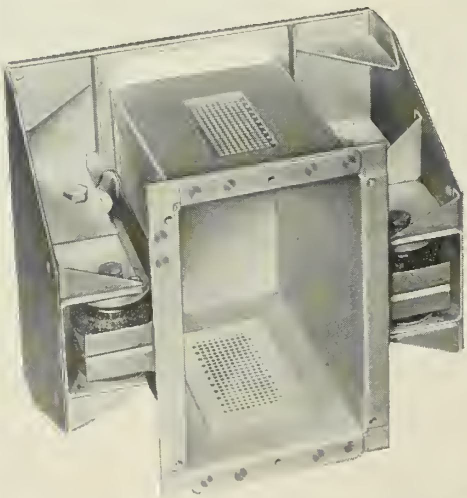
PROBLEM

VIBRATION • SHOCK AND COOLING

GUIDED MISSILE RELIABILITY

PROTECTION OF FUEL CONTROL EQUIPMENT from destructive vibration and shock in high temperature propulsion section of IRBM missiles.

SOLUTION



MODEL 1322 FOR REDSTONE AND JUPITER MISSILES
developed ond produced in quontity for Redstone Arsenol ond Chrysler Corporotion.

ENGINEERED MOUNTING SYSTEM

MODEL 1322:

Robinson Model 1322 is a center-of-gravity all-metal mounting. Providing consistent performance regardless of high or low temperature extremes, this design incorporates highly damped Met-L-Flex resilient elements. All-attitude, multi-directional protection is assured.

SPECIAL FEATURES:

1. Ventilation screens at top and bottom of mounting enclosure allow the flow of cooling air, thereby extending the range of environmental protection.

2. Versatile mounting design facilitates adaptation to a wide range of components of varying dimensions.

PERFORMANCE:

Model 1322 protects against the rugged environment in the propulsion section of large rocket-type missiles. **Vibration, shock and acceleration forces** are controlled by the mounting system through a careful combination of spring rate and damping design characteristics. Natural frequency of model shown is 16 c.p.s. for an impressed excursion of .060 ins. and equipment weight of 8 lbs.

RESULT:

Adequate protection provided and reliability accomplished for vital elements of fuel control equipment through a light-weight standardized mounting system design. (Approximately six (6) systems installed in each Jupiter missile.)

ROBINSON CONTROL IS RELIABILITY CONTROL

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AVIATION, INC.
Teterboro, New Jersey
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in the missile era . . .

Materials Build a New Technology

by W. C. Rous, Jr.

IN THINKING about earth satellites or even hypersonic rocket gliders, structural and materials people are concerned, among other things, with operational stress and temperature histories in relation to design requirements. Of necessity, this kind of thinking is based on many assumptions which vary with personal opinions.

Beginning with takeoff, rocket-thrust variations are programmed for considerations of flight mechanics and structural strength. Variations in stress occur during the boost phase, depending on the number of rocket stages being fired in parallel and in sequence. Generally, the stress on a rocket-propelled vehicle varies most rapidly and is greatest during boost. In heat content, however, the maximum temperature is usually encountered during re-entry into a planet's atmosphere.

A number of magazine articles have been published indicating typical temperature which might be encountered. For example, during the first boost stage, the skin temperature about one foot from the leading edge might reach a temperature of the order of 500°F. After all the rockets have been fired, the temperature may rise to about 1000°F. Depending on configuration, the temperature may then rise to about 1500°F magnitude sometime after burnout.

Critical design criteria include the relationship between skin temperature, amount of required cooling, and structural weight as indicated; relationship of time with nose equilibrium skin temperature; temperature of an insulated skin, a heat skin and a transpiration cooled skin. Equilibrium temperatures could be of the order of 2000° to 3500°F at leading edges.

Structural weight and cooling load compromises are possible with a radiation-cooled, or a high-skin-temperature structure. If the structure is highly conductive, the heat transfer to the interior will be high, but the skin temperature will be low, resulting in a low structure weight and a high internal cooling load.

As the structure is made more insulating, the heat transfer through the structure into the interior will decrease, and so will the cooling load. However, the skin temperature will increase, requiring heavier structure. An optimum skin temperature is sought where the combined structural weight plus the internal cooling system weight will be a minimum.

An optimum balance must be attained between the structural and coolant weight, and the rate of coolant flow for a transpiration-cooled structure. At low coolant flow rates, the structural weight will be high and the coolant weight itself will be low. As the flow rate is increased, the structural weight decreases because the skin temperature will be lower as the coolant weight increases.

These environments constitute the problem. For primary structural materials, Figs. 1 and 2 present evaluation of possible materials as published in recent literature.

In Fig. 1, titanium and carbon steel will probably not be used extensively as construction materials. Stainless 347 is recommended by handlers of fluorine,

The author is Senior Manufacturing Research Engineer at Convair, Fort Worth, Texas.

Structural Material	Outstanding Temp. Range (°F)	Significant Characteristics	Availability: Current Status	Availability: Probable Future Status	General Processing Procedures	Potential Development
Titanium 6Al-4v	R.T.-800	Superior str/wt below 800°F; embrittlement-susceptible	9 months lead time	Good	Heat-treated @ 1750°F; aged @ 1000°F for 2 hrs.	Limited
Carbon steel:						
Hy-Tuf	R.T.-500	Heat-treatable; heat-vulnerable	Good	Good	Forged or rolled; heat-treated @ 1650°F max. tempered 450-1075°F pending use	
4130	R.T.-500	Heat-treatable; heat-vulnerable	Good	Good		
4340	R.T.-500	Heat-treatable; less heat-vulnerable	Good	Good		
Stainless steel:						
301	R.T.-550	General low-temp. utility	Good	Good	Cold- or hot-worked	Limited
316	R.T.-1200	General use; corrosion-resist.	Good	Good	Cold- or hot-worked	Limited
347	R.T.-1300	General use; corrosion-resist.	Good	Good	Cold- or hot-worked	Limited
17-7RH950	R.T.-800	New superior stainless	Limited	Good	H.T. @ 1750°F, cooled to 100°F, aged @ 950°F	Limited
Alloys:						
Udimet 500	800-1700	Superior str/wt of Ni, Cr, Co alloys	Limited, unevaluated	Probably good	Vac.-Cast; H.T. 1975°F; age 1550°F, 24 hrs; age 1400°F, 16 hrs.	Little
Inconel X	1000-1500	Practical; efficient; corr.-, ox.-resist.	Satisfactory	Good	Arc-cast; H.T. 2100°F, 4 hrs; 1500°F, 24 hrs; 1300°F, 20 hrs.	Little
Inco. 700	1000-1500	Slightly superior to Inconel X; similar	12 mos. lead time; bar only	Similar to Inconel X	Arc-cast; H.T. 2160°F, 2 hrs; 1600°F, 4 hrs.	Little

Fig. 1—Ferrous and nonferrous structural materials.

but is not currently satisfactory for structural use due to its strength and availability status.

Inconel X and Udimet 500 have good characteristics in the superalloy range of application. The current availability of Udimet 500 is limited, but its strength-to-weight ratio in the 800 to 1700°F temperature range is best.

Figure 2 indicates considerable potential for molybdenum. Its ductility and strength from 1700°F up to perhaps 2600 to 2800°F make it an excellent choice in regions of high heating rates and high temperatures, and where thermal stresses must be combined with stresses due to aerodynamic loads.

Adequate protection from oxidation must be provided for molybdenum as well as other efficient materials which are feasible for high-temperature structural use. Although molybdenum's behavior at very low tempera-

Structural Material	Outstanding Temp. Range (°F)	Significant Characteristics	Availability: Current Status	Availability: Probable Future Status	General Processing Procedures	Potential Development
Molybdenum (Mo+5 Ti)	1700-2600	Only current useable alloy above 2000°F; best E/ρ from R.T. & up; high conductivity	Limited; difficult processing	Fair; pending development	Vac-cast; cold-rolled	Considerable
Tungsten	2400-4000	Poor ox. resist. 900°F & up. Dense, strong up to temp. limits; brittle	Gen. avail. limited quantity	Fair; potentially on critical list	Powder metall.; hot-formed	Limited; unpredictable
Tantalum	2400-4000+	Poor ox. resist.; dense, strong up to temp. limits; ductile, corrosion-resistant	Gen. avail. limited quantity	Unpredictable; critical material	Powder metall.; cold-formed	Performance good; avail. unpredictable
Rhenium	2400-4000+	Good ox. resist.; dense, strong; little data	Very rare	Unpredictable; scarce	Powder metall.	Performance good; avail. unpredictable
Carbon	3000-5000+	Best str./wt. above 3000°F; brittle; poor ox. resistant	Good	Good	Molded; baked @ 2300°F	Limited
Cermets (Ti C+Ni, Cr, Co)	1800-2500	Marginal impact strength; good oxidation resist. to 2200°F; good resist., thermal shock, high strength, stiffness	Good; some design & matl. development needed	Good	Powder metall.; finish grinding	Limited; somewhat unpredictable
Ceramics oxides	2500-4500	Critical thermal-shock resist.; critical impact strength; superior oxidation resist.; superior comp. str./wt.; poor tensile strength; low elec. conduct.	Good; design & matl. dev. needed	Good	Powder metall.; finish grinding	Very limited; unpredictable
Carbides		Low thermal shock resist.; low impact str.; marginal oxidation resist.; superior compr. str./wt.; poor tens. str.	Good; design & matl. dev. needed	Good	Powder metall.; finish grinding	Very limited; unpredictable
Reinforced plastics	200-600	Medium impact resist.; readily formed; low elect. conduct.; adequate str. for limited use	Good	Good	Fiber laminate; plastic-impregnated; hot-press cured	Limited by low-temp. capacity

Fig. 2—Refractory structural materials.

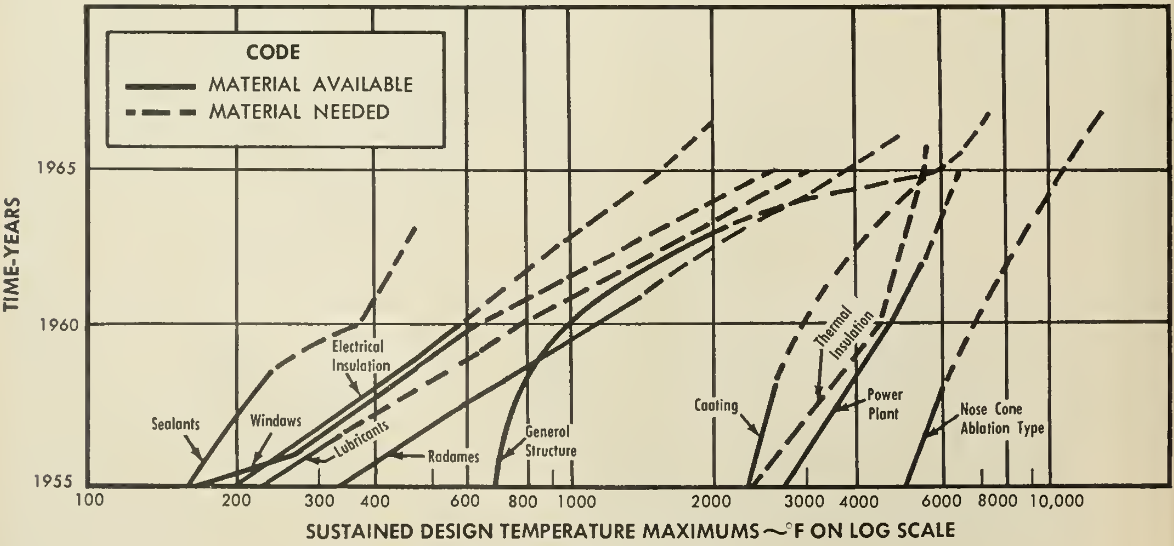
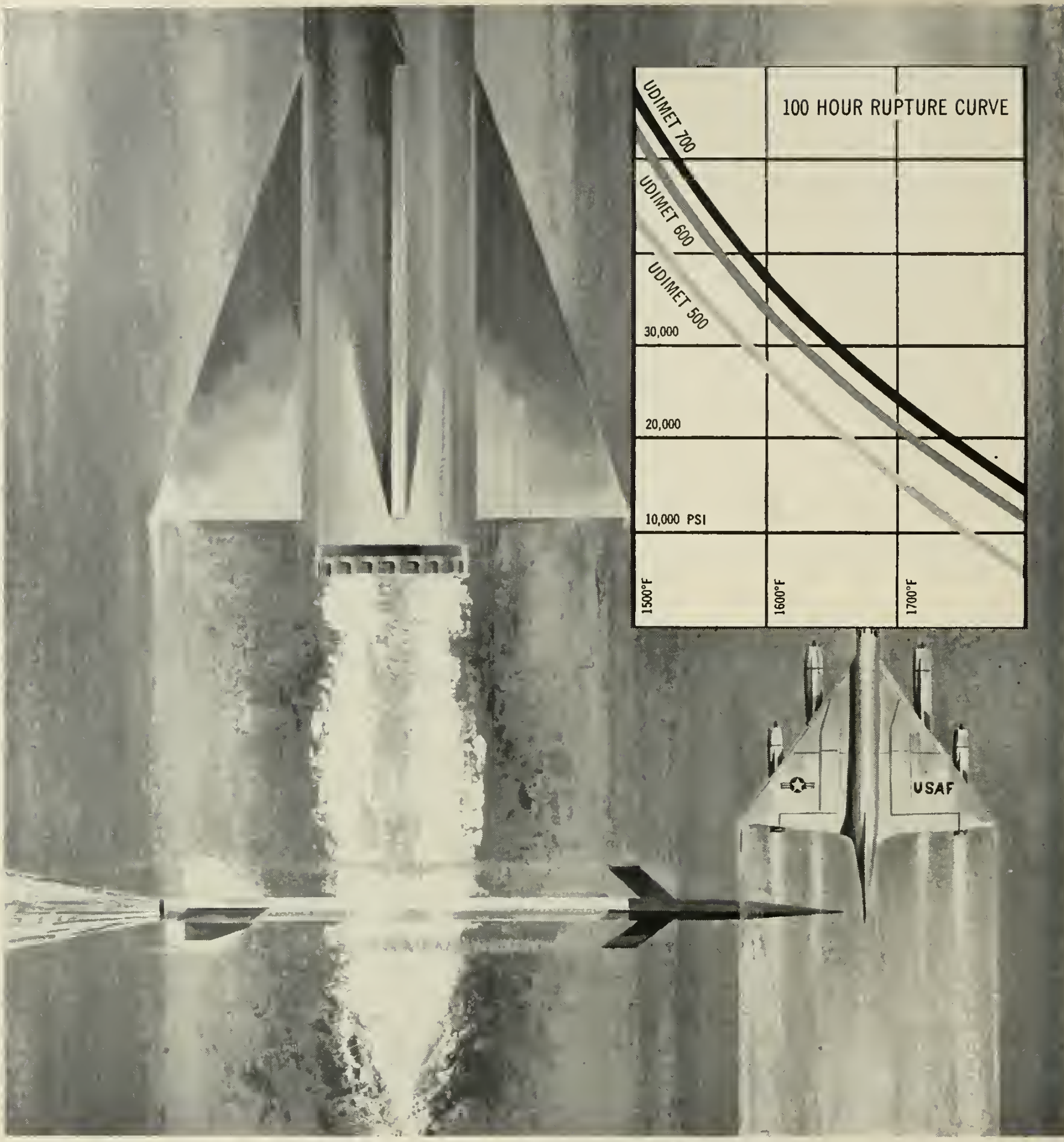


Fig. 3—Material development needs.



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for a wider range of applications at elevated temperatures!

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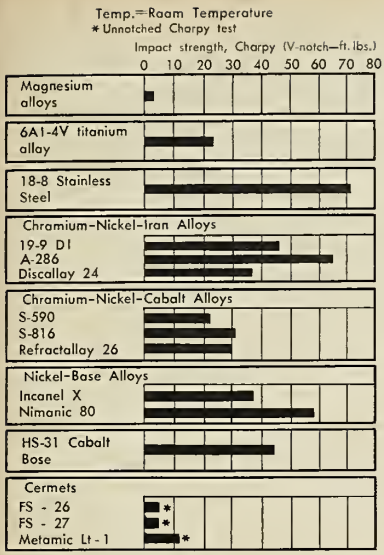


Fig. 4—Comparison of impact strength of various structural materials.

ture requires further investigation of its brittle, stain-rate and notch-sensitive characteristics, its use seems feasible.

Development of adequate coatings for molybdenum amounts to a major engineering effort. A number of manufacturers are spending considerable effort on this problem.

Tungsten, tantalum and rhenium all have very high-density and high-temperature resistance. They are very scarce, are difficult to produce in specific shapes and their future development is unpredictable. Their use would be restricted to local structural components.

Carbon has the best strength-to-weight ratio above 3000°F. Its availability is good, but its potential development is probably limited. Carbon and carbides would also probably be restricted to local use.

Cermets and ceramics have good temperature-resistant characteristics. Their greatest disadvantage is their inherent notch sensitivity and poor impact strength. The value of ceramics, particularly oxides, is their oxidation resistance. Their greatest use will probably be as coatings for efficient structural materials, and as parts subjected to high temperatures, but low or nonexistent stresses.

Existent ceramic coatings are used to: (1) substitute less strategic alloy without sacrificing life; (2) increase life of existent parts; (3) allow use of existing parts at higher temperature.

In their use, these coatings take the following forms: (1) refractory coatings (*viz.*, for tank mufflers, 3 to 8 mils thick); (2) very thin vitreous coatings (NBC A-418 for jet parts); (3) refractory oxide, carbide or nitride cermet coatings (Ni-MgO flame-sprayed coat for combustion liners); (4) refractory insulating coatings attached to base metal by cementing or by mechanical means; (5) "ceramic paints" which can be brushed on and require no firing prior to use.

Less progress has been made in evaluation of mechanical and thermal properties of nonstructural materials than on primary structural materials. This status is indicated in Fig. 3 and may be outlined as follows:

Radomes

Glass fibers impregnated with silicone resins are limited to about 900°F. Radomes of Al_2O_3 are usable to 1500°F. Pyroceram 8606 has good strength up to 1500°F. These materials appear favorable strengthwise for anticipated radome temperature of 1200°F for one and one-half hours. Simple surfaces and flush mounting in design favor use of ceramic dielectrics.

Potential methods of ceramic randome fabrication are (1) Solid-wall high-temperature glass, high-temperature porcelain, high-temperature synthetic mica (with a glazed surface), and high-temperature sintered Al_2O_3 or ZrO_2; (2) ceramic air-spaced sandwich (with ceramic internetwork for rigidity); (3) inorganic cement plus glass fiber; (4) glass foamed in place sandwich and artificially loaded foams.

Windows

The need for windows is not established one way or the other. Successful development of a solder glass interlayer may extend temperature usage from the present 350° to 800° or 1200°F. If better scratch-resistance could be built into solid glass, temperature limits could be raised to 1500° or 1800°F, and even 2500°F, for short periods. Glider windows protected by cooling, or eyelids, which can withstand 1800°F, may be useful.

Seals and Sealants

Assumed design life will have

(*Continued on page 98*)

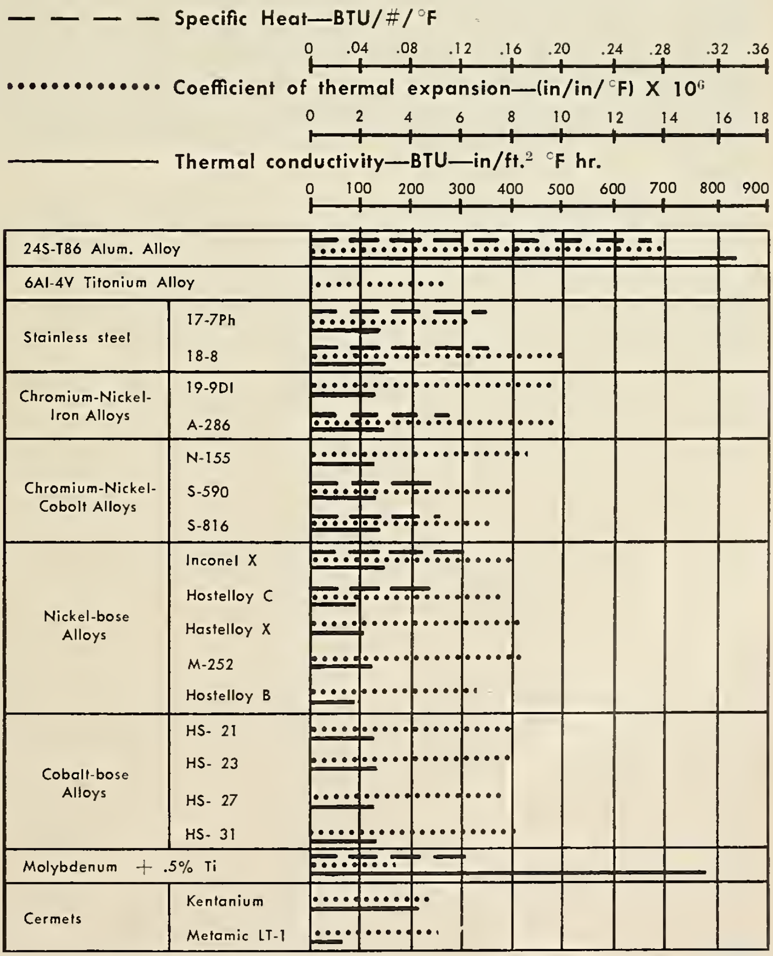
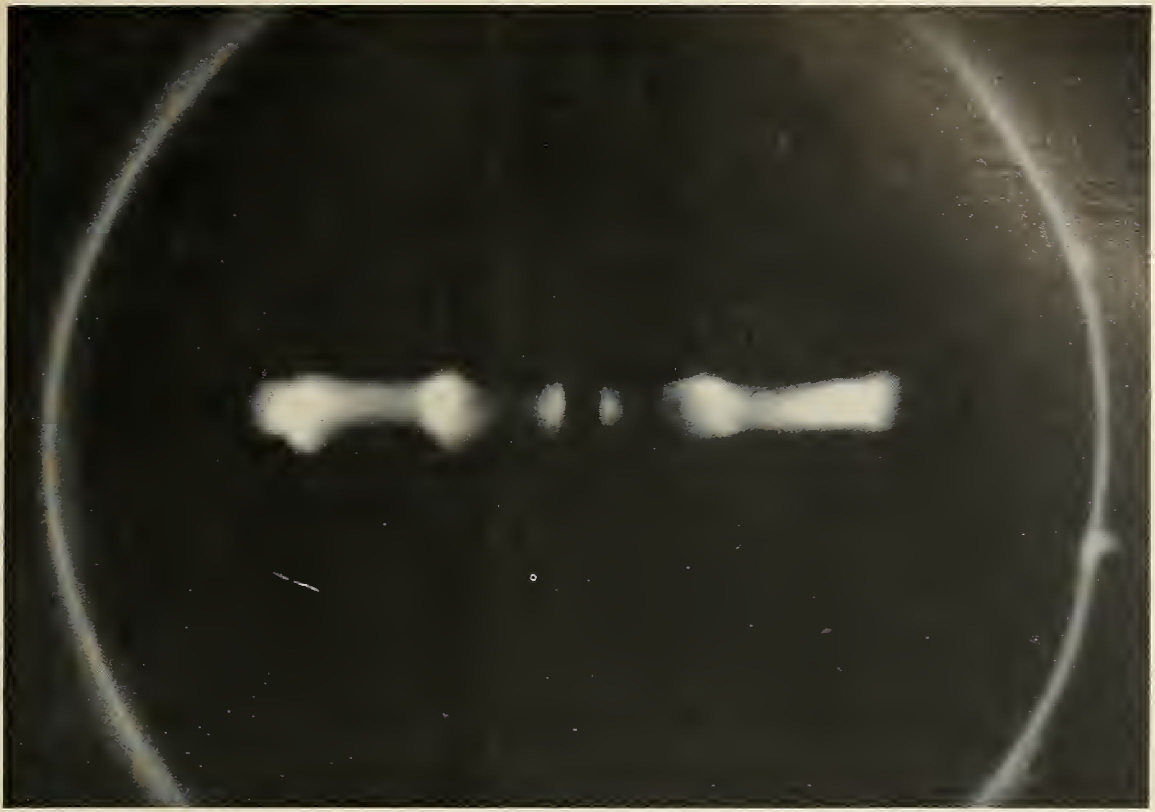


Fig. 5—Comparison of thermal properties of various structural materials, 700°F.

Metal	Melting Point (°F)	Density (lbs/cu. in.)	Characteristics	Short Time Tensile F_{tu} Ksi at —°F	Vapor Pressure at Melting Point (mm. Hg) ((-3)=10^{-3})	Oxidation Resistance in Air	Order of Probable Feasibility for 2000°F Structure	Miscellaneous Comments
Tungsten (W)	6150	0.70	Good: high-temp. strength Poor: oxidation resis., ductility, fabrication	120-300 at R.T.; 32 at 2500°F; 3.4 at 4100°F	1.75 (—2)	Forms nonprotective oxide 900-1400°F; oxide volatile at high temperature	3	
Rhenium (Re)	5750	0.73	Good: high-temp. strength Poor: very scarce	48 at 2500°F; 9 at 4000°F	2.45 (—2)	Resistance is five times cermets at 2500°F	3	
Tantalum (Ta)	5425	0.60	Good: high-temp. strength Poor: oxidation resis. and some mech. properties	50-110 at R.T.; 6.7 at 5000°F	5 (—3)	At 896°F weight gain due oxidation is 1% per 24 hours; poor resistance to air at elevated temperature	2	Softening temperature of 810-1170°F for pure Ta
Osmium (Os)	4890	0.82	Poor: high cost, oxidation resis., unworkable	Approximately 160-200 at R.T.		Rapid oxidation in air at elevated temperature; oxide is volatile		Completely unworkable in pure state
Molybdenum (Mo)	4760	0.37	Good: high-temp. strength, abundant Poor: oxidation resistance	13° at R.T.; 10 at 2500; 5.24 at 4500	2.2 (—2)	Forms volatile trioxide above 930°F	1	With siliconized coat may be used for extended time; with Ni, or Inconel clad use in air to 1800-2000°F
Ruthenium (Ru)	4530	0.44	Poor: high cost	Approximately 115-190 at R.T.	9.8 (—3)	Similar to Ir in corrosion resistance		
Iridium (Ir)	4450	0.83	Poor: high cost	Approximately 100-160 at R.T.	3.55 (—3)	Slight oxidation at 1100-1850°F; oxide volatile > 1850°F		
Niobium (Columbium Cb)	4380	0.31	Good: high-temp. strength Poor: oxidation resis., ductility	48-60 at R.T.	6.4 (—4)	Oxidizes above 500°F in air; forms nonprotective oxide (0.052% wt. gain/5 hours at 662°F)	2	Softening pt. Cb ≏ Ta (800-1170°F)
Hafnium (Hf)	3830	0.47	Poor: very scarce			Oxidizes readily in air, similar to Zr but O_2 penetration into metal is slower.		
Rhodium (Rh)	3625	0.45	Poor: high cost	73-300 at R.T.	1 (—3)	Oxidizes at 1475°F rapidly; oxide volatile > 1830°F		
Chromium (Cr)	3435	0.26	Poor: high vapor pressure	40-60 at R.T.	63.5	Forms protective oxide scale W. maximum temperature stability 1650°F	6 (Alloyed)	
Zirconium (Zr)	3325	0.24	Poor: oxidation resis., med.-high vapor pressure	90 at R.T.	1.4 (—5)	Loss of strength becomes significant above 900°F	5	More plentiful in earth than Cu, Ni, Pb; is 2 years behind Ti development; low neutron absorp. cross-section
Thorium (Th)	3320	0.41	Poor: high-temp. strength, therm.-stress resistance	37 at R.T.; 17 at 900	9.3 (—5)	Highly reactive at elevated temperatures		
Platinum (Pt)	3225	0.78	Poor: high cost	19 at R.T.; 4 at 1800°F	1.6 (—4)	Good to 2700°F for short times; oxide volat. > 1600°F		
Vanadium (V)	3155	0.23	Poor: med.-high vapor pressure	70-110 at R.T.	1.2 (—4)	Above 300°F must be protected from oxide, hydride and nitride formation		
Titanium (Ti)	3140	0.16	Poor: high vapor pressure	90-100 at R.T.	8.4 (—2)	Forms protective oxide scale, embrittles between 1100-1800°F oxide porous; > 1800° oxide may sinter together.		Not recommended for continuous service over 1000°F (At 1800°F 6Al-4V has 95 mg/cm²/48 hours, cumulative wt. increase/orig. unit area.)

Fig. 6—Status of high-melting-point metals.



Magnetic fields, acting as a double piston, drive luminous ionized shock waves through transparent tube. One-tenth microsecond exposure in STL's Physical Research Laboratory.

MAGNETOHYDRODYNAMICS and SPACE TECHNOLOGY

Magnetohydrodynamics provides one of the most promising approaches for attaining the velocities and specific impulses that will be required for manned space flight to a planet, landing, and returning.

The critical problem in attaining velocities of hundreds of thousands of miles per hour is the containment of temperatures comparable to those in the interior of stars. Because the temperature of the driving reaction will have to rise as the square of the exhaust velocity, temperatures greater than one million degrees will be encountered in reaction chambers. Magnetohydrodynamics offers a unique solution to the basic problem of containing the reaction without contact with the chamber walls.

Briefly, the physical principles of magnetohydrodynamics are these. Since gas at such temperatures is completely ionized and is an effective conductor of electricity, the introduction of currents in the gas (in this state called a plasma) creates an electromagnetic field. This field makes it possible to control the plasma by applying an external opposing magnetic field which creates a magnetic bottle to contain the charged gas particles. Similarly, a magnetic-field piston can be used to accelerate the particles. Such magnetohydrodynamic reactions are expected to develop exhaust velocities that are an order of magnitude greater than those generated by present chemical rockets.

At Space Technology Laboratories, both analytical and laboratory work are proceeding in the field of magnetohydrodynamics. This work illustrates the advanced research in STL's Physical Research Laboratory, which emphasizes the application of basic physical principles to the requirements of space technology.

In support of its over-all systems engineering responsibility for the Air Force Ballistic Missile programs, and in anticipation of future system requirements, STL is engaged in a wide variety of research and experimental development activity. Projects are in progress in electronics, aerodynamics, propulsion, and structures.

The scope of work at Space Technology Laboratories requires a staff of unusual technical breadth and competence. Inquiries regarding the many opportunities on the Technical Staff are invited.

SPACE TECHNOLOGY LABORATORIES

A Division of The Ramo-Wooldridge Corporation

5730 ARBOR VITAE STREET • LOS ANGELES 45, CALIFORNIA great influence on the choice of sealing materials. Smoothness to reduce hot spots can be maintained with 250° to 350°F. Development work on silicone rubber should allow approximately 750°F for fillets and faying surfaces. Inorganic materials may permit over 1000°F for use. Sealant temperature capacities require further investigation.

Hydraulic Fluids

Development of hydrogenated aromatic mineral oil or methyl phenol silicones may extend the current 350°F limit for silicone base fluids. Where hydraulic fluids are a limitation, other types of mechanisms can be devised.

Bearings and Lubricants

Targets for the next five-year period will probably be 300 to 450°F for sliding friction applications and 750 to 1000°F for antifriction bearings. High-temperature greases of improved lithium soap base with aryl urea thickener are currently being evaluated. Development may extend this to 1000°F.

Bearings and lubrication for movable control surfaces which can withstand 2000°F are desirable. In the folding wing-tip area, use of boron nitride to prevent freezing, and air-pressure blown into a ball and race during movement, may be feasible. Other approaches may be fabrication of high-temperature bearings of hot-pressed synthetic mica impregnated with boron nitride or some type of cermet.

Electrical and Thermal Insulation

Electrical insulations of organic types are limited to lower temperature applications. Fibrous ceramic thermal insulation may prove usable to 3000-to-3200°F with acceptable reductions in properties. Various emissive and reflective coatings become effective above 1200°F. Ceramic honeycomb sandwich may have good thermal insulating properties, but requires further development.

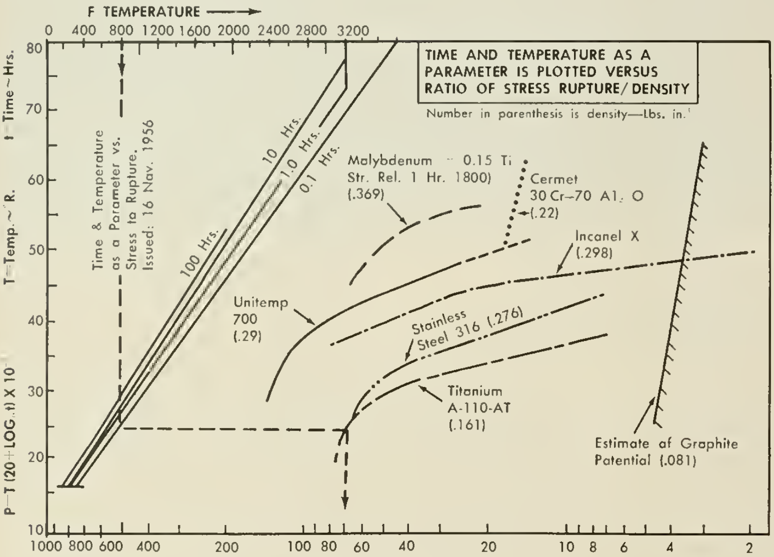


Fig. 7—Master material stress-rupture curve.

Metal	Elastic Modulus psi x 10^6 R.T.	Linear Expansion Coef./°F R.T. (70°F)	Thermal Conductivity cal/cm²/cm/°C per sec, R.T.	Specific Heat cal/g/°C R.T.
Tungsten (W)	50	2.2	0.399	0.032
Rhenium (Re)		. .		0.033
Tantalum (Ta)	27	2.5	0.130	0.036
Osmium (Os)	80	2.8	. .	0.031
Molybdenum (Mo)	42	2.7	0.35	0.063
Ruthenium (Ru)	60	5.0	. .	0.057
Iridium (Ir)	75	3.8	0.14	0.031
Niobium (Columbium Cb)	42	4.0	. .	0.065
Hafnium (Hf)	20	3.4	. .	0.035
Rhodium (Rh)	42-55	4.6	0.21	0.059
Chromium (Cr)	36-42	3.4	0.16	0.11
Zirconium (Zr)	14	2.8-3.6	. .	0.066
Thorium (Th)	10	. .	. .	0.034
Platinum (Pt)	21	4.9	0.17	0.031
Vanadium (V)	20	4.8	0.38	0.120
Titanium (Ti)	16.8	4.7	0.130	0.126

Fig. 8—Temperature properties of refractory metals.

Coatings

Aluminum silicone paints provide oxidation resistance for metals to approximately 1200°F in still air, and about 900°F in Mach 0.8 air. Vitreous ceramic coatings will protect stainless steel 321 from oxidation for several hours at 2200°F or for 150 to 300 hours at 1600°F.

Molybdenum has been protected for several hours in still air at temperatures to 2800°F and for over 300 hours at 1800°F. Protection can be provided by several metallic and ceramic materials or a composite of layers of different materials.

It is felt that the conditions used in evaluating the above coatings may not adequately represent rocket environments. This subject requires further consideration.

Another important design factor is the ratio of tensile strength to density versus temperature for various materials. Generally speaking, an increase in weight becomes necessary due to higher temperature environments.

Udimet 500 and Inconel X are the most efficient in the 1000° to 2000°F range, but exhibit an extreme sensitivity in strength with small temperature changes. The strength of Udimet 500 at 1500°F decreases 50 per cent at 1700°F.

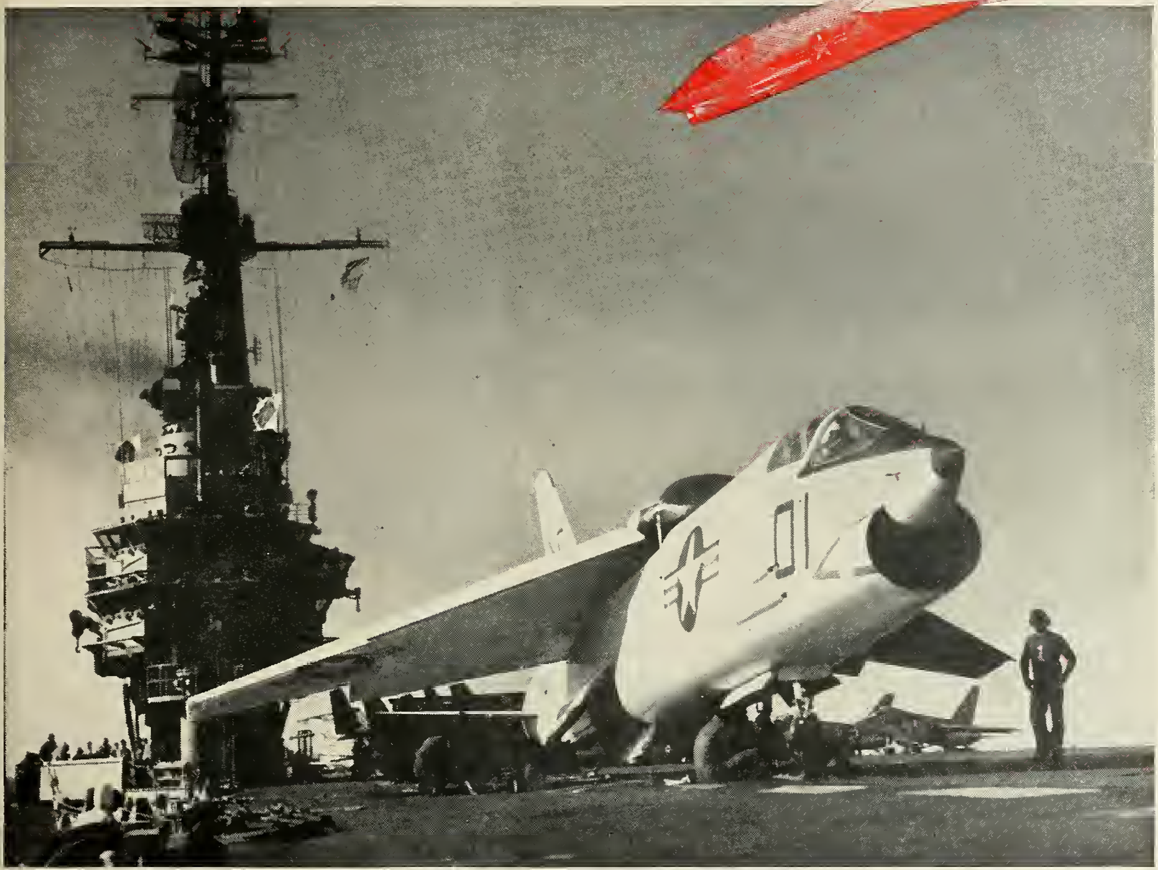
Inconel has a strength at 1700°F which is 70 per cent of its 1500°F strength. Thus, a 200°F temperature design error (which is a 10 per cent error on the absolute temperature scale and is acceptable engineering accuracy considering the present state of temperature prediction techniques) has a drastic effect. This means that the less efficient material, molybdenum, is favored for use at 1500°F when the sensitivity to temperature is given heavy emphasis.

Fig. 4 is a comparison of several standard structural properties; that is, impact strength and thermal properties. Most of the metals have acceptable impact resistance. The cermets and ceramics have poor impact strength and the strength indicated on the bar graph may be somewhere of the order of 10 times less than indicated here.

Efforts directed toward increasing cermet impact resistance by cladding or infiltration techniques have given some increase in strength, but a major breakthrough in strength has not yet been achieved.

FIRST

1000 M.P.H. CARRIER-BASED FIGHTER



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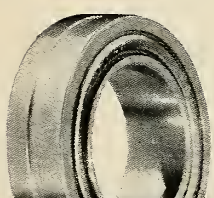

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It is not known if basic work on composition, dispersion of nonmetallics in metallic phase, particle size and shape will be the answer. This condition places increased emphasis on the refractory metals.

The thermal superiority of molybdenum is due to a combination of high thermal conductivity and low thermal expansion, with a conventional specific heat. This combination is desirable in areas of high heating rates, high temperatures, and high thermal stresses.

As a vehicle's heat sink capacity is exhausted during flight, the heating rates decrease. Molybdenum would decrease in thermal conductivity with resultant reduction in heat conduction and cooling requirements, but at the cost of higher skin temperatures.

High Melting Point Metals

Molybdenum, tantalum, tungsten, and columbium (niobium) are the most feasible metals for development as elevated temperature structural materials on the basis of melting point, availability, price and vapor pressure.

The significance of melting point, availability, and price in determining feasibility is more readily apparent than is vapor pressure. The effect of vapor pressure is shown in the following table (from HIGH TEMPERATURE TECHNOLOGY by I. E. Campbell, Wiley & Sons, 1956):

Metal	1% Vaporization per 100 hours Temp. °F	Melting Point Temp. °F
Tungsten	4640	6150
Tantalum	4350	5425
Rhenium	4315	5750
Niobium (Columbium)	4045	4380
Osmium	3830	4890
Iridium	3615	4450
Molybdenum	3470	4760
Ruthenium	3450	4530
Rhodium	3040	3625
Platinum	2910	3225
Zirconium	2730	3325
Vanadium	2625	3155
Titanium	2030	3140
Chromium	1645	3435

Not much published information is available regarding properties of binary and more complex alloys of Mo, Ta, W and Cb, and those involving small amounts of the platinum group (osmium, ruthenium, iridium, rhodium). Apparently these are being investigated by people like Battelle who believe that in this area developments may lead toward practical metallic materials for high-temperature service.

Density at about 1700°F, the strength-to-weight ratio of molybdenum plus 0.5 per cent Ti becomes increasingly superior with increased temperature when compared to such materials as cermets and superalloys. Additions of small amounts of Cb, Co, Zr, and V to molybdenum are under investigation at Climax Molybdenum.

Areas of high-temperature materials for future investigation are: (1) cermet evaluation; (2) composite structures; (3) development of new and unknown high-temperature compounds; (4) corrosion protection (Convair work includes study of ceramic-coated aluminum mild steel, stainless steel and titanium); (5) structural uses of cermets and reinforced ceramics (including ductile ceramics); (6) high-temperature adhesives (ceramic bonded aluminum and stainless lap shear joints are being developed); (7) erosion protection (flame-sprayed ceramics are being investigated); (8) thermal and radiation reflectivity at elevated temperatures; and (9) thermal insulation.

Miscellaneous applications are: (1) rocket nozzles and combustion liners; (2) high-temperature bushings, gaskets and shroud rings; (3) internal pump parts for handling molten materials; and (4) electric insulators, dielectric materials and separators in vacuum tubes.★

The views expressed in this article do not necessarily reflect those of Convair.

ORDNANCE

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a new missile material . . .

Welded Stainless Steel Hollow Core

by Dr. Michael Watter

MISSILE AND aircraft structures, although they represent only a part of the weapon system, play a vital role in the performance of the whole system and confront the designers with many new problems. The task confronting the industry is twofold:

One is to create the most advanced weapons compatible with just enough of the extrapolation of known means as to be able to reduce the time between design and its experimental realization; second, to push aggressively research of all phases necessary to assure maximum future weapon potential if there be time to take advantage of it.

Because of their novel features, this article stresses the subject of integrated core structures and is limited to a few typical examples designed and built to meet specific requirements. They emphasize the fact that each structure must be patterned to suit the specific loading and environment conditions of the design problem.

Budd integrated core structures utilize several basic types of integrated core sandwich panels. One type employs a double "vee" corrugated core, while in another type the core is of a stamped type made of two pieces. In both cases the core sheets are welded together on the neutral axis and then, in turn, to each face sheet.

Still another type employs a single "vee" core welded between two face sheets. The specific dimensions of the panels, gauges of the core and face sheets, as well as the material used, are selected to meet best the engineering requirements of the problem. The materials are those satisfying the temperature and design requirements and suitable for resistance welding.

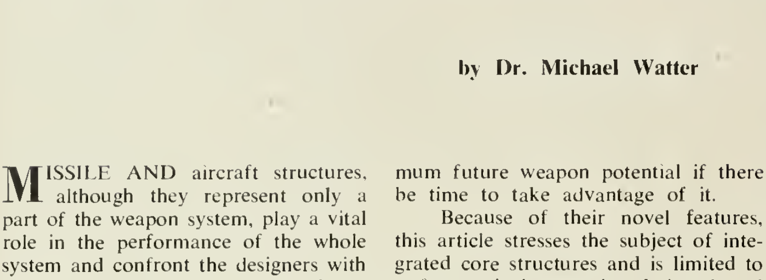
The significance of resistance-welded structures lies in several well-established but not generally known factors. For instance, because spot welding causes local reduction in the tensile strength of the weld nugget, it is sometimes thought that this local reduction limits the strength of the structure.

Actually, however, a lap joint with a double line of welds, made either of cold-rolled or heat-treated-prior-to-welding material, may have an efficiency in tension of over 95 per cent. With a small amount of additional material, tension joints can approach 100 per cent efficiency.

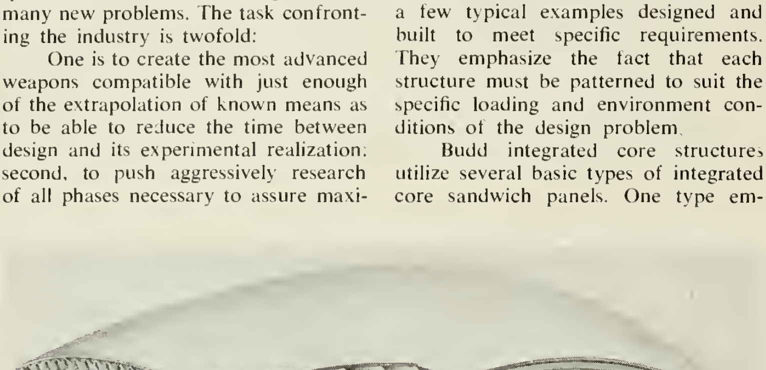
The development and present availability of the extra hard 301 stainless steel with its high physical properties, as well as the utility of increasing the strength of heat treatable alloys by subsequent cold reduction, stems from their ability to utilize effectively high strength in resistance-welded structures.

In addition to the 301-type stainless steel, the same high-strength properties can be obtained in 201-type as well as austenitic stainless alloys which do not contain nickel, such as Tenelon and TRC.

The geometry of the integrated



Welded stainless steel—double "vee" corrugation.



Welded stainless steel—double elongated waffle panel.

Dr. Watter is Director, Airframe Research Defense Div., The Budd Co.

core makes it possible to fabricate structures of exceptional efficiency from either cold-rolled, or heat-treated and subsequently cold-rolled alloys supplied directly by the mills with their highest physical properties.

Structures of the integrated core type can be fabricated as cylinders, cones or as surfaces of compound curvature which make them eminently suitable for rocket motor and missile structures. The directional characteristics of the single and double "vee" type of sandwich prove to be significantly advantageous in a number of missile structures because the core is a load-carrying member in addition to its contribution to the rigidity of the panel.

Because of the nature of the manufacturing method, missile shells, rocket motor casings, bulkheads and other missile structures are not limited in size, disposition of the internal or external structure, or the location of fittings. Their dimensional accuracy is assured by progressive fabrication permitting corrective adjustments without encountering problems normally present in heat treating large and usually considerably less rigid assemblies.

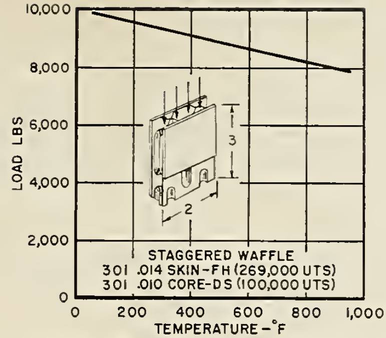
In the course of design experience, it has been found that these structures are very effective in a wide range of applications. For instance, they can be proportioned to have either low thermal conductivity or, when needed to minimize thermal buckling, a rather high thermal conductivity without sacrifice of their structural efficiency. They are also eminently suited for situations which would require cooling.

The availability of 301 stainless steel with an ultimate strength of 300,000 psi and the effectiveness of resistance-welding techniques of assembly have resulted in appreciable gains in structural efficiency in several applications which did not require resort to a sandwich construction. In other instances where high-temperature conditions were present, other alloys such as A-286 and L-605 were employed with satisfactory results.

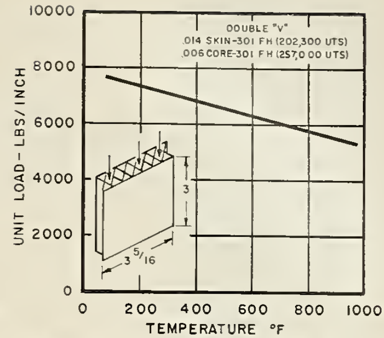
Airframe and missile structures confront the designer with two—or a combination of two—basic problems. In the case of airframes, the problems predominantly fall in the class customarily called elastic stability, while in the case of missiles they also often involve problems of tensile strength.

As stated, many of the materials potentially important in missile and airframe structures can have their physical properties enhanced through cold working, irrespective whether these materials fall into the category of heat-treatable alloys or alloys whose high physical properties can be obtained only through cold working.

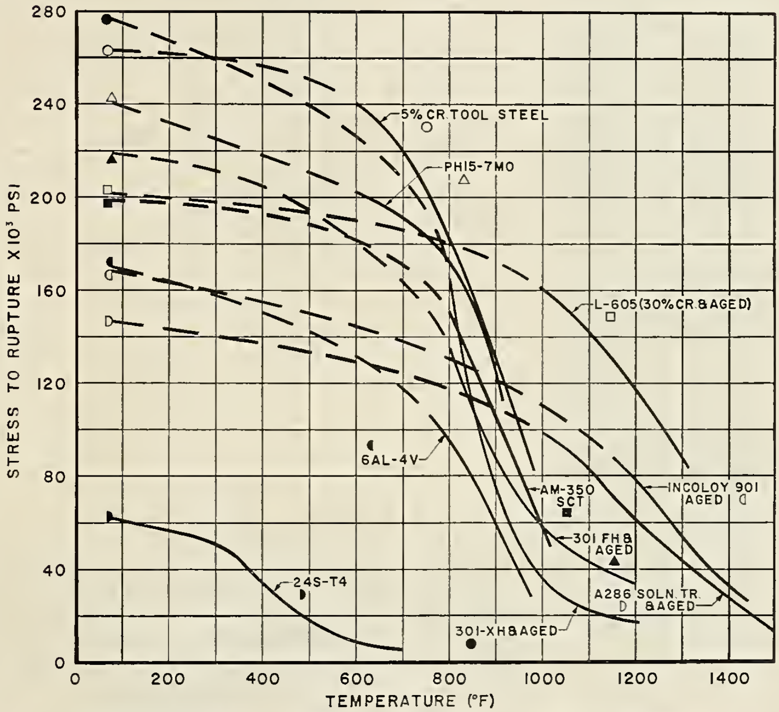
These cold-reduced materials



Double waffle compression load curve.



Double "vee" compression load curve.



Stress-to-rupture curves of various materials that can be resistance-welded.


Single "vee" resistance-welded stainless-steel hollow-core tube may have rocket uses.

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often possess highly anisotropic properties. In addition, many composite structural elements do not or need not display isotropic behavior. The treatment of anisotropic plates is found in a number of classical texts familiar to structural engineers and requires no further discussion. The subject of anisotropic materials, however, has not been widely treated.

The necessity of analyzing structures to be made in 301 stainless steel offered another useful discipline, since classical elastic behavior is not the virtue of the material. It thus became necessary to consider the true behavior of the material which was done by applying the usual methods of inelastic behavior, *i.e.,* behavior displayed by materials in the region beyond proportional limit.

To simplify routine calculations it is useful to prepare a series of effective curves for buckling, crippling, bending and shearing. In this instance, buckling is defined as a recoverable deformation while crippling denotes a permanent failure. In treating the subject of buckling of anisotropic materials, this author combined the inelastic behavior beyond proportional limit with the treatment of buckling of plates reinforced by ribs. The sufficiency of this approach for engineering analyses has since been supported by Bureau of Standards tests, the author's company's experience, and independent tests.

In the problems of missile shell design one often encounters the problem of tension, which may appear to offer no chance to apply design and analytical skill. Actually, this is not necessarily the case. The structure is always more complex than a simple tensile test coupon and hence there are problems of making joints, providing local attachments and assuring maximum rigidity of the shell particularly when fabricated in very large sizes.

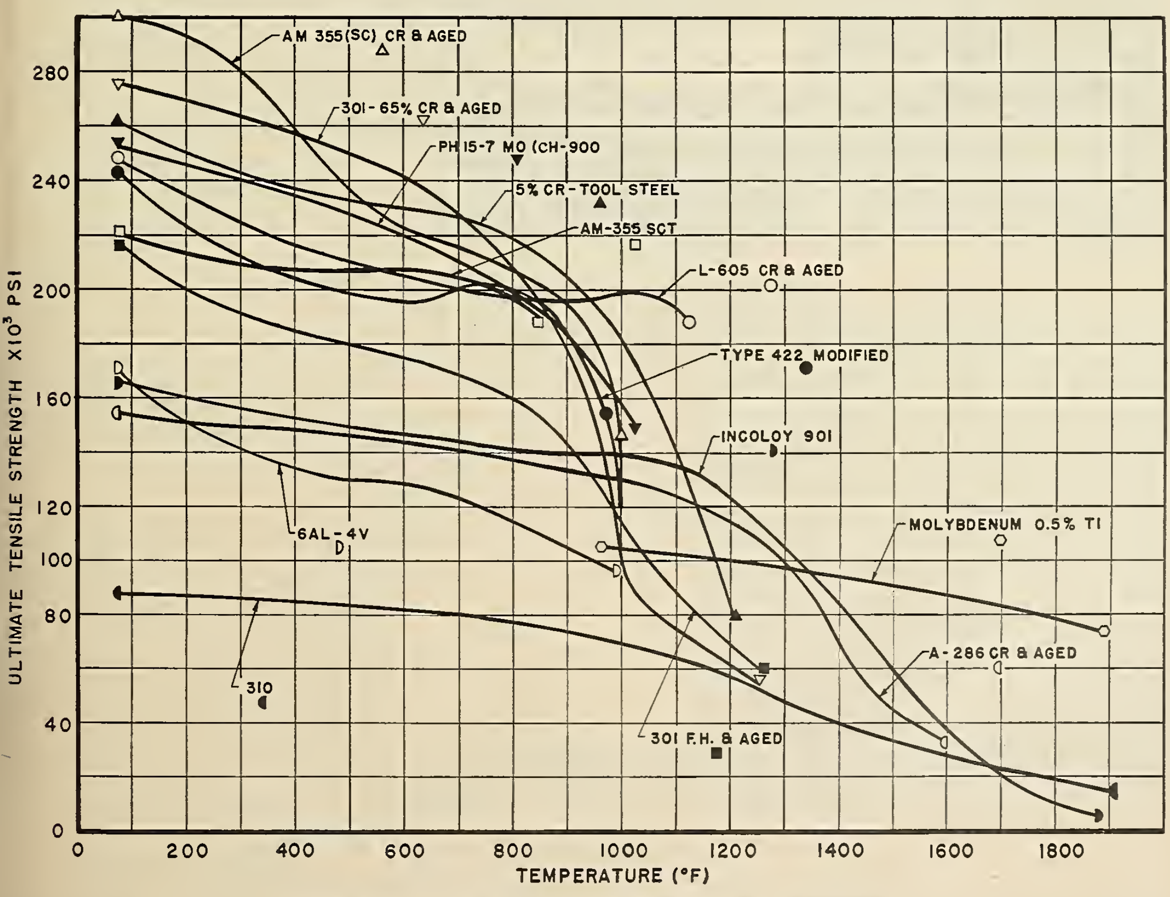
Competent proportioning of the structure can, however, assure only its theoretical correctness. Since resistance-welded design differs radically from either brazed or mechanically fastened design, the sequence of assembly must be well thought out and established by the designer in cooperation with tool engineers; it must take cognizance of the fabricating techniques and welding tools.

Welding limitations, although very much fewer than generally thought, do exist, and incorrect sequence of assembly can prejudice both the structure and the ability to fabricate it.

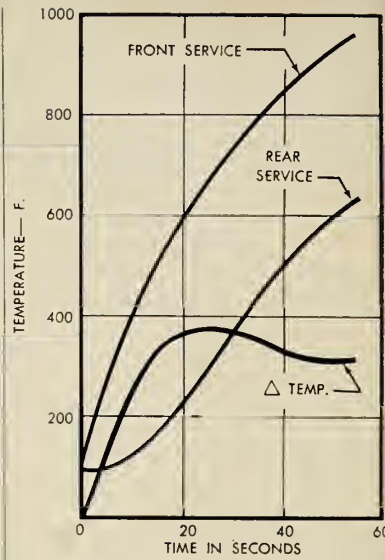
The problem of designing resistance-welded structures subject to fatigue is not different from that involved in any other structure, except that it requires specific experience. In one aircraft company, there was a sign across the drafting room which said "Don't forget the fillets!"

All structures must guard against "stress raisers" but where to look for them and how to cope with them is a matter of good judgment and accumulated knowledge.

Resistance welding has been and is used successfully in many structures subject to severe vibrations. It has been used for aircraft fuel and oil tanks; it is extensively used in jet engines, afterburners and other locations having drastic service requirements. It can assure pressure tightness, fuel tightness, ability to withstand sonic vibrations,



Ultimate tensile strength of various materials plotted against temperature.



Heat transfer rate through stainless-steel hollow core, showing total differential.

but one must provide a correct design and use suitable materials.

To expect that it can be used under all circumstances is unreasonable. Under certain conditions, considering the design limitations and service requirements, competent designers will not attempt to use resistance-welded structures—in many other cases only service or well-conceived simulated tests can establish what type of structure will meet the requirements.

Properly designed resistance-welded structures display a very favorable fail safe behavior. It limits crack propagation and having failed under excessive loading, in bending or compression, most of the time can still support a major percentage of the load which caused failure. The speed brake, referred to above, after having failed at 130 percent of ultimate load, supported about 70 percent (almost the limit load) without further distress.

Materials

In order to view the materials in the light of their possible application to actual structures, they must be considered not just on the basis of their physical properties, but on the available means of joining and forming.

Materials which derive their high physical properties at room and elevated temperatures only through cold reduction, such as 301, L-605, and A-286, can be joined advantageously only by resistance welding in this condition.

To proportion the structure in a given material, complete information must be available in the form of stress-

strain curves which, in the case of cold-rolled materials, must include longitudinal and transverse curves both for tension and compression. Customary physical data must be consulted.

The significance of these data must be weighed not only in the abstract of test a coupon, but as a result of the material application in a specific structure. To illustrate this point one may consider the stress-strain behavior of some cold-rolled materials. These materials often exhibit a very low proportional limit which may lead the designer to fear a high cumulative permanent set of his structure.

Tests prove, however, that complete structures, properly designed, approach the ideal of Hooke's law throughout the working range of the structure. A rational explanation for this lies in the fact that, unlike a test coupon, in a complex structure under a given condition of loading only a few fibers of a few members are under maximum loading. Once this loading is taken off, the elastic energy of the complex structure plays its part in the recovery of the structure to its original state. It would appear to this author that a designer may justifiably hope that the strain temperature behavior may not prove as much of a problem as it would appear to be on the strength of data currently available from test coupons.

Budd's long experience in the fabrication of resistance-welded structures served as a valuable guide in the selected approach to fabricate Budd integrated core panels. It was decided that the important feature was to adopt a method which would allow the fabrication of panels not limited either in size, gauges or compound curvatures and, in addition, suitable to permit assembly of these panels into a complete structure with the necessary attaching members and fittings.

One of the fundamental problems in any structure is, of course, the technique of joining and the reliability of joints. Resistance welding has its specific problems which must be recognized and understood.

Just as in the design of resistance-welded structures one must adopt a special approach, so in their fabrication there must be employed ample safeguards and controls.

Having originated the first controlled method of resistance welding of stainless steel known as the "Shot-Weld" process, The Budd Co. early in its experience recognized the importance of proper methods, equipment and instrumentation required to assure safe and economic resistance welding.

Missile and aircraft structures accentuate the requirements necessary to assure reliable and consistent welded joints as well as dimensional accuracy with aerodynamic smoothness. (At this point it would be pertinent to interject that The Budd Co. resistance-welded panels have met known airframe and missile finish specifications.)

In addition to the techniques and safeguards of welding control familiar to the aircraft and missile industry, there are two additional quality control methods under development. One of these consists in the use of an entirely novel automatic weld controller. This device—and there are two types under development at the present time—controls the essential variables, namely current and time, to assure the weld of a required size and strength. It is able automatically to adjust these variables for different thicknesses. It is equipped with an automatic lockout so that, if the local conditions preclude making the required weld, the welding is discontinued and a warning signal is flashed to the operator.

The second method under development makes it possible to determine on the surface of the finished part the size of the weld nuggets as well as of the heat-affected zone and to obtain a permanent record without resort either to photography or X-ray.

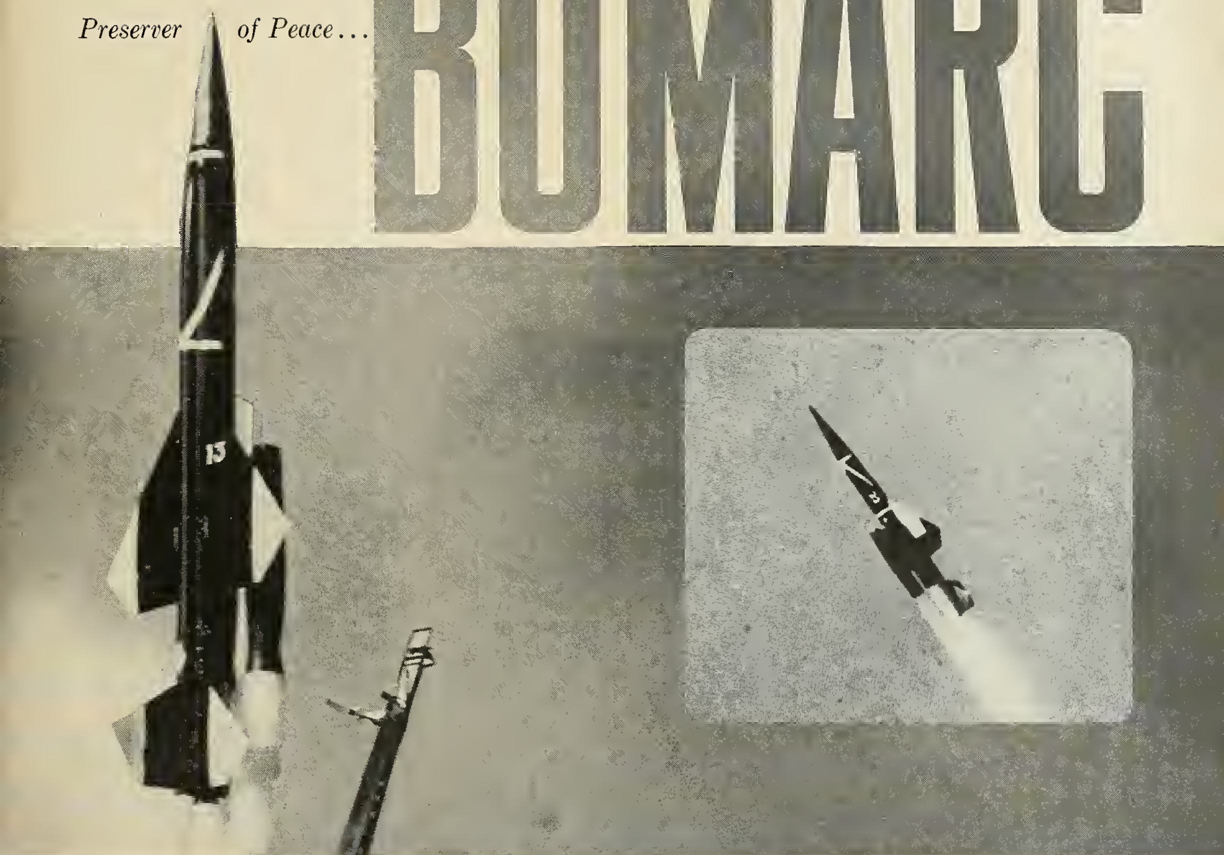
This method shows considerable promise; the correlation between macro-etch and shear-test data and the information supplied by Perma-Weld, as this method has been named, has been encouraging.

In addition to these two methods of quality control, a third technique being employed is simple and conclusive. It consists of internal pressure tests. This is a nondestructive positive test visibly demonstrating the integrity and the pressure-tightness of each panel.

It is well known that the aircraft industry, with notable exceptions, views resistance welding with considerable concern. This attitude is both proper and understandable. Some of it stems from past experience when resistance welding was applied to low density alloys of high electrical conductance and high tendency to oxidation. More recent experience with high density alloys, although directed to materials eminently suitable for resistance welding, has sometimes failed because the latest techniques and equipment were not employed.

Currently there are both prime contractors and subcontractors in aircraft industry who have the required competence in resistance welding and are doing an excellent job. It is their experience that should be used as a criterion in assessing the value of resistance welding as a safe and effective method of fabrication.★

Preserver of Peace . . . **BOMARC**



Official U.S. Air Force Photo

It tracks down an enemy at 300 miles

Described as the most potent of all ground-to-air defense missiles, the Bomarc pilotless interceptor, designed by Boeing, stands poised for the destruction of any "enemy" bomber within a 200-300 mile range. Its booster rocket has the power to hurl it more than 60,000 feet straight up; then, powered by two ramjet engines, it hurtles by electronic instinct to its target at up to 3 times the speed of sound. For this guardian of our homes and way of life, RCA has been privileged to supply important advance components of the guidance system.

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at last:

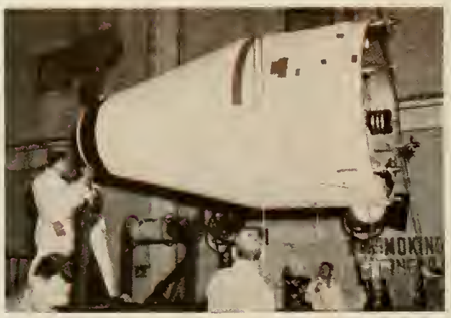
U.S. Satellite Aloft

by **Norman L. Baker**

TEN FIFTY-EIGHT PM January 31, 1958—the date the United States officially entered space. Just as dramatic as the actual launching of the *Explorer* satellite was the conclusive proof that the early decision to divorce space research from military missiles was a very unwise decision indeed.

The launching climaxed almost four years of frustrated efforts by the Army to prove its rocket abilities and give the United States the lead in the race to space. It is now official that an *Explorer*, weighing approximately five pounds, could have started orbiting the earth on Sept. 20, 1956, when a four-stage *Jupiter*-C re-entry test vehicle flew 3300 miles over the Atlantic range. The last-stage rocket and satellite were replaced by dummies on direct orders from the Pentagon to prevent the Army from making an unauthorized satellite launching. Just 27 days from the official authorization and 86 days from the undocumented nod from Defense Secretary Neil McElroy, the Army's determination paid off.

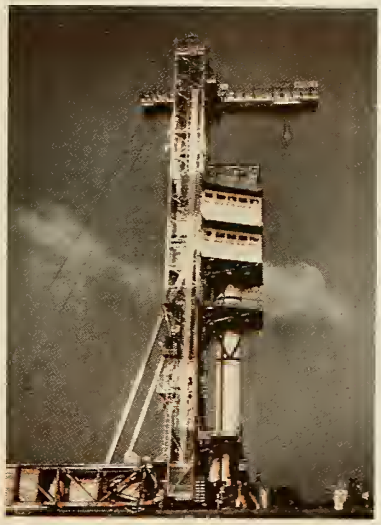
Explorer II is on the pad at Cape Canaveral. Launching date: before April 1. The Army's role in the satellite field after *Explorer* II is highly speculative. Once again they must pool their proposed projects with those of the Navy and the Air Force and hope that the people who make the selection do not repeat the mistake of 1954, when the *Vanguard* was chosen over Project *Orbiter*.★



Control section of the EXPLORER launching rocket. This section positioned final stages to satellite launching attitude shortly after separation from first stage.

Modified REDSTONE first stage is prepared for checkout in the assembly hangar at launch site. Using a hydrazine-based fuel, booster lifted the satellite to approximately 56 miles above earth.

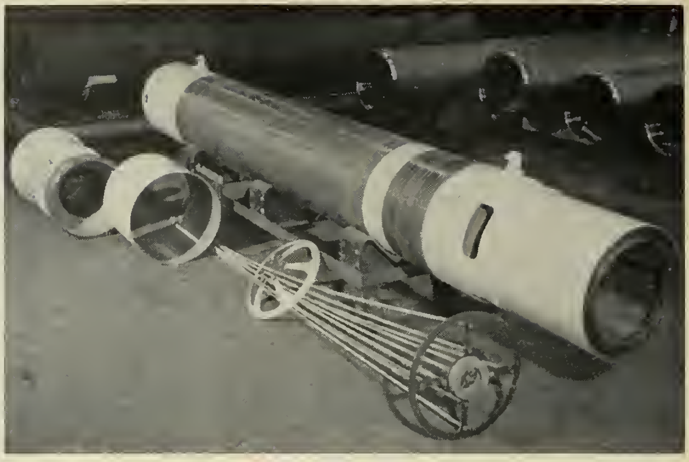
Sealed in polyethelyene to protect it from the elements, EXPLORER I is carried from instrumentation checkout trailer to gantry for mounting on fourth stage of the rocket configuration. Total electronic payload weight was approximately 11 pounds, total payload 17 pounds.



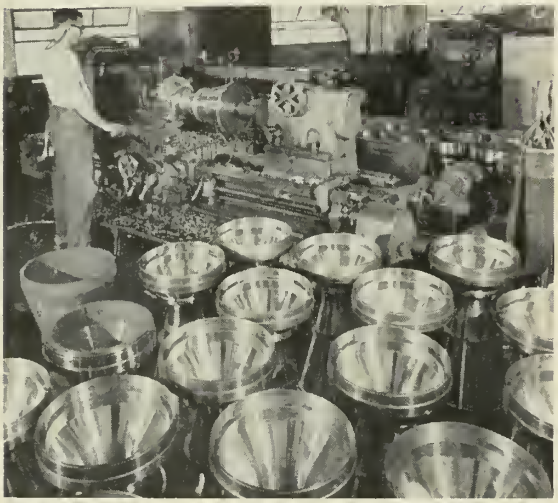
January 29th — Technicians check out the instrumentation and make final adjustments on the JUPITER-C's guidance and control in anticipation of an evening firing. High winds at upper altitudes forced postponement for 48 hours. Up to a few hours before launch the jetstream was reported to be producing blasts up to 200 mph.

January 31st — With countdown for launching under way and proper weather conditions assured, last minute checkouts induced unwarranted tensions. Fuel spillage caused several minutes delay when leakage was suspected. At countdown "zero" missile pressurization was started. Ignition started at X plus 14 seconds. The rocket took off at 15.75 seconds after "zero."

Case for GOODYEAR



A plastic-impregnated, fiberglass NIKE rocket, manufactured by Goodyear while investigating better ways to make the boosters.



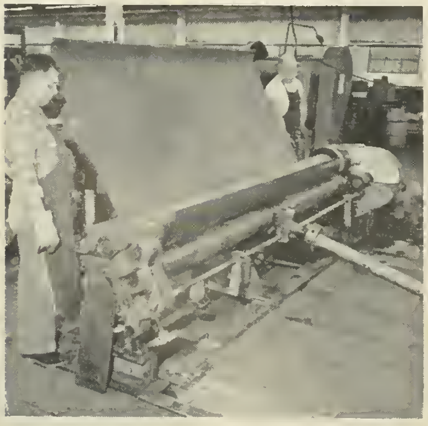
The nozzles are received from the foundry as rough forgings and machined to final shape to maintain the tolerances needed.

GOODYEAR AIRCRAFT'S rocket activities have produced more large rocket motor cases than any other manufacturer. In order to achieve this standing in the industry the company entered the business in 1948 with an extensive development program for an engine case that could be produced economically in quantity. The success of that development program is depicted in accompanying photos of the company's current production facilities.

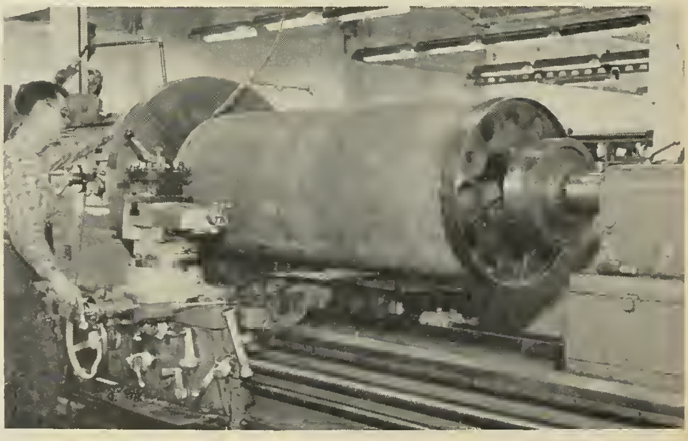
Starting with Jato bottles, Goodyear soon expanded its facilities to produce a large number of units a month for the Army's *Nike-Ajax* missile. *Nike* booster cases are still the chief production item in an expanded program, but the company has built or is building rocket motor cases for the *Nike-Hercules, Matador, Genie, Hawk, Recruit* and other missiles.

Although past and current production has been largely cases made of special steel, extensive investigations have been made into the use of aluminum, fiberglass, magnesium and plastics.★

Steel sheets are rolled into tubes as the first step. Later, tubes are longitudinally welded.



After the longitudinal welding operation is completed, the rough cases are mounted in a lathe and accurately cut to the required length.



Largest Special Metals Company Formed

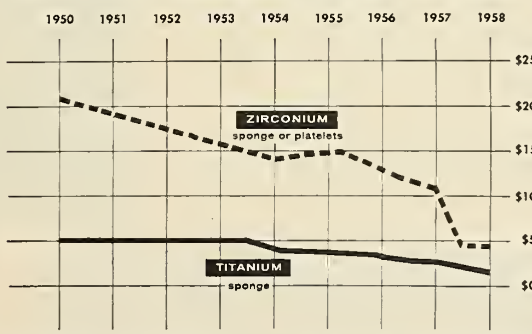
MALLORY-SHARON NOW INTEGRATED PRODUCER OF TITANIUM, ZIRCONIUM, SPECIAL METALS

Mallory-Sharon Titanium Corporation has broadened its scope in the special metals field with acquisition of all the titanium and zirconium sponge production facilities of National Distillers & Chemical Corporation, plus full ownership of Reactive Metals, Inc., formerly owned jointly by Mallory-Sharon and National Distillers.

Our new name is Mallory-Sharon Metals Corporation. Our products include titanium, zirconium, and hafnium in sponge form and in a broad range of mill products including sheet, plate, rod, bar, billets, etc. Planned for the future are other special metals.

LOW COST PROCESS—Now a fully integrated producer, Mallory-Sharon will use the new sodium reduction process for making titanium and zirconium sponge. This process is believed to be the lowest cost method developed to date for this purpose, and produces metal of unusually high ductility. It will contribute to making titanium and zirconium economically attractive in more and more applications.

WHAT THIS MEANS TO YOU—Mallory-Sharon's leadership in the special metals field will mean continuing improvements and importance to these metals. In addition to titanium's broad use in aircraft and missiles, and zirconium's in the nuclear field, both metals provide exceptional corrosion resistance—offering lower costs in a broad range of processing and industrial applications. Let us help *you* design ahead with these new metals.



Regular price reductions in titanium and zirconium sponge have also been reflected in lower prices for mill products. This trend shows the wisdom of evaluating titanium and zirconium now for your new products.

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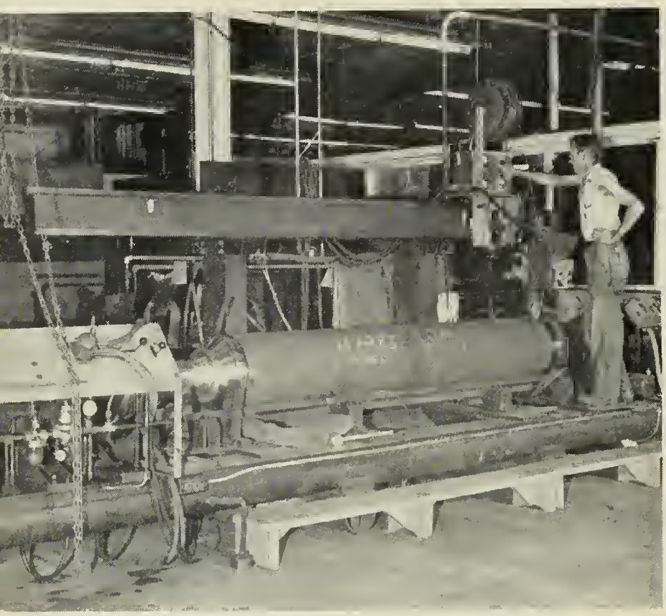
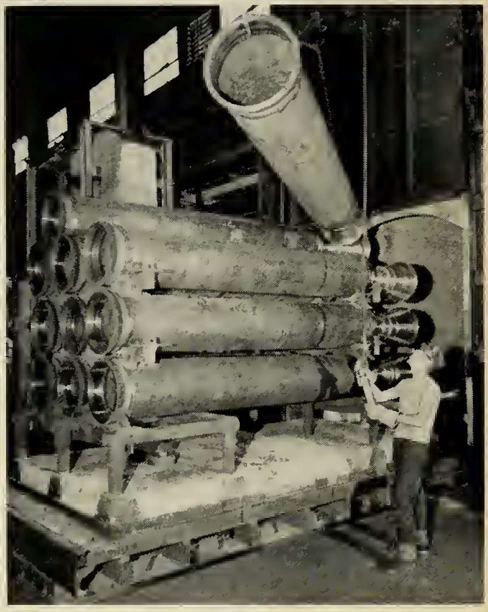
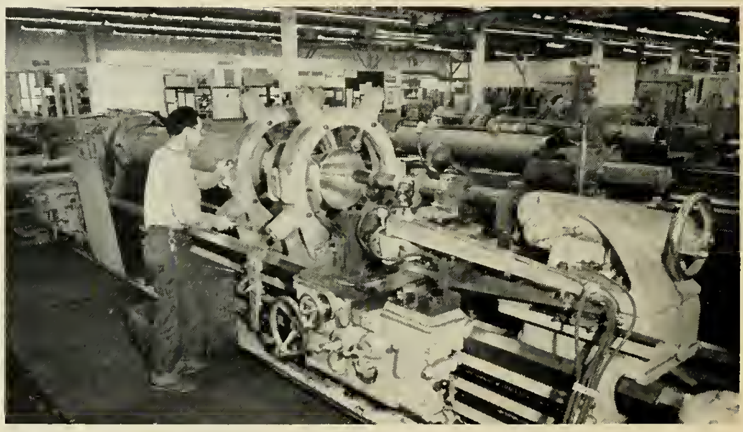


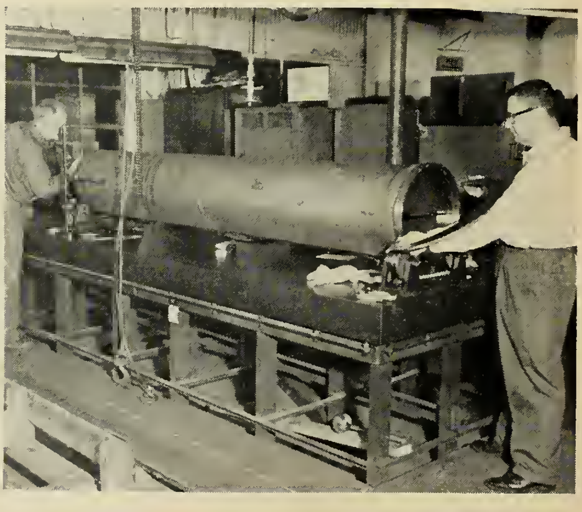


In an assembly fixture, the three principal parts of the motor—nozzle, tube, and forward ring—are welded into a single unit (Above).

Stresses produced by the welding operations are then relieved in a furnace (Above right). To correct any misalignment which may have been caused by welding or heat-treating steps, rockets are given final thrust alignment cuts on a tracer lathe (Right) plus final alignment for fin attachment rings. Rocket motors which have been through operation show bright rings around nozzle (Below).

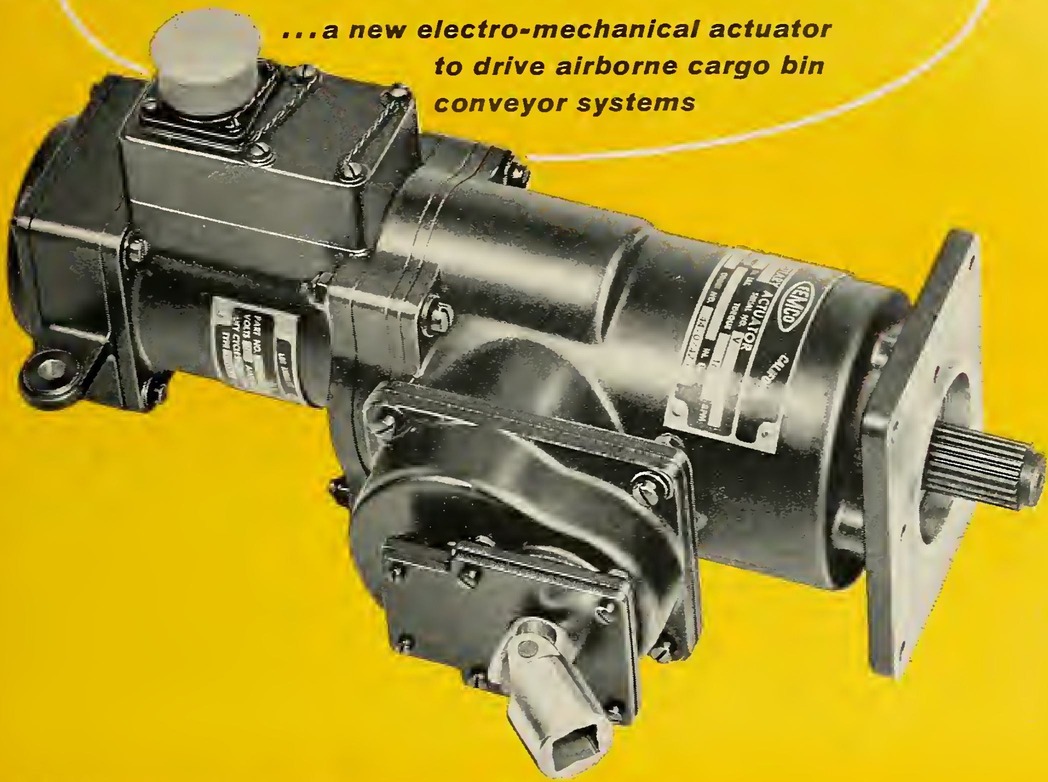
After machining, inspectors check inside and outside dimensions carefully and alignment of nozzle to case. Past inspection, the rockets are cleaned, bonderized and painted (Below, right).





EEMCO ANNOUNCES

...a new electro-mechanical actuator to drive airborne cargo bin conveyor systems



EEMCO electro-mechanical rotary actuator Type D-961 has been developed for use on airplanes to drive their baggage bin conveyor systems. Operated either electrically or manually, the actuator moves the bins forward or aft, and holds the bins in any desired place.

This new **EEMCO** rotary actuator consists of an intermittent duty 200 volt, 3-phase, 400 cycle AC motor and gear box. It is electrically reversible and includes an AC operated brake, thermal overload protection, manual drive input shaft, and reverse torque lock mechanisms.

The unit is designed for normal operating load of 810 in. lbs. torque at 16 rpm, 1.4 amps, and meets all pertinent military specifications. The maximum static load without permanent deformation is 5100 in. lbs.

EEMCO specializes in the design and production of precision-built actuators and motors. The majority of the latest and fastest aircraft and missiles carry one or more **EEMCO** systems. Prime contractors of civil and military aircraft rely on **EEMCO's** years of experience in the exclusive design and production of motors, linear and rotary actuators.

SPECIFICATIONS FOR TYPE D-961

Motor:
200-volt, 3-phase, 400-cycle AC motor with gear box.

Normal operating load:
810 in. lbs. torque at 16 rpm, 1.4 amps.

Maximum static load:
5100 in. lbs.

Weight:
12 pounds.

Qualification:
Type D-961 has been designed and qualified to meet applicable military and aircraft manufacturers' specifications.

Your inquiry is invited.

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3-554

Silicone Applications in the Missile Industry

can polymeric silicon compounds solve today's critical problems?

by Norman L. Baker

ORGANIC COMPOUNDS of the earth's second most abundant element are utilized in many ways to help solve critical problems in the rocket and missile program. Applications range from oils, greases and plastics to heat-resistant lubricants, varnishes, binders and electronic insulators.

A major portion of the missile program is invested in the guidance systems operated and controlled by complex electronic devices. These nerve centers must function perfectly even after storage for extended periods in the humid tropics, in the frozen Arctic or on the salt-sprayed decks of boats or submarines. Silicone rubber and resin coatings, potting compounds and protective shields are providing the answer to these rigorous conditions.

Entire circuits are protected by coatings of silicone rubber. These are moistureproof, fungusproof and impervious to weathering or ozone attacks. These units may be exposed to a temperature range of from −70°F to several thousand degrees within seconds. Even if the silicone rubber covers on the wires and circuits do burn, continuity of the circuits and control of the missile are maintained because silicone rubber leaves a nonconducting silicone residue.

Gaskets, sealing rings and tubing must resist all of the above hazards, as well as function during brief exposure to concentrated peroxides, strong acids and various liquid fuels. These seals must function perfectly even after they have been opened and closed many times during the assembly, testing and preflight periods. Silicone rubber parts are the answer; specifically silicone rubber compounds with the vinyl-containing gums which provide the near ultimate in resistance to taking permanent set.

Silicone fluids with a very high viscosity go into several very ingenious mechanisms such as "grain immobilizers" to compensate for distortion due to temperature in mechanical linkages.

Radome Polyesters

In the structure of aircraft and missiles, silanes and silicones have found important areas of application. Radar transparent radomes are a necessity in all phases of aircraft and missile operation, and glass-fiber-reinforced polyesters are almost universally used for this work. Radar antennas on the ground, as part of the air defense system, are protected by such devices. The units for guiding aircraft and for aiming guns are also covered with radar transparent radomes. An essential ingredient of these products are the vinyl silanes which couple the resin to the glass, thereby increasing the strength and effectively eliminating most of the effects of water or high humidity on both electrical and mechanical properties.

Silicones today are used for the high-altitude, high-speed research rockets and missiles which are being used to secure weather and ballistics information, as well as those which are part of the antiaircraft and antimissile defense.

Guided missile weapons and many other free-flight devices which are electronically guided at very high speeds, as already mentioned, require

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extensive use of the silicones. Their miniature motors increase operating temperatures—already very high because of the high in-flight ambient temperatures. Silicone rubbers and resins on wires and components, together with supporting silicone laminates and moldings, afford the structural rigidity, dielectric integrity and ultimate in dependability which are necessary under these conditions of severe heat and physical shock.

Silicone Oil Applications

The unusual ability of silicone materials to withstand high and low temperatures and high ozone concentrations also applies to the silicone oils. In addition, the silicone oils offer a range of mechanical properties which suit them for diverse uses.

At moderate viscosities the effective liquid range of a silicone fluid,

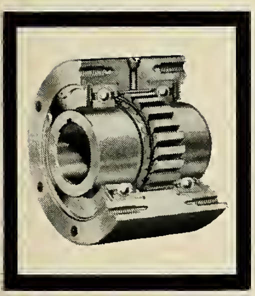
Extensive use of silicone is needed for high-speed missile radomes to overcome the high heat of aerodynamic friction.

such as L-45 dimethyl silicone oil, is from −40°F to 400°F for short periods. It offers much better resistance to breakdown due to mechanical work than organic oils, and has at the same time very high dielectric strength and corona resistance. Consequently, uses of the silicone oil in missiles and rockets can range from such applications as the fluid in shock absorbers for the *Nike* guided-missile launchers to capacitor fluid material for the electrical systems.

The *Nike* shock absorber takes advantage of the long-term stability of the dimethyl oil at all temperatures and its fluidity at low temperatures, which permit the use of the shock absorbers in all climates.

Here and in other applications, the higher compressibility of the silicone oils is used to good advantage. Several hydraulic-system arrangements use the dimethyl fluids because of the good viscosity temperature coefficient.

Electronic systems utilizing fluid-



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filled capacitors are using silicones. The long life of silicone fluid suits it for sealed capacitors, and the fluid's high dielectric strength, excellent insulation resistance and low power factor are as important here as its thermal stability. Surface creepage in electrical systems by moisture absorbed on the surface between contacts is defeated by very thin, baked-on films of dimethyl fluids.

Aerodynamic Heating Protection

The exterior surfaces of many missiles and rockets reach high temperatures because of high-speed flight. The glass-reinforced phenolic exterior parts of these units are rapidly deteriorated in mechanical strength at 500°F or higher. Use of aminopropyltriethoxysilane finishing treatment on the glass permits sustained use at higher temperature or short exposure to temperature extremes which were heretofore impossible.

Here, too, coupling of the resin to glass occurs and is believed to be responsible for the effects. Vinyl silane and amino silane glass finishes make these improvements possible.

More conventional silicone materials available today are a far cry from what they were 10 years ago, and it is well to have a new look at some of the silicone resins and rubber used for electrical insulation.

Silicone impregnating varnishes have the common functions in all Class H systems of sealing, bonding and filling. The degree to which the silicone varnishes perform these functions is much greater today than ever before. For example, R-620 silicone varnish has improved performance for all three functions due to two significant improvements: first, the bond strength of the varnish is retained even though it quickly cures to a hard waxy film; secondly, the varnish is manufactured and supplied in a diluent which allows immersion or vacuum-impregnation of warm units without fear of component breakdown or varnish thickening.

Insulation Improvement

Ground and turn insulation, which has consisted of glass cloth saturated with silicone resins in combination with mica flakes or asbestos, has greatly improved in quality. Uniformity of thickness and retention of dielectric strength at the crease had been major shortcomings of the silicone bonded product, but the new tapes and laminates of today are tough and uniform, and Class H silicone resins have been developed which display better solvent resistance.

Incorporated in glass cloth or

laminates, R-62 silicone resin offers the added protection of component integrity during subsequent contact with adhesives, varnishes or paints. Very flexible resins such as R-61 retain bond strength in mica glass tapes and laminates when wrapped or formed to their insulation task.

These improvements in inorganic materials and silicone binders, together with application technique improvements on the part of the component manufacturer, have placed effective new insulation material at the disposal of manufacturers of such items as motors, transformers and coils for aircraft, rockets and missiles.

A new silicone resin, especially designed for cold-blending with alkyd, melamine and acrylic-type baking enamels to give them improved color and gloss retention, thermal stability and resistance to weathering, has been developed by Union Carbide. The resin, R-64, is expected to find wide use as a base for aluminum paints to operate in the 500°-1200°F range as protective coatings for engine systems.

A new silicone rubber with exceptionally high conductivity has been developed in the Union Carbide laboratories. This material, K-1516, is compounded with carbon black and has a volume resistivity of less than 10 ohm-cm. Mixtures of this compound with normal silica-filled silicone rubber compounds provide a variety of resistivities. Applied to coils as a tape or from a solvent solution, this material provides an improved corona precipitator. Actually, this rubber is versatile enough to be either a conductor or an insulator, depending on the way it is compounded.

Silicon Rectifiers

All applications outlined here utilize polymeric silicon compounds especially prepared to meet individual demands of the industry. The nonmetallic element is receiving wide usage in its nearly pure form, much of it in the semiconductor field.

Silicon rectifiers offer a most promising range of applications, from extreme cold to high temperature, and from a few watts of output power to very high voltages and currents. Inherent characteristics of silicon allow junction temperatures in the order of 200°C before the material exhibits intrinsic properties. This extends silicon's operating range beyond that of any other efficient semiconductor. The excellent thermal range, coupled with very small size per watt of outpower and extremely high efficiency because of high inverse resistance, make sili-

con rectifiers applicable where other semiconductor rectifiers were previously considered impractical.

Silicon, as used in silicon rectifiers, is a nearly perfect single crystal of pure metal to which has been added an element from either group III or group V of the Periodic Table.

Silicon does not readily lend itself to zone refining. Therefore, the most popular method to produce single crystals or pure silicon is crystal "pulling," where a seed of pure single-crystal silicon is dipped into molten silicon, rotated slowly and withdrawn at a predetermined rate. A major problem in crystal "pulling" is to keep the resultant crystal free from contaminants. Molten silicon is very active and attacks the materials used in containers and holders. Quartz crucibles are commonly used and the entire process is conducted in an inert atmosphere to reduce the possibility of contamination. Temperature of plus or minus 0.1°C at approximately 1430°C must be maintained.

When it is determined that the crystal has resulted in the desired type, and that the resistivity is within the range that will produce suitable voltage ratings, the crystal is cut into thin slices and finally into small wafers or dice of desired size and thickness.

After suitable etching and grading to separate wafers that do not conform to established thickness specifications, the dice are alloyed by a special process. Alloying is conducted at high temperatures and provides not only a junction on one side of the wafer but a low ohmic contact on the base. Low resistance contacts are important, since once the internal space charge is overcome the resistance of the cell decreases exponentially and contact and lead resistances become factors limiting current flow.

Alloyed dice are brazed to a base and then hermetically sealed after a contact is provided to the alloyed side. Extreme care must be taken during the mounting and assembly operations to keep the surface free from contamination of any type since contaminants will ionize and shunt the junction.

Final electrical and mechanical tests are performed before and after successive heat cycles to make certain that the rectifier is stable under all conditions of temperature, humidity, altitude and shock.

Silicone chemistry has contributed immeasurably to the sensational development of rockets and missiles. Engineers are looking to silicones to satisfy many of the complex requirements of the missiles of tomorrow.★

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- Clearance & Recovery
- Propellant Handling

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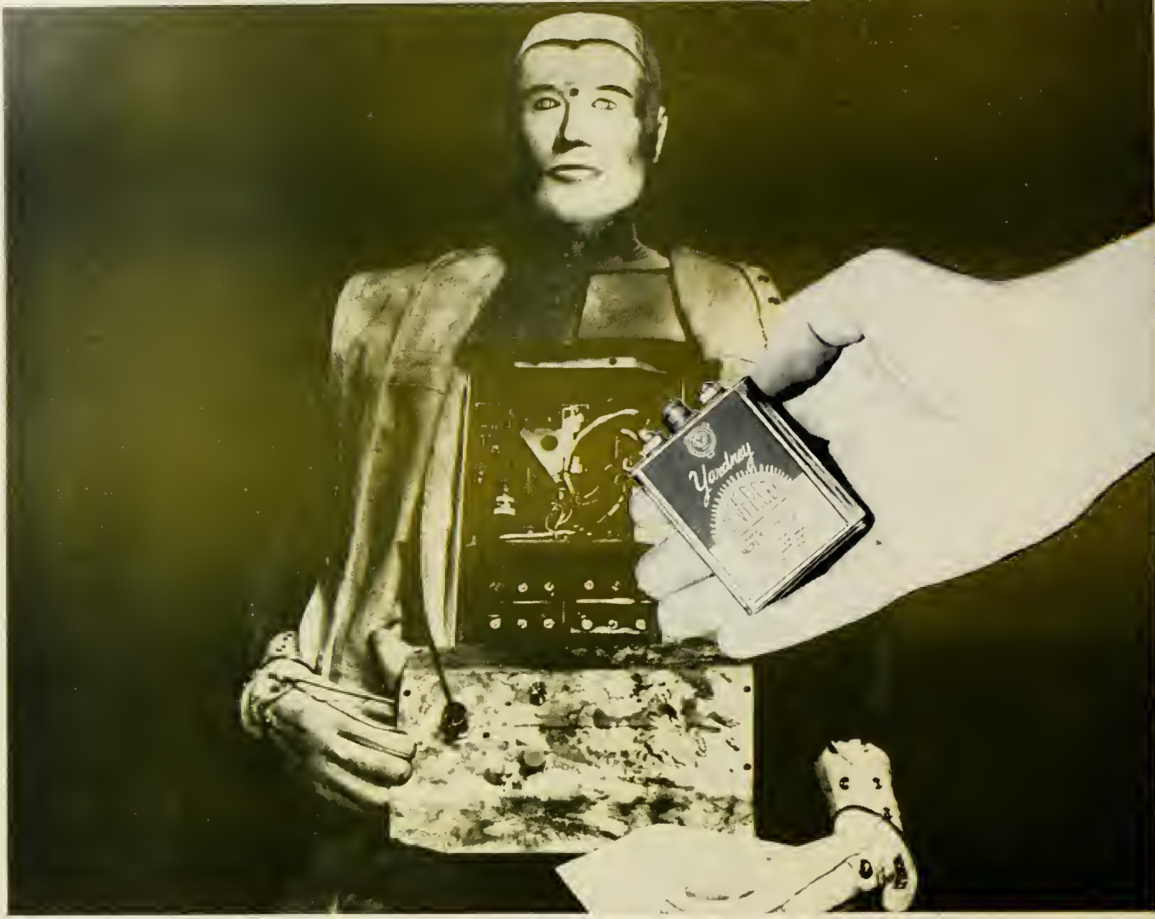

To perfect supersonic escape techniques, the Coleman Engineering Company has created Hurricane Sam, an amazingly real 6-ft., 180-lb. "man". Internally, a YARDNEY SILVERCEL® Battery—a power pack smaller than a human heart—runs strain gauges, accelerometers and a telemetering transmitter, that measure and transmit his almost-human reactions to a 1,500 m.p.h. catapult from Utah's Hurricane Mesa. Throughout this leap, and many others, Sam's YARDNEY SILVERCEL® heart continues to power vital instruments that will mean survival for human flyers under actual emergency conditions.

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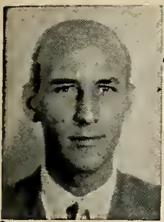


Propulsion Engineering

by Alfred J. Zaehringer

Ion rocket performance measured. Giannini Research Lab reports helium gives an I_{sp} of 600 seconds. Heavier ionization could result in a specific impulse of near 1000 seconds. The measurements were reported at an USAF advanced propulsion symposium held recently in Los Angeles.

•

Hydrocarbons are still king fuels. They are still bigger production items than boron fuels, alcohol, aniline and hydrazine. Yet, hydrocarbon rocket fuels account for only an insignificant portion of U.S. production.

•

Hypervelocity missile launcher. Naval Ordnance Laboratory at White Oak has fired projectiles from a gun using hydrogen-oxygen mixture as a propellant at chamber pressures of 65,000 psi. Small missiles (on the order of 10 grams weight) can hit a velocity of about 15,000 ft./sec. Plugging the barrel results in pressures of 21,300 psi and temperatures of 3710°F. The launcher may be a novel reaction vessel to study new chemical pressures now difficult to attain.

•

Smog-free LOX? Air Products has completed two LOX plants in California for rocket testing. One is a $3-million plant at Boran, Calif. The other is a $4-million facility that serves Aerojet at Sacramento. The latter plant also produces nitrogen.

•

Promising ceramics for nozzles are titanium boride, titanium carbide, zirconium boride and zirconium carbide. The Carborundum Co., working on these materials, reveals that its KT-silicon carbide can take 4260°F in a neutral atmosphere and 2730°F in an oxidizing atmosphere. The material is 96.5 per cent SiC and has 97 per cent of the theoretical density. Unlike other ceramics, KT-SiC acts as its own binder. Its good tensile strength makes it a candidate for rocket nozzles.

•

Impulse loss of control vanes in rocket exhausts. This is slight say Langley Field scientists of NACA who tested both polished SAE 1020 steel and carbon graphite vanes in the 6.25-inch *Deacon* rocket motor. The steel vanes were entirely satisfactory for stabilization. Four vanes pulsed to ±12.5° result in a 3.6 per cent impulse loss. At maximum deflection there is a 4.5 per cent loss and about 3 per cent for zero deflection.

•

New boron advances. Scientists at the University of Michigan have reported work on new, high-energy, highly reactive compounds of boron, nitrogen and phosphorous. Also important is the working arrangement between Thiokol and Callery Chemical to develop HiCal boron solid fuels. Stauffer Chemical and Aerojet-General have joined hands to form Stauffer-Aerojet Co., presumably to work on boron solids.

•

Chemicals for solids. Look to increased markets for the following solid oxidant materials: ammonium nitrate, ammonium perchlorate, lithium nitrate and perchlorate, and diethylene glycol dinitrate. Nitroglycerine and nitrocellulose may also chalk up sales gains. Gaining solid fuel-binders will be the polyesters, polysulfides, epoxy, and synthetic elastomers. Showing R&D gains will be decaborane, polycarbonates, phenolics, vinyls, polyamide and polyurethane.

MISSILE AGE

By Norman L. Baker

Chemical Milling Key to *Thor*, *Jupiter* Structure

The *Thor* and *Jupiter* IRBMs are fabricated by a new concept in missile structure design, developed to achieve maximum weight saving with an overall increase in body strength. This has been made possible by the use of large integrally stiffened panels chemically milled to the thickness desired.

The United States Chemical Milling Corp., contractor to both ABMA and Douglas, has been milling parts for the *Thor* and *Jupiter* body structures in the form of very large panels. The panels, three feet wide and over 25 feet long, are milled to exact tolerances of ± .003 inch.

Missile designers have long taken full advantage of the weight saving, heat resistance and superior strength made possible by the extensive use of light metals, such as aluminum and titanium. However, machining of these materials, especially titanium, is extremely difficult. But now, through recent advances in the art of chemical milling, further impressive weight saving is made possible. North American Aviation was one of the first companies to utilize chem-milling for the manufacture of small airplane parts during World War II.

Eight of the 3-by-25-foot panels are interlocked to form a cylindrical shell 24 feet in circumference which forms the ballistic missile body. Missile fuel and oxidizer tanks, being cylindrical in shape, fit neatly inside the shell formed by the panels. For some applications, this outside shell actually forms the exterior of the tanks. In other words, the tanks are an integral part of the missile structure. Several bulkhead rings are used to give the shell additional structural rigidity.

The individual panels are extruded and then stretch-formed into an eighth of a circular arc. Locking members on either side and two I-section stiffeners are extruded from the original plate. To allow the metal to flow properly during the extrusion process, a section thicker than required to withstand the stresses is used. Such a heavy panel could not be used for a missile without suffering a large weight penalty.

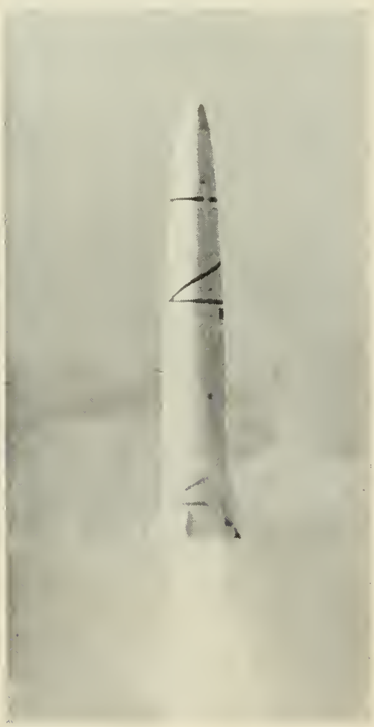
Overall weight reduction was accomplished by chemically milling the entire panel down to a thickness that will carry all loads. Additional design and weight advantages are obtained by providing a taper over the 25-foot length. More than 10 pounds of weight penalty are removed from each panel, resulting in an overall weight reduction of more than 80 pounds.

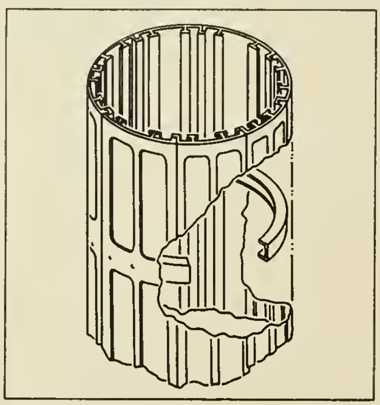
The bulkhead rings, to which the panels are attached, are first extruded into a channel section, and then chemically milled to remove unnecessary weight after they are rolled into rings. Removal of weight on both parts and the tapering of the panels could not have been done in any other way.

Titanium and supersteel alloys are extremely difficult to form and machine in a conventional manner, and as a result have been greatly limited in their applications. However, it is now possible to produce almost any shape or contour, such as these complicated panels, because of chemical milling.

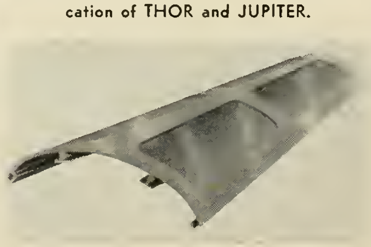
With a pound of unnecessary weight removed from a missile, approximately 18,000 feet of additional altitude and an extended increase in range can be gained by the ballistic missile. Such gains in missile performance, which have been made possible through chemical milling, are vital in the continuing struggle to improve mass-ratio values.

The list of missile programs utilizing chemically milled components is extensive. The numerous applications of this process have proven that no design is too complex for at least a partial chemically milled operation.





Integrally stiffened panels 3 feet wide and over 25 feet long are chemically milled to exact tolerances of ± .003 inch for fabrication of THOR and JUPITER.



Electric Boat to Build Ballistic Missile Subs

A naval shipyard and one private yard have been selected to construct the three nuclear-powered fleet ballistic missile (FBM) submarines recently approved by Congress in the fiscal 1958 supplemental budget.

The Electric Boat Division, General Dynamics Corp., Groton, Conn., will build two submarines subject to acceptable contract negotiations, and the Mare Island Naval Shipyard will build one.

These two yards were selected because, in the Navy's judgment, these assignments will permit the earliest possible completion date. Rear Adm. A. G. Mumma, USN, chief of the Navy's Bureau of Ships, said that capabilities of other qualified yards will be further considered when additional *Polaris* submarine construction programs are approved.

Orders for reactor compartment components for these three ships, including long lead-time components such as pressure vessels, pumps, steam generators, main turbines, gears and other auxiliary components, are in process.

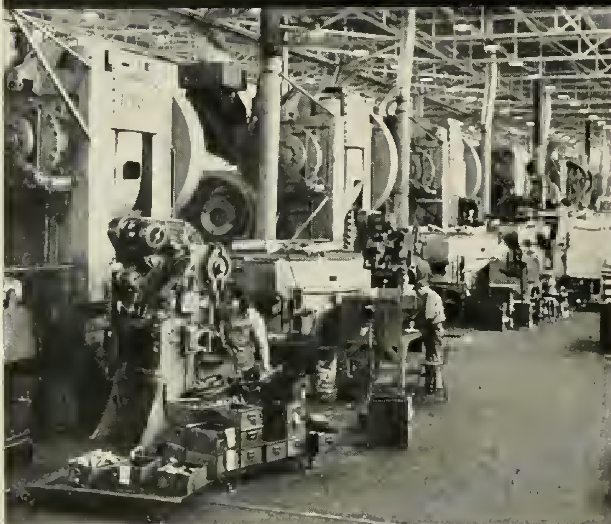
They will differ from nuclear-powered submarines now under construction chiefly in their missile features, R.Adm. W. F. Raborn has announced. Their hull configuration, similar to that of the USS *Albacore,* will give them high underwater speed. They will be equipped with SINS, the Navy's revolutionary new navigation system, and with new stabilizing and electronics equipment incorporating the most recent engineering advances.

EG&G Under Contract for Nuclear Rockets

An Atomic Energy Commission contract with the firm of Edgerton, Germeshausen & Grier, Inc. will include work on the program aimed at developing nuclear propulsion systems for rockets and missiles.

Under the contract EG&G has been given the responsibility of installing and operating some of the control and measuring systems planned for use in the testing of nuclear reactors which may lead to the development of nuclear rocket propulsion systems. The project is under the direction of the Los Alamos Scientific Laboratory.

Tests will be conducted at the Commission's Nevada test site where EG&G has been responsible for some of the sequence timing, instrumentation and technical photography in all of the tests of nuclear devices conducted there.



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Goodyear Boosts Astronautics Division

Goodyear Aircraft, one of the first companies to get into the astronautics field, recently announced that its activities were to be expanded. Studies performed by Goodyear under current military contracts have led the advanced planning for further space orbiting and travel. The company's astronautics section is comprised of a large group of engineers and scientists engaged in studies directly connected with space travel or closely allied with it. Many of these studies bear directly on investigation of the problems of establishing a manned space satellite.

Goodyear astronautics engineers feel that true domination of space does not really start until man has been placed in orbit around the Earth and returned to Earth again safely. From then on, trips to the Moon, Venus, Mars and possibly other planets, are only a matter of time.

Darrell C. Romick, widely known authority on space travel, heads the astronautics section. He has been to Europe to give papers before the International Astronautical Federation and has talked before scientific and engineering groups in all parts of this country since the early 1950s. As a member of the American Rocket Society, Romick was one of the scientists who recently sent their space flight recommendations to the White House.

From the studies made by Romick and several other engineers, notably Richard E. Knight and Samuel Black, there has evolved a concept for a three-stage rocket to get man into orbit and bring him back, with this difference—the two booster stages would be also manned and recoverable for reuse.

The concept is called *Meteor* and a smaller version, less costly and which can be put into operational status within six to eight years, is called *Meteor, Jr.*

In the *Meteor* concept, Romick visualizes three delta-wing aircraft taking off vertically and nested tail in nose, the first booster separating from the group at about 35 miles altitude and returning to Earth in a ballistic-hypersonic glide.

On making a conventional landing, the booster is fitted with jet engine pods and fairing, and makes a conventional airplane-type flight back to the original launch site. The same thing occurs with the second stage, except that, due to higher altitude and greater speed at separation, it would land at a more distant point from the launch site. The third stage would likewise be capable of making an unpowered glide back to Earth.

The astronautics section has worked out not only the requirements for the rocket vehicle itself in considerable detail, but have made advanced studies of necessary ground-

Thomas A. Knowles (seated), president of Goodyear Aircraft Corp., is briefed on the company's space flight program by Darrell C. Romick, head of the astronautics section. E. A. Brittenham, chief engineer, is at left. Romick is holding model of the METEOR, JR.

handling equipment. The permanent earth satellite has been extensively studied and provision has been made to house technicians and scientists while the vehicle speeds around the Earth at 16,500 mph. There will be laboratories, living quarters and as many other of the normal conveniences of Earth-life as possible.

Goodyear has emphasized that even though a system such as *Meteor* would be costly to develop and take time to get into operating status, figures show that economies inherent in the concept make it an attractive way to approach the problem.

Engineers Sought by Boeing Airplane Co.

Boeing Airplane Co. currently is seeking several hundred engineers for work in all Seattle-area divisions, it has been announced by Stan Little, employment administrator.

Boeing is particularly interested in hiring engineers with advanced degrees and those with electronics background, he said. Many of the new engineers will be assigned to the pilotless aircraft division, where work is under way to accelerate the pace of *Bomarc* IM-99.

Engineers also are needed to step up developments in other divisions.

New X-ray Developed to Inspect Solids

A new high-voltage X-ray generator for detection of flaws in solid rocket and missile fuel charges has been developed jointly by High Voltage Engineering Corp., Thiokol Chemical Corp. and the Friez Instrument Division of Bendix Aviation Corp.

Internal cavities, cracks, fissures or bits of foreign material can affect performance of the missile since there is a critical predetermined balance ratio between the missile charge and the centerline of the missile proper. In actual operation, as the combustion line advances along the propellant charge surface, hidden pockets or cavities can result in uneven burning, conceivably affecting the forward thrust of the missile and altering its course or possibly burning a hole out the side, destroying the missile itself.

Inspection of solid propellants heretofore has been a costly, cumbersome process. Radiographic film is wrapped around the outer surface of the missile or arranged in a flat plane. X-rays are passed diametrically through the fuel, with resultant exposure of film.

Limitations of this technique are due to the high loss of intensity incurred by the X-rays as they pass through the entire thickness of the missile before exposing the film. Engineers concluded that if a small and powerful enough radiographic generating unit could be developed, it might be lowered into the hollow core of the fuel, cutting penetration requirements by 50 per cent.

Thiokol contacted High Voltage on design of a special Van de Graaff X-ray generator for this particular application. High Voltage engineers devised a special 10-foot electron-tube extension for one of their standard supervoltage machines, which would slip down into the propellant core. High energy X-rays are generated from the tip of the tube to concentrate intensity in one direction at a relatively acute angle.

Engineers at Thiokol then moved forward on development of a handling system. This system consists of a rotating base or platform where the fuel charge is placed on end. This platform also has a vertical range of movement equal to half the length of the longest fuel castings.

A Lumicon viewer, manufactured by the Friez Instrument Division of Bendix Aviation Corp., is mounted in a fixed position to one side, with the 10-foot extension of the Van de Graaff generator coming down in a fixed position through the ceiling. The accelerator itself is mounted in a room above.

Method of operation consists essentially of rotating and raising the fuel charge, spiral-fashion, about the X-ray source. The charge is raised a few inches during each revolution. Thus the fixed X-ray source, monitored on the Lumicon receiver outside, provides a continuous radiographic picture covering the entire volume of the fuel charge.

Directors and Officers Named by Astrodyne

Officers and directors to head Astrodyne, Inc., have been named following incorporation of the company to specialize in solid-propellant activities in Delaware.

Officers of the new corporation include: president, J. L. Atwood, who is president of North American; vice president, R. W. Thomas, who is Phillips vice president for research and development; treasurer, R. A. Lambeth, who is North American's vice president finance and its treasurer; and secretary Paul J. Parker, who is secretary and assistant treasurer of Phillips.

Eight officials of the two founding companies were elected as directors

of Astrodyne. From North American, they were J. L. Atwood, R. A. Lambeth, J. S. Smithson, vice president-administration; and S. K. Hoffman, vice president and general manager of North American's Rocketdyne division.

Phillips officials elected as directors of the new company were: Paul Endacott, president; Stanley Learned, chairman of the executive committee and assistant to the president; W. W. Keeler, executive vice president.

The new company will have its headquarters and operations at Air Force Plant 66 near McGregor in central Texas where Phillips has conducted solid-propellant research and development for the Air Force since 1952 and currently employs about 900 people. Phillips employees at Air Force Plant 66 and some of North American's personnel will transfer to the new company.

Astrodyne officials explained that within a few weeks contracts and operations for the government at Air Force Plant 66 would be transferred to Astrodyne subject to Air Force approval of the company's proposal.

Col. John Paul Stapp, renowned authority on aviation medicine, holds a chunk of the solid rocket fuel, developed by Phillips Petroleum Co. The fuel powered the huge "Megaboom" rocket motor built by Phillips. This new motor accelerated a rocket sled to 1337 miles per hour in a few seconds. At the instant of peak speed, it was producing about 112,000 lbs. thrust.

Girdler Building Callery Hydrogen Plant

A $3.4-million contract to design and build hydrogen, nitrogen and carbon dioxide producing and purifying units for Callery Chemical's high-energy fuel plant has been awarded to the Girdler Construction Division of National Cylinder Gas Co.

Callery Chemical, prime contractor for the Navy's $38-million plant

Checking the lead of the internal gear used in the second stage of the Sikorsky S-58 Helicopter. Permissible lead error is only .0003 in. of face. This gear is finish cut at 50 Rockwell C. It's actually much harder than a good penknife blade.

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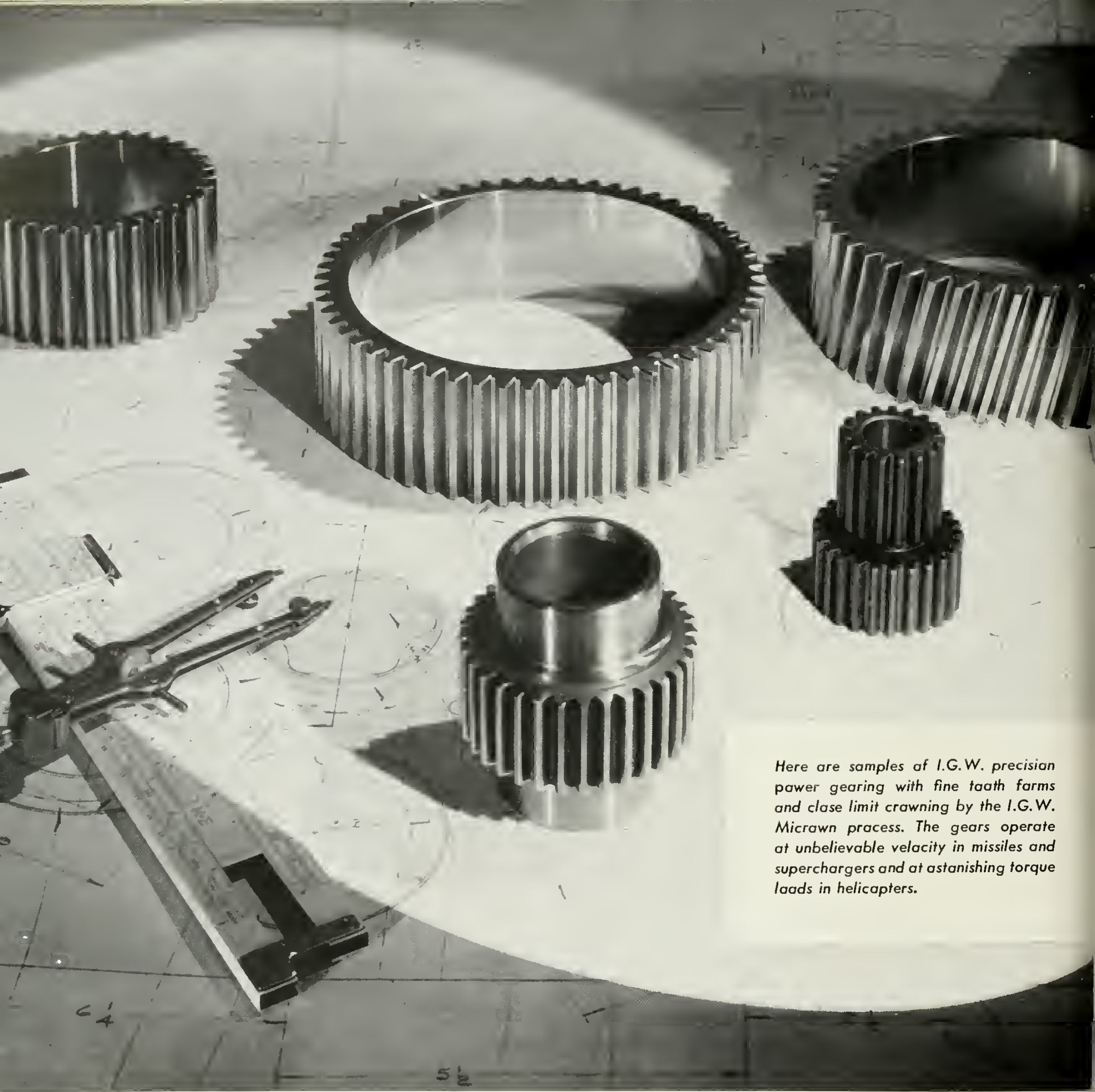

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now under construction at Muskogee, Okla., announced that Girdler Construction will furnish all engineering, apparatus, material and complete field construction and start-up services for the high-purity industrial gas plants. The Muskogee plant, scheduled for completion at the end of 1958, will produce tonnage quantities of the high-energy boron fuel for powering jet aircraft and missiles.

The subcontract includes a plant to produce hydrogen as raw material to be chemically processed for its end role in the high-energy fuel molecule. Additional Girdler plants on the Muskogee site will produce nitrogen, an inert gas to be used as a protective atmosphere in various processing steps, and carbon dioxide. Storage units for hydrogen and nitrogen are included in the contract. Completion of the Girdler units is scheduled for late summer. Specialty catalysts for the hydrogen plant operation will be produced by the Girdler catalyst plant in Louisville.

$2-Million Expansion Set for Martin-Denver

A new two-story structure, totaling 115,000 square feet, is to be added to the factory at the Martin-Denver facility at a cost of approximately $2 million.

A $125-thousand contract has been awarded to Connell, Pierce, Garland & Friedman, Miami, Fla., for planning and designing the new building. The Miami firm recently completed the new Martin-Orlando plant, one of the largest industrial installations in Florida.

Preliminary plans for the Denver project will be started immediately, with construction to begin on June 1 and completion due by January 31, 1959. When occupied, the new factory addition will eliminate storage and warehouse operations now located in Denver.

First ICBM Squadrons to be Activated April 1

The first two intercontinental ballistic missile squadrons will be activated at Camp Cooke, Calif., on April 1. The Air Force announced that the two are: the 576th Strategic Air Command Intercontinental Ballistic Missile Squadron and the 393rd ICBM Training Squadron.

The 393rd Training Squadron will be responsible for the training of the 576th and later squadrons. The 576th Squadron will move to Francis E. Warren AFB, Wyo., after completion of training. Commanders for the groups have not been announced.

Brooklyn Polytech Gets Rocket Research Grant

Polytechnic Institute of Brooklyn will conduct a year-long study of combustion instability and scaling-up of rocket motors using liquid propellants under a grant of $50,000 awarded by the Air Force Office of Scientific Research.

Largely concerned with analytic formulations, the contract also calls for experimental work entailing an exhaustive study of fuel injection units under a wide range of conditions. For this phase of the research two combustion chambers have been constructed in Polytechnic's rocketry laboratory.

The contract is under the direction of Dr. T. Paul Torda, professor of mechanical engineering. Dr. Torda's work on liquid-fuel rocket motors dates back to World War II when, as a graduate student at Polytechnic, he worked with a 15-man team on the study of various problems connected with the first Navy jet aircraft. A native of Budapest, he joined the faculty of the University of Illinois in 1949 after receiving his doctorate at Brooklyn Poly. In 1955 he returned to Polytechnic as a full professor.

contract report

Trends

The volume of contracts being let by the Government has now returned to a somewhat normal pace. However, money for performing on these contracts has still not been released. This is because of an astounding amount of confusion in Washington, added to the "conventional" volume of red tape. One reason for the hold-back on money is the fact that there is still not a space-flight program in Washington—four months after *Sputnik*. Nobody has the courage to make a decision.

$ $ $ $

Write and ask for a copy of House bill H.R. 8002 which would return Government accounting to an accrued expenditure accounting system. It could mean some drastic changes in how you plan ahead. If you've got objections, write them in to your Congressman.

$ $ $ $

The right of the Government to unlimited use of technical data developed by Government contractors is under dispute again. Contractors interested in gaining greater protection for their commercial "rights" and interests should make themselves heard.

$ $ $ $

Three new revisions of the Armed Services Procurement Regulations have been made public—Revision No. 27, dated January 2, effective April 2; No. 28, dated January 28, effective April 28; No. 29, dated February 5, effective May 5. These cover unacceptable bids, patent rights and mistakes in bids, and bid-form preparation. All are available from the Superintendent of Documents, Washington 25, D.C.

$ $ $ $

Air Force is using a new contract clause which limits reimbursements made to contractors. It reads: "Notwithstanding any other provision of this contract, the Government shall not be obligated to reimburse the contractor, for work performed under this contract, any sum which is in excess of the cumulative amounts indicated for each period specified in the following Schedule of Reimbursement." It doesn't limit the final amount which you get under a contract, but it does limit how much is paid in the form of progress payments.

$ $ $ $

Don't go running to ARPA (Advanced Research Projects Agency) for business. It will be three months at a minimum before the new Defense Department agency really has an idea of what it's supposed to do. Even then, most of the funds over which it has control will be allocated for research rather than production projects.

$ $ $ $

If it's any help for your morale, Defense Secretary McElroy says that missiles will get 24 cents out of every procurement dollar in fiscal year 1959, when share for manned aircraft drops to 50 cents.

$ $ $ $

This is a period of flux. Congress is still trying to find out just what has been and is going on. The Executive seems even more in the dark. In a word, everyone is waiting for everyone else to make their minds up so that they can go along with the crowd. This will all sort itself out in a fairly short time. Meanwhile, any selling you do now will pay real hard cash dividends later when definitive programs get under way. The pressure to do something—to get on with it—is building up to a point where even bureaucratic Washington will be unable to resist it. The chips are still down despite the success with *Explorer*.

Awards

For nuclear warhead test equipment: Nuclear Instruments Division of Telecomputing Corp. has been awarded a $1,000,753 addition to existing Army Ordnance contracts.

For service test of liquid rocket engines: Reaction Motors, Inc., has received a $3,027,266 contract from Air Materiel Command.

Nuclear Rocket: Rocketdyne Division of North American is working on nuclear rockets under contracts administered by the Wright Air Development Command in coordination with the Atomic Energy Commission.

RAT: Allegany Ballistic Laboratory has received contracts to build the rockets for Navy's new rocket-launched torpedo. **Librascope, Inc.,** has the guidance contract.

Re-entry: Aeronutronic Systems Division of Ford has received an Air Force contract to study gas interactions of ICBM nose cones upon atmospheric re-entry.

Hawk: Raytheon Manufacturing Co. has received a $13,249,594 contract for procurement of *Hawk* missiles and components; includes an estimated 20% of subcontracting for missiles and supporting ground equipment.

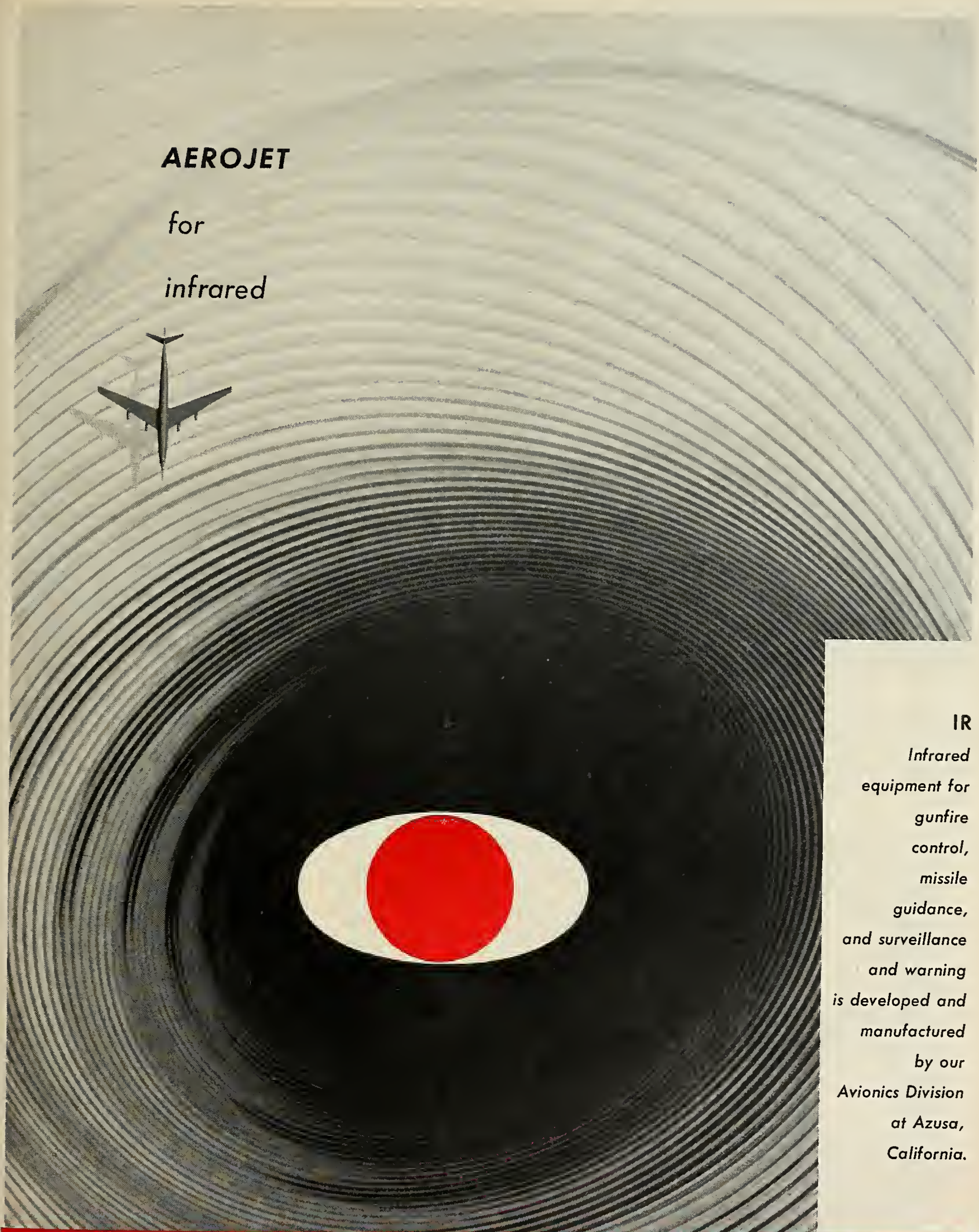
Falcon: Hughes Aircraft has received a $19,278,275 contract for GAR and GAR-3 rockets. Hughes has also received a $21,188,717 contract for interceptor aircraft and weapon control systems.

Logistical planning: Planning Research Corp. has received a $234,000 contract for a detail study of requirements for logistic support of the Army during 1960-70.

Bell Aircraft has received two subcontracts for work in its Avionics and Rocket divisions, but cannot reveal details due to security.

Countermeasures: Hoffman Electronics Corp. has received an $11-million Air Force contract to develop the electronic reconnaissance system known as Tall Tom (AN/ALD-3). Subcontractors include **Cornell Aeronautical Laboratory, Inc.; Filtron Co., Inc.; Lockheed Aircraft Services, Inc.; Olympic Radio and Television, Division of Siegler Corp.; Radiation, Inc.; Sanders Associates, Inc.;** and **Stanford Research Institute.**

Additional missile contracts placed during the month include: **Radiation, Inc.,** $230,000 for increase in funds . . . **Potter Instrument Co.,** $50,000 for increase in funds . . . **Westvaco Chlor-Alkali Div. of Food Machinery & Chemical Corp.,** $38,157 for rocket propellant.



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Contract Awards

Cubic Corp., $85,877 for increase in funds . . . **Aerophysics Development,** Santa Barbara, Calif., $1,325,000 for *Dart,* antitank guided missile . . . **Douglas Aircraft Co., Inc.,** $136,750 for repair parts for *Nike* system . . . **Giannini Research Corp.,** $105,243 for material testing by means of plasma jets . . . **Reynolds Industries, Inc.,** $63,490 for antenna items.

North American Aviation, Inc., $1,167,000 for engineering, investigation and development . . . **Firestone Tire & Rubber Co.,** $511,003 for ground handling equipment for guided missiles . . . **Grand Central Rocket,** $232,955 for propellant development . . . **Consolidated Diesel Electric Corp.,** $106,695 for missile handling skid . . . **Edcliff Instruments,** $110,360 for accelerometers.

G. M. Giannini & Co., $232,422 for accelerometers . . . **Reynolds Metals Co.,** $82,837 for various aluminum shapes, mostly sheet . . . **McDonough Construction Co., of Fla.,** $1,244,000 for rehabilitation of base facilities and electronic radar laboratory for AF-WS-219-L downrange facility, Naval Station, Trinidad, British West Indies (WS-219-L, Classified).

Haller, Raymond & Brown, Inc., $42,572 for additional research and study for 12 months to continue investigations of the vulnerability of electronic equipment . . .

Radio Corp. of America, $42,000 for RCA data reduction unit #DRU-1 . . .

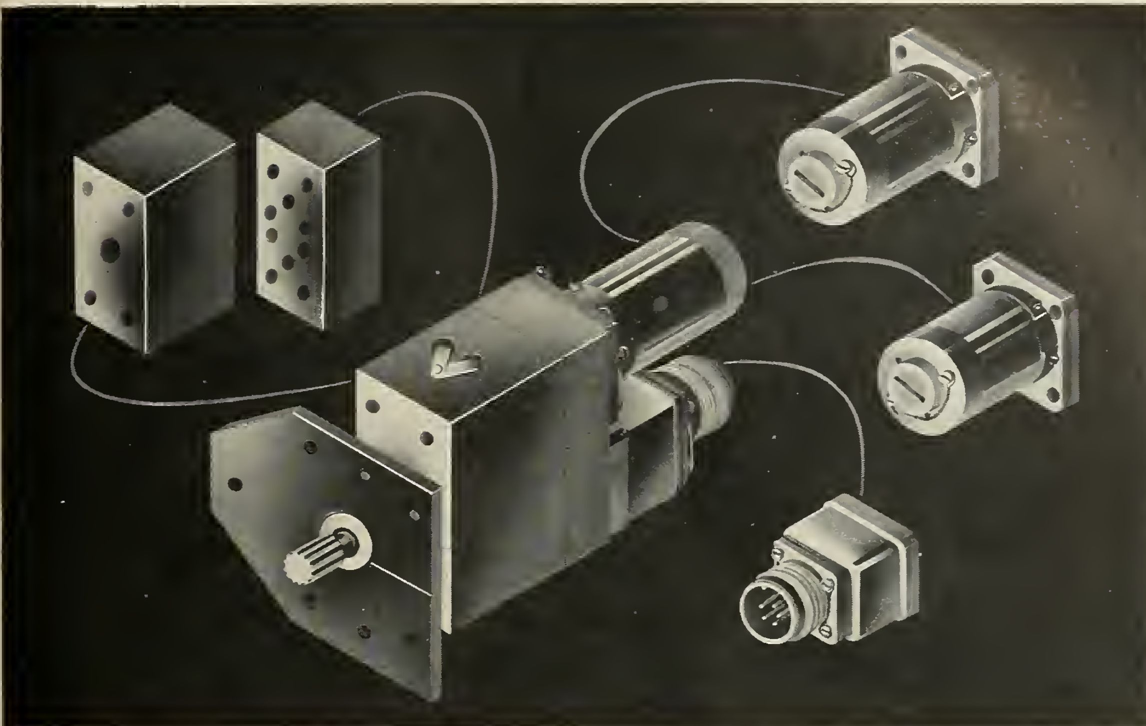
Stanford Research Institute, $30,576 for research work for 12 months toward development of techniques of dielectric materials . . . **National Co., Inc.,** Malden, Mass., $472,060 for frequency standard-NC 1001 . . . **Levinthal Electronic Products, Inc.,** $90,200 for klystron transmitter, type PC-49.

Burroughs Corp., $39,000 for rental of electronic digital computer for month of Feb. 1958 . . . **Linde Co., Div. of Union Carbide Corp.,** $25,500 for liquid oxygen . . . **General Chemical & Dye Corp.,** $63,580 for chlorine and trifluoride . . .

Aeronutronic Systems, Inc., $35,995 and **Gilfillan Bros., Inc.,** $39,853 for feasibility study on antitank guided missile system . . . **Firestone Tire & Rubber Co.,** $1,195,365 for *Corporal* handling and launching equipment . . . **The Pennsylvania State Univ.,** $44,991 for research and reports concerning structures of complex ions and their salts . . .

Arthur D. Little, Inc., $40,493 for research and reports concerning combustion ignition . . . **Yale Univ.,** $31,000 for research and reports concerning study of functional equations and spectral operations . . . **Univ. of Maryland,** $41,254 for research and reports concerning mathematical studies in fluid dynamics and elasticity . . . **Washington Univ.,** St. Louis, $49,982 for continuation of research on paramagnetic resonance of free radicals.

Nems-Clarke Co., Div. of Vitro of America, Silver Spring, Md., $64,470 for increase in funds . . . **Centronix, Inc.,** Cocoa, Fla., $116,500 for central timing records . . . **The Univ. of Chicago,** $39,941 for research relating to temperature and radiation in atmosphere . . . **The N. Mex. College of Agriculture & Mechanic Arts,** $289,631 for personnel engineering, materials and facilities to assist in support of *Talos* missile program evaluation . . . **Stevens Inst. of Technology,** $32,200 for personnel, materials and facilities to conduct research in connection



This new Airborne modular actuator—rated 20 lb./in. at 26 v d-c—is not a standard model in the usual sense. Rather, it is merely one example of the many different rotary actuator packages that can be assembled from Airborne's new line of standardized, interchangeable actuator components.

AIRBORNE now offers you the advantages of modular design in rotary actuators, too

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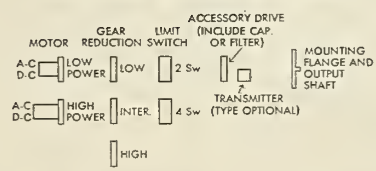

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Contract Awards

with the *Polaris* missile program . . . **Geo-Science, Inc.,** Alamogordo, N. Mex., $87,879 for satellite tracking and orbit determination system . . . **Allen M. Campbell Co.,** $550,997 for ABMA vertical launching facilities, White Sands Proving Ground . . . **Western Electric Co., Inc.,** $120,830 for *Nike* spare parts and components.

Consultants and Designers, Inc., $46,000 for engineering and design services . . . **Southern Associated Engineers, Inc.,** $315,000 for engineering services . . . **Westinghouse Airbrake Co.,** $27,875 for hermetically sealed relays . . . **Firestone Tire & Rubber Co.,** $61,296 for surface-to-surface guided missile; and $48,329 for replenishment of spare parts for guided missile artillery M2 . . . **Associated Aero Science Laboratories, Inc.,** $162,567 for technical assistance . . . **Aerojet-General Corp.,** $92,338 for system equipment . . . **Gilfillan Bros., Inc.,** $29,899 for spare parts for *Corporal* missile system.

Federal Electronics Corp., $22,720 for design and development of telemetry system . . . **National Academy of Sciences,** $235,000 for research work on materials . . . **Control Data Corp.,** undesignated amount for *Bomarc* computer components . . . **Epsco, Inc.,** undesignated amount for wind tunnel instrumentation at **United Aircraft Corp.**'s research center.

Gilfillan Bros., Inc., $124,272 for *Corporal* missile parts . . . **Air Reduction Sales Co. Div. of Air Reduction Co., Inc.,** $93,350 for *Jupiter* missile welding fixture . . . **Air Logistics Corp.,** $542,344 for aircraft missile engine trailer . . . **Nuclear Products-Erco Div.,** $47,427 for research reactor study . . . **General Dynamics Corp., Convair Div.,** $1,297,340 for design, development of Azusa service, transponders . . . **Armour Research Foundation of Illinois Institute of Technology,** $120,000 for improving steel forging operations . . . **Electronic Tube Div., Westinghouse Electric Corp.,** $90,000 for developing methods for the production of fused and diffused silicon power transistors . . . **Aerojet-General Nucleonics,** $62,500 for improving neutron flux measurement.

Union Carbide Chemicals Co., Union Carbide Corp., $59,340 for special fuels for service tests . . . **Marquardt Aircraft Co.,** $27,964 for services for J43 ramjet engine . . . **Hughes Aircraft Co.,** $98,540 for research on atomic and molecular resonances . . . **Regents of the Univ. of California,** $38,700 for research on study of crossed field amplifiers . . . **Trustees of the University of Pa.,** $25,000 for research on radar environmental simulator . . . **Georgia Tech. Research Inst.,** $34,861 for services on bibliography of radar reflection characteristics . . . **Harvard College,** $28,000 for study of high-precision techniques in molecular beams . . . **G. C. Dewey & Co., Inc.,** $112,973 for research relating to zone of interior antiaircraft defense system . . . **Missilconics, Inc.,** $74,908 for decommutation system, FM telemetry . . . **Cubic Corp.,** $200,000 for increase in funds . . . **Riverside Research Lab., Div. of Motorola, Inc.,** $329,590 for passive homing drones.

Gilfillan Bros., Inc., $378,551 for *Corporal* missile system parts . . . **Douglas Aircraft Co.,** $37,092 for repair parts for *Nike* system . . . **North American Aviation, Inc.,** $176,000 for rocket engines . . . **Preshaw & Thompson, Inc.,** $164,638 for warhead tester . . . **Telecomputing Corp.,** $462,361 for warhead testers . . . **Sperry-Rand Corp., Sperry Gyroscope Co.,** $496,000 for command guidance data transponder sets for XQ-4A drones.

Thiokol Chemical Corp., $399,995 for research and development of large solid-propellant-type engines . . . **Thiokol Chemical Corp.,** $68,266 for the development of XM-10 rocket engines . . . **Board of Trustees of the Univ. of Illinois,** $33,000 for ceramic and cermet bodies . . . **Fairchild Engine Div., Fairchild Engine & Airplane Corp.,** $116,740 for research on supersonic combustion . . . **The Univ. of California,** $40,000 for research on an "experimental study of the development and stability of detonations."

The Univ. of Chicago, $65,220 for research on "semiconductors and physical electronics." . . . **The Trustees of the Univ. of Pa.,** $26,500 for research in experimental quantum electrodynamics . . . **Polytechnic Institute of Brooklyn,** $100,000 for research on "electromagnetic theory and information processes." . . . **The Johns Hopkins Univ.,** $93,147 for investigations of new particles and their interactions with nucleons . . . **Washington Univ.,** $25,288 for research concerning "problems in mathematical analysis" . . . **Mass. Institute of Technology,** $106,130 for research in heat transfer characteristics of diffusion boundary layers.

North American Aviation, Inc., $140,284 for research concerning stability and transition of the laminar boundary layer . . . **Engineering Service, Jackson, Miss.,** $66,787 for western USSR, topographic maps.

Magnetics May Aid Return of Satellites

The new science of magneto-aerodynamics may provide the means for the safe return of artificial satellites to the earth's surface, according to an advance summary of research results in this field. Dr. William R. Sears, director of the Graduate School of Engineering at Cornell University, in a lecture at the National Academy of Sciences declared that further research in this field may also lead to a tremendous increase in the thrust of conventional rocket motors.

Magneto-aerodynamics is concerned with the partial ionization of air that occurs when objects pass through it at extremely high speeds, notably during the re-entry of rockets and satellites into the earth's atmosphere. As friction and compression heat the air in front of the object to very high temperatures, the atoms of which air is composed release free electrons and the air then becomes a conductor of electricity.

According to research at Cornell, this conductivity can be further increased by "seeding" the air near such a high-speed body with a small amount of an easily ionizable substance such as sodium or potassium. At speeds of Mach 12 to 14, a state of conductivity several times greater than salt water can thus be induced.

"If this technique can be worked out, and if magnetic field strengths comparable to those of permanent magnets can be provided in flight," said Dr. Sears, "electric currents will be set up by the motion of the air, and significant forces can be applied directly to the airstream."

In the case of a satellite re-entering the atmosphere at high speed, the electromagnetic relationships will resemble those of an electric generator. The hot, seeded air, being a conductor of electricity, takes the place of the windings of the generator armature, while the magnetic field emanating from the satellite in flight will supplant the generator's fixed field. As the satellite plunges back into the atmosphere, the moving of this hot-air "armature" across the magnetic field of the satellite will generate an electric current.

Just as torque tends to retard the armature of an operating generator, so will the air flowing past the missile tend to be decelerated. "This retarding effect," said Dr. Sears, "may prove useful in slowing down satellites to prevent their overheating as they enter the atmosphere."

Aerojet Will Add 1000 Employees by June

Aerojet-General Corp. expects to add 1000 professional and skilled workers at its Sacramento plants by June. The company currently employs about 7000 people in the Sacramento facilities where work is in progress on rocket engines for the *Titan* and *Polaris* ballistic missiles.

Mr. R. H. Stevens, manager of industrial relations, emphasized that almost all of the new openings will require professional engineers or highly skilled tradesmen. He said there will be very few jobs for untrained workers.

Mr. H. R. Todd, head of engineering placement, estimated that about one-fourth of the 1000 additional personnel will fall in the professional or college-trained class.

"We need 500 top-level scientific personnel to work in many fields including mechanical, aeronautical, electronics and chemical engineering. They will engage in research and development work on the world's most advanced rocket propulsion systems," Todd said.

Britain Developing Advanced IRBM

A White Paper on Defense released by the British Information Services disclosed the development of a British IRBM of more advanced design than the *Jupiter* or *Thor* that will be launched from "hard" bases underground. The British IRBM is reported unofficially to have a range of 2500 miles.

The announcement stated that the agreement for supplying Britain with intermediate-range ballistic missiles will be completed and published shortly.

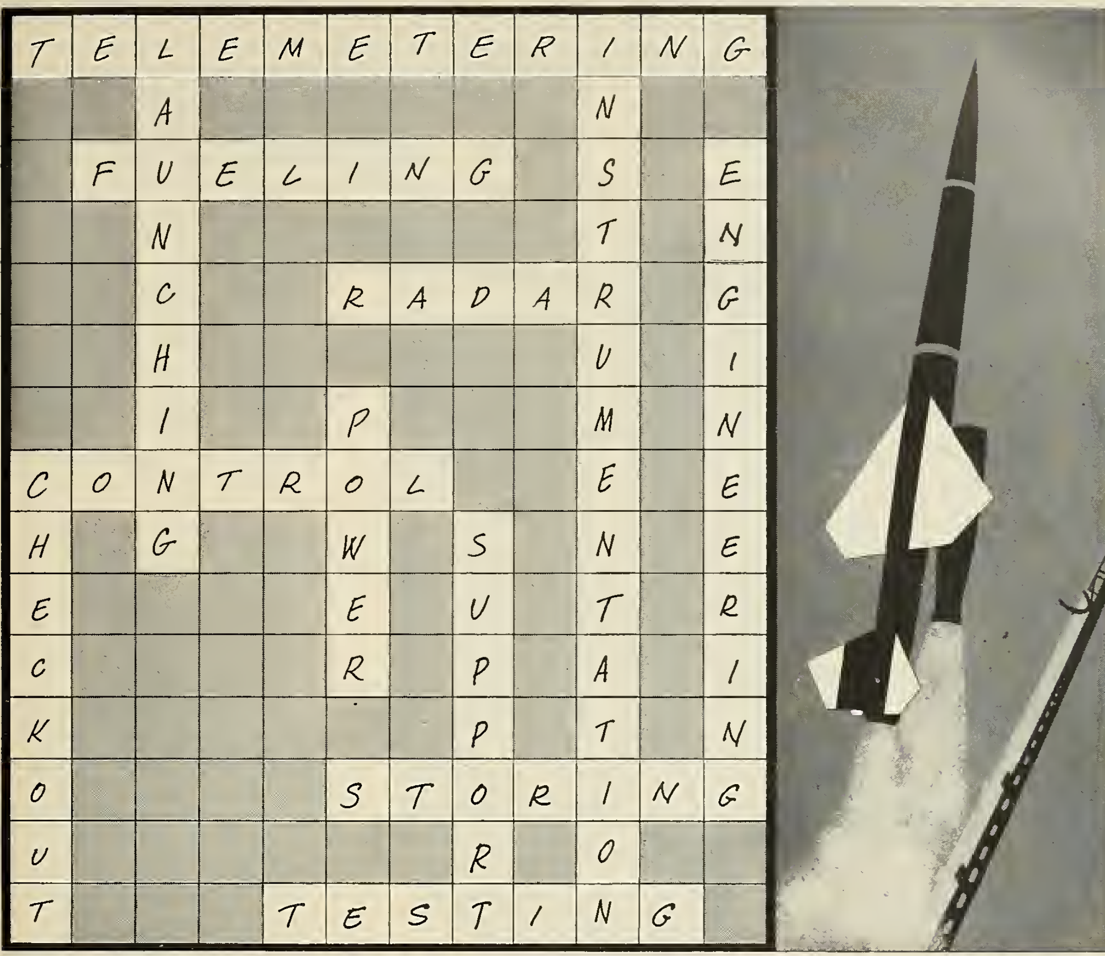
In discussing the Russian military position and the contribution the Free World must make to offset the Russian threat the government said:

"Peace is being maintained by a balance of arms. The ultimate aim, however, must be comprehensive disarmament by all nations coupled with comprehensive inspection and control by a world authority. The West is ready to discuss proposals of all kinds with Russia, and with sincerity and perseverance agreement should not be impossible, but negotiations are bound to be protracted. Meanwhile the Free World cannot afford to lower its guard.

"Though Russia has been making great strides in the field of nuclear weapons and rockets her basic strength lies in her superiority in conventional forces; the West relies primarily upon the nuclear deterrent. Russia's successful launching of satellites has not upset the balance of military power; in fact, the overall superiority of the West is liable to increase as a consequence of the introduction of medium-range ballistic rockets.

"The protection of the Free World must be undertaken by a collective effort. Britain will continue to make her main contribution to peace through NATO, the Baghdad Pact and SEATO. An increasing degree of interdependence must be accepted.

"The frontiers of the Free World



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must be resolutely defended on the ground. The three regional defense organizations together provide this vitally necessary defensive shield, the effectiveness of which, however, depends ultimately on the fact that behind them stands the immense nuclear power of the West to which Britain is making an increasingly significant contribution, British megaton bombs are in production and deliveries to the RAF have begun.

"Progress is being made with the development of a propelled bomb. The role of Fighter Command is now limited to that of protecting the bomber bases. When the Russians can knock out our airfields with rockets, the value of fighter defense will decrease. But that point has not yet been reached."

Southwest Research Designs *Thor* Shelter

Prototypes of the launching complex shelter for *Thor* missiles are now being built by the missile engineering division of the Douglas Aircraft Company, Inc. from designs furnished by the architectural staff of Southwest Research Institute.

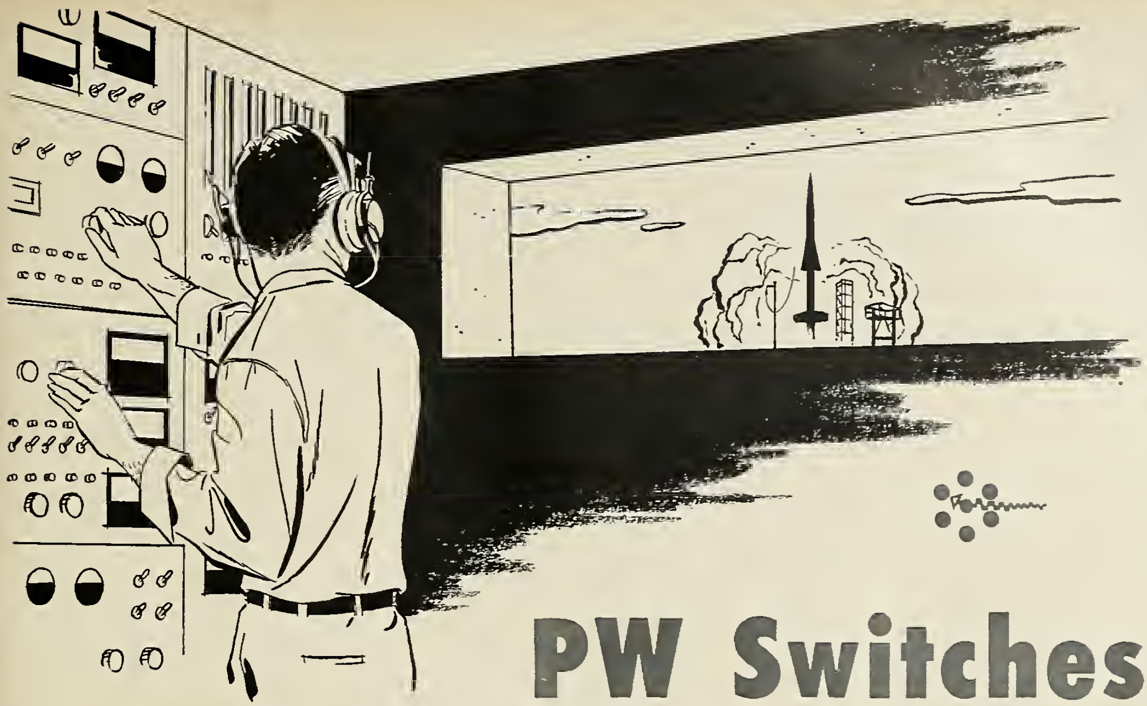
The unit is designed for sheltering the missile in either extreme heat, cold or other varying environmental conditions. The demountable structure is designed to be flown to its location with its largest component being 8 by 15 feet. It will withstand winds up to 120 miles per hour.

The shelter will cover the launching pad and the missile in a horizontal attitude to permit suitable maintenance and firing check-out operations. The front doors slide horizontally on a manual basis. The main shelter then moves over the missile by remote control. The missile is then erected on the pad by a hydraulic lift.

NACA Space Committee Holds First Meeting

The special committee on space technology of the National Advisory Committee for Aeronautics held its organization meeting in February at NACA committee headquarters, in Washington, D.C. The full 15-man membership headed by Dr. H. Guyford Stever attended. Also participating in the meeting were NACA Chairman James H. Doolittle and Dr. Hugh L. Dryden, director of the NACA.

Working groups to deal with specific aspects of space technology were set up yesterday. They and their chairmen are as follows: objectives, Dr. James A. Van Allen; vehicles,



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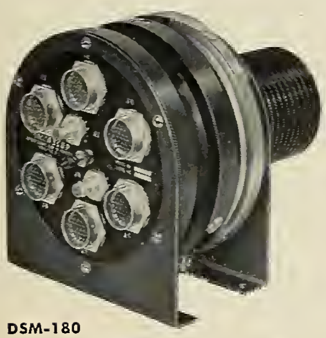

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Dr. Wernher von Braun; re-entry, Dr. Milton U. Clauser; range, launch and tracking, James R. Dempsey; instrumentation, communication and navigation, Dr. William H. Pickering; space surveillance, Dr. Hendrik W. Bode: human factors and training, Dr. W. Randolph Lovelace II.

In addition, the long-established NACA technical committees on aerodynamics, structures, propulsion, and operating problems, will be called on in connection with problems in their particular fields.

The members of the Space Technology Committee, and their affiliations are: Dr. H. Guyford Stever, associate dean of engineering, Massachusetts Institute of Technology; Chairman, H. Julian Allen, NACA Ames Aeronautical Laboratory; Col. Norman C. Appold, U.S. Air Force; Dr. Hendrik W. Bode, director of mathematical research, Bell Telephone Laboratories; Dr. Milton U. Clauser, director of aeronautical laboratory, Ramo-Wooldridge Corporation; Prof. Dale R. Corson, Cornell University; James R. Dempsey, manager, astronautics division of Convair; Robert R. Gilruth, assistant director, NACA Langley Aeronautical Laboratory; S. K. Hoffman, general manager, Rocketdyne Division of North American Aviation, Inc.; Dr. W. Randolph Lovelace II, Lovelace Clinic, Foundation for Medical Education and Research; Dr. William H. Pickering, director, Jet Propulsion Laboratory, California Institute of Technology; Dr. Louis N. Ridenour, Jr., missile systems division of Lockheed Aircraft Corp.; Abe Silverstein, associate director, NACA Lewis Flight Propulsion Laboratory; Dr. James A. Van Allen, Department of Physics, State University of Iowa, and Dr. Wernher von Braun, director, Development Operations Division, Army Ballistic Missile Agency.

Boeing Reveals Antimissile Project

Boeing's pilotless aircraft division is currently developing two new defensive missile projects at its Seattle plant. The new missiles are in addition to the IM-99 *Bomarc* now being produced as area defense weapons for the Air Force.

Lysle A. Wood, Boeing vice president and general manager of the pilotless aircraft division, said that both of the new projects are defensive weapon systems aimed at counteracting the threat of new enemy offensive weapons in the next decade, including ballistic missiles.

First of the new weapons is an advanced model of the present *Bomarc*. The second is an antiballistic missile system. The advanced *Bomarc* now is well along in its development stages. It would be able to seek out and destroy enemy aircraft and missiles of 250 to 400 miles. The new missile would provide additional depth and strength to the defensive protection supplied by manned interceptors, point defense missiles and shorter range area defense missiles. Identical in external appearance to the present *Bomarc*, the new missile, armed with a nuclear warhead, will fly above 60,000 feet at speeds up to Mach 5.

The anti-ICBM weapon was described only as a substantial research project undertaken by Boeing in conjunction with other firms long associated with the missile field. Object of the program is the development of a weapon system capable of detecting, intercepting and destroying ICBMs "so far above the earth that atomic fallout would not be a problem." Velocity of this anti-missile is expected to be above Mach 8.

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missile systems for the U.S. Air Force since 1945," Wood said. "Our experience has convinced us that there is no sound reason why practical and effective defensive missiles cannot be developed to counter any enemy offensive missile threat whether it be via extremely fast air-breathing missiles, combinations of missiles and manned aircraft or ICBMs."

Performance differences between the present *Bomarc* and the advanced flight vehicle will be substantial, but the ground alerting, guidance and logistical portions of the advanced *Bomarc* system would be virtually identical with those of the present *Bomarc*, thus permitting standardization of ground equipment for the two weapons. The liquid-propellant rocket currently used in the *Bomarc* will be replaced with a solid-propellant motor in the advanced version.

In addition to the announced projects, Boeing is known to be working on manned boost-glide rocket bombers, a defense against this type of weapon (Russia has been developing the T-4 boost-glide rocket for many months) and an anti-anti-missile missile missile for destroying an anti-missile defense system.

Boeing's manned glide rocket concept is believed to be a delta-winged bomber with a flat underside. It would be boosted above 100 miles by a three-engine rocket stage and propelled to approximately 16,000 mph by a single rocket sustainer.

Sylvania and Army Report *Plato* Progress

Project *Plato*, the Army's anti-missile missile system has made "significant progress" in the years since its inception according to a joint report by the Army and Sylvania Electric Products, Inc. "Successful tests have been made on key components of the project," Sylvania President Don G. Mitchell said.

"The *Plato* Project, a mobile anti-missile missile system, is being designed to use the *Nike-Zeus* missile in the defense of overseas military installations of both the United States and its allies," he added.

Mr. Mitchell said that Sylvania, acting as prime contractor and weapons systems manager on the project for the Ordnance Corps, began working almost four years ago on the *Plato* system when it was generally considered to be "the impossible project." He said that in order to solve the anti-missile missile problem, "completely new approaches had to be conceived and developed, in addition to the application of some of the most advanced

technology in the electronics field."

Lt. Gen. James M. Gavin, Chief of Army Research and Development, in discussing the application of the new system, stated that "the Army is responsible for developing, procuring and operating point defense missiles to be employed against enemy piloted aircraft and missiles of all types."

The multimillion-dollar program is under the technical supervision of the Boston Ordnance District. Three other companies have participated in supplying certain specialized services to Sylvania on a subcontract basis, including Sanders Associates, General Electric Co., and American Machine and Foundry. Sylvania's missile systems laboratory was originally established in 1953 specifically to develop the *Plato* system. It became part of the Waltham Laboratories in 1955, with the completion of a 120,000-square-foot building. Construction has been completed on a new 40,000-square-foot facility for missile systems activities, adjacent to the present building.

Sylvania has also been named a major subcontractor for the development and production of a superradar system for the detection of intercontinental ballistic missiles.

Pt. Mugu to Become National Range

Guided missile range areas supporting the existing Naval Air Missile Test Center, Pt. Mugu, Calif., will be extended to form the National Pacific Missile Range. Managed by the Navy, the range will provide missile range support to adjacent military operations, including ballistic missile training launchings from Cooke Air Force Base and Pacific Fleet missile training operations.

The new range will not supplant the triservice missile test range extending southeast from Cape Canaveral, Fla. The two ranges are complementary. For ballistic missiles the Pacific range will support training operations while Canaveral will continue to specialize in research and development support.

The Pacific range will extend along the Pacific Coast approximately 500 miles and 250 miles seaward and be supplemented by test corridors in support of ballistic missile training launchings from Pacific Coast locations to impact areas thousands of miles seaward. Test intercept for aerial targets and impact will be limited to areas free from ship and air traffic.

The new range will be equipped gradually over the next few years to support test and training operations of conventional guided missiles and the training operations of ballistic missiles (IRBMs and ICBMs).

Stavid Awarded Contract for *Regulus* Guidance

Stavid Engineering, Incorporated has received a multimillion-dollar contract to produce additional guidance systems for the submarine-launched *Regulus* missile.

The company is prime contractor for the development and production of the submarine command guidance systems used on *Regulus* I and II. It also has responsibility for maintenance of the guidance equipment with the Fleet.

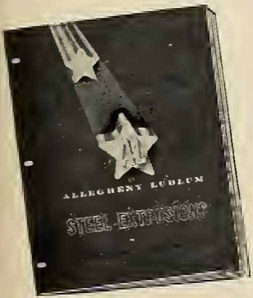
Field Service Training Under Way for *Bomarc*

As the Boeing IM-99 *Bomarc* weapon system approaches operational status, major attention is being focused on the pilotless aircraft division field service program which may become the largest ever undertaken by the company, it was reported recently by James Lucas, division service manager.

Field service engineers are now in training for assignment later this

Intricate Allegheny Ludlum Steel Extrusions

cut material needs up to 60%, slash machining costs



Write for this technical book on A-L Steel Extrusions

12-pages of design and engineering information on steel extrusions. Process and product explanation, material properties, design tips and limitations, tolerances, order instructions, etc.

Address Dept. MR-3

There's no doubt about extruded shapes saving money on materials and on machining. Non-ferrous applications in the last decade have proven it.

Now even greater savings are possible with tough, strong metals in Allegheny Ludlum Hot Steel Extrusions.

Extruded shapes in all stainless grades, tool steels, carbon steels, electrical steels, high temperature alloys . . . even in zirconium, nickel alloys . . . are now in production at Allegheny Ludlum, cutting costs in many different industries.

If you're hogging out sections, paying for special mill rolls on small orders, or waiting for minimum rolling mill tonnages, Allegheny Ludlum Steel Extrusions are your answer. They will save you scrap loss, slash your machining costs, hold down your inventory requirements and cut delivery time. Charge for die design is low—under $200. Orders taken for as little as 40 pounds.

To learn more about the time and cost-cutting possibilities of Allegheny Ludlum Hot Steel Extrusions, send for the technical booklet at the left or call any A-L office for technical assistance.

Allegheny Ludlum Steel Corporation, Oliver Bldg., Pittsburgh 22, Pa.

WSW 6907

ALLEGHENY LUDLUM

for all your special steel needs

Stainless and high-temperature, electrical and tool steels, magnetic materials, and sintered carbide

Circle No. 60 on Subscriber Service Card.

year to assist the Air Force in operating and maintaining the first *Bomarc* site near Eglin Air Force Base, Fla.

By the end of 1958, about 15 field service engineers will be on assignment as *Bomarc* technical representatives at various locations, with a substantial additional number in training for future assignments and field service support functions.

Approximately five months of the training will be spent in the *Bomarc* training school on Harbor Island in Seattle with the remainder to be on "productive job assignments" at Boeing "according to the needs of the individual."

As each *Bomarc* base is readied for operation, a "special implementation" team of field service engineers will be assigned to assist the Air Force. After the base becomes operational, the special team will move on to another *Bomarc* base, leaving two field service engineers who will remain at the base for an extended assignment.

Kearfott Adds Astronautics Lab.

Kearfott Co., Inc., Little Falls, N.J., designers and producers of flight inertial guidance equipment, recently established an astronautics laboratory within the company's navigation projects department.

This new laboratory will be responsible for the design and development of advance systems, subsystems and components for the guidance and control of satellites and space vehicles. It will draw on a decade of experience and background in terms of proven approaches and will anticipate, in view of this entirely new environment, the requirements for hardware of sufficient accuracy and long-term performance to meet the problems posed by space travel.

Will the Human Pilot Become Obsolete?

Methods of applying lessons learned from rocketry to civilian aircraft will be one topic of a special conference of the American Society of Mechanical Engineers, to be held in Dallas, Tex., March 16-20.

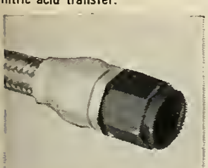
The joint aviation conference of The American Society of Mechanical Engineers and its affiliate, the American Rocket Society, will consider such topics as whether human pilots will become obsolete, how to keep pilot and passengers comfortably cool in aircraft speeding through the thermal barrier, the use of special high-energy fuels in passenger planes, guided missile instrumentation and lunar colonization.

Water is sprayed over protective clothing of engineers to wash away residue as they load fuel into rocket. Transfer line is Aeroquip 610 KEL-F Hose.

problem:
transfer of dangerous nitric acid during missile fueling operations

Aeroquip Solved it with Corrosion-Resistant KEL-F Hose

610 Hose Lines of KEL-F* for nitric acid transfer.



Hose Lines of TEFLON** for fuel and oxidizer supply lines.

Through the development of 610 KEL-F Hose for safe transfer of nitric acid, Aeroquip again demonstrated its ability to meet the wide range of fluid line requirements in the missile industry. 610 KEL-F Hose is but one of many new Aeroquip products designed for specific missile applications.

Years of experience in the aircraft and missile fields helps Aeroquip recognize, even anticipate, plumbing problems. Extensive research, development and engineering facilities, plus highly qualified personnel, assure solutions to even the most extreme fluid line problems.

Engineering assistance is available. Mail coupon below for complete information.

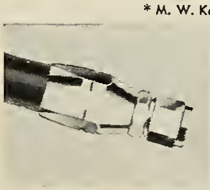
Aeroquip

REG. TRADEMARK

AEROQUIP CORPORATION, JACKSON, MICHIGAN
AEROQUIP CORPORATION, WESTERN DIVISION, BURBANK, CALIFORNIA
AEROQUIP (CANADA) LTD., TORONTO 19, ONTARIO
AEROQUIP PRODUCTS ARE FULLY PROTECTED BY PATENTS IN U.S.A., CANADA AND ABROAD.

* M. W. Kellogg trade name for fluorocarbon polymers ** Du Pont trade name for its tetrafluoroethylene resin

Corrosive Fluids Coupling for nitric acid, hydrogen peroxide and other hazardous fluids.



Aeroquip 659 high pressure Pneumatic Hose for air and gaseous nitrogen, helium and oxygen.

Pneumatic Check-Out Valve for missiles, with quick attaching hose coupling.

Tubing and Special Fittings for Missiles. Stainless steel, aluminum, titanium and other materials.

Pneumatic Connectors for quick-connecting bulkhead or cluster-mounted breakaway connections.

AEROQUIP CORPORATION, JACKSON, MICHIGAN PLEASE SEND INFORMATION ON THE FOLLOWING AEROQUIP PRODUCTS: MR-3

☐ 610 Hose Lines of KEL-F for nitric acid transfer lines
☐ Hose Lines of TEFLON for fuel and oxidizer supply lines
☐ Corrosive Fluid Self-Sealing Couplings.
☐ 659 High Pressure Pneumatic Hose
☐ Pneumatic Checkout Valve
☐ Precision Tube Assemblies
☐ Pneumatic Bulkhead Connector

NAME__________
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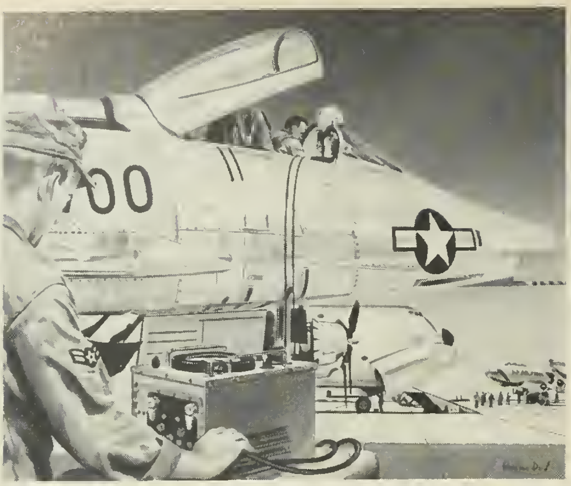
COMPANY__________
ADDRESS__________
CITY______ ZONE____ STATE____



TEST INSTRUMENTS Bulova's rugged Tachometer Tester for all jet and reciprocating systems meets MIL-T-945A requirements—is accurate to 0.1% with engines on or off. Simple to operate and maintain, this field unit also serves in maintenance depots. Precise Bulova testers include the dual purpose Torqmeter—a dynamometer or calibrated torque source

RECONNAISSANCE SYSTEMS Bulova-developed miniaturized sensor packages, geared to specific tactical missions, feed combat surveillance data to Bulova analysis and display systems. Camera, infra-red, TV and radar techniques, combined and integrated, aid decision-making on land and in space. Satellite applications? Unlimited!

Bulova's capability helps to solve today's most challenging problems

To conceive, develop and manufacture a broad range of advanced electronic and electro-mechanical devices...this is the Bulova capability.

Meeting the needs of defense and industry is an unusually creative group of scientists, engineers and technicians, backed by 80 years' experience in precision production.

With dynamic imagination, Bulova's capability has invaded the often uncharted technological areas to originate many modern-day miracles in miniaturized systems and components.

Here is a proven capability ready to assist you from concept to mass production. For full information, write Department G.I.S.-2.

BULOVA
watch company

BULOVA RESEARCH AND DEVELOPMENT LABORATORIES, INC.
BULOVA PARK — JACKSON HEIGHTS — NEW YORK

INFRA-RED COMPONENTS Bulova's advanced IR projects include mosaic cells that will automatically filter out unwanted wave lengths and picture targets clearly against any background. Bulova infra-red R&D covers lead selenide and lead sulfide cells, missile seeker cells, reticles, filters and thermistor bolometers...for defense and industry.

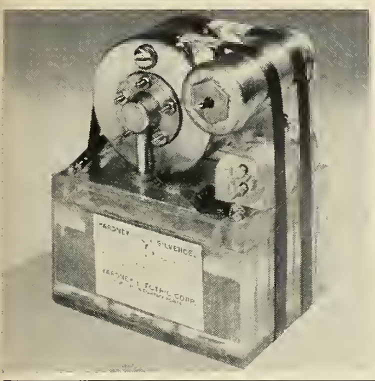
INFRA-RED SYSTEMS Bulova's IR illuminators put unseen spotlights on night objectives. Bulova's development capability extends to fire control systems that detect, track and automatically lock on target. Designed for accuracy and simplicity, these high resolution units will serve our nation's land, sea and air forces.

Circle No. 61 on Subscriber Service Card.

NEW MISSILE PRODUCTS

AUTOMATIC ACTIVATION

Yardney Electric Corp. has developed a new high-speed method of automatic activation which features an efficiency ratio allowing complete interchangeability between Yardney Silvercel primary and secondary batteries. The process also allows Yardney batteries to be activated and operated in any position. Automatically activated primaries can be made equivalent to secondaries in power rating, weight and size, and secondaries may be used for exercise and test runs. Simultaneously, equivalent primaries may be utilized for tactical end use.



Now used in Silvercel primaries, the new method replaces the slower mechanical activation process, which depended on gravity and required that liquid primary cells remain in an upright position. Activation may now be accomplished in seconds, and the battery is then ready to provide 100% power.

The activation mechanism consists of three parts that may be placed in whatever position will best fit space requirements. Illustrated is an ICBM battery weighing 10 lbs. and using the automatic activation process. When a spring-loaded plunger is triggered, it breaks a gas tank seal. The gas inflates a bladder at one end of a hermetically sealed electrolyte cylinder and the electrolyte operates a snap valve at the opposite end. The electrolyte is forced into the feed tube to the manifold, where it is evenly distributed through feed holes into the individual cells.

Special vents permit the escape of surplus electrolyte, gas and vapors through a return manifold into a sump. Since the electrolyte is originally in a separate container, and it is not in contact with the electrodes until the battery is activated, the Yardney Silvercel primary may be stored in the dry state for long periods.

Circle No. 225 on Subscriber Service Card.

ELECTRONIC FILTER

A dual unit, direct coupled, electronic highpass/lowpass filter is now available from Spectrum Instruments, Inc. Model LH-24D is designed for installation in standard 19" rack or table cabinet and offered for a variety of applications demanding availability of response to dc, or zero frequency.

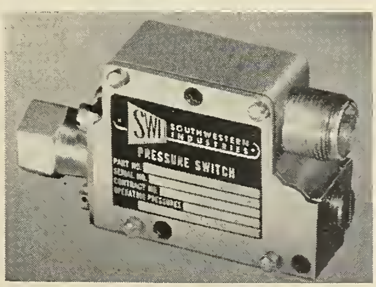
The two individual filter units are identical and may be converted from highpass to lowpass, or vice versa, by manipulation of a panel selector switch. The units may be used as independent filters or interconnected to secure bandpass, bandstop, or highpass/lowpass operation with doubly steep rate of cut-off. The individual section cut-off frequency is continuously adjustable over five decades extending from 0.2 to 20,000 cycles/sec.

Circle No. 226 on Subscriber Service Card.

MINIATURIZED PRESSURE SWITCHES

A series of miniaturized, lightweight, high-pressure, vibration-damped pressure switches for missile applications has been developed by Southwestern Industries, Inc. Weighing approximately 0.4 lb. the series PS 3800 switches operate in inert gases and fuels, engine and hydraulic oils and aromatic fuels and are designed to withstand vibrations up to 25g's, from 10 to 2000 cps. Small and compact, they are flush-mounted and allow installation in applications where sensitive response must be accomplished under conditions of extreme vibration.

Because the pressure switches are externally adjustable, they can be readjusted through their actuation pressure range as required by the installation. The PS 3800 series is available in actuation pressure ranges from 400-2000 psig (proof pressure 4000 psig) or 2000-3500 psig

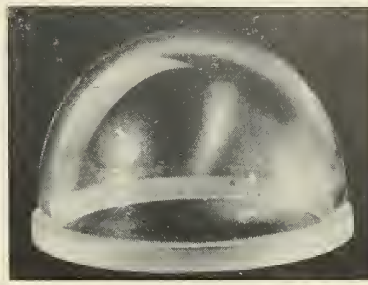


(proof pressure 5000 psig). Actuation to deactuation maximum differential pressure is 250 to 350 psi. Operating temperatures range from –40° to +160°F.

Circle No. 227 on Subscriber Service Card.

INFRARED DOMES

A new method of producing infrared protective domes has been developed by Precision Lapping Co., Inc. The irdomes can be obtained with spherical curvatures ranging from a slight meniscus to con-



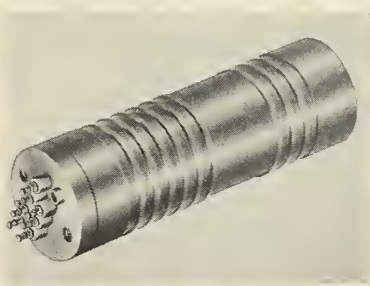
siderably more than a hemisphere, and in aspheric shapes. Physical dimensions are controlled during manufacture to achieve extremely close tolerances. After final grinding and polishing, spherical tolerances are held to millionths of an inch, diameters to ten thousandths, and concentricity between inner and outer surfaces within ten thousandths.

Dome materials may be specified according to user requirements of band spectrum, thermal shock resistance, abrasion resistance strength, and diameter needed. Quick deliveries can be made on domes of quartz, silicon, calcium aluminate, sapphire, arsenic, trisulphide, germanium, glass or metal. Sizes range from 1" to 72" in diameter, with integral flanges if desired. When dome must be larger than material available, *i.e.,* sapphire, small sections can be bonded or fused together to form the blank.

Circle No. 228 on Subscriber Service Card.

MAGNETIC AMPLIFIER

The 100C series, low-level DC magnetic amplifier developed by California Magnetic Control Corp. has been de-



signed for a wide range of applications in electronic and electrical control systems where light weight, minimum bulk and high reliability are important factors. Its characteristics make it adaptable for use in missiles, atomic reactor control circuits, and in industrial control equipment.

This low-level DC amplifier weighing only 6 oz. and occupying about 6 cu. in. of space, has a significantly higher degree of reliability than vacuum tube and transistor amplifiers of much greater size and weight. It is polarity sensitive, and *can you use this seal?*

Need to seal these temperatures? Then you should find out about . . . **Met-O-Seal**

MET-O-SEAL was developed by the Franklin C. Wolfe Company to provide a practical answer to *no-leakage* sealing at extreme temperatu
Here are just some of the advantages obtainable:

- Lower machining costs
- Less flange weight
- Can not blow out
- No loss of structural strength
- No leakage!

If you design in these temperature ranges why not find out about MET-O-SEAL, one of the pr *members of the Gask-O-Seal Family?*

New literature NOW available upon request. Write For Free Copy.

FRANKLIN C. WOLFE CO.

Culver City, California

"sealing design specialist"

A DIVISION OF Parker Hannifin CORPORATION
creative leader in fluid systems

Circle No. 62 on Subscriber Service Card.

is intrinsically stable, having stability comparable with chopper stabilized amplifier systems.

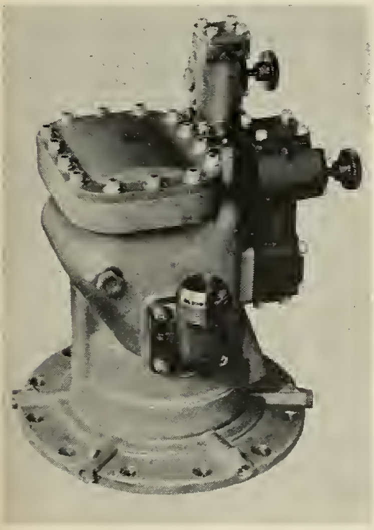
The 100C amplifier is supplied in gains of 500 and 1000 with linearity of 1/10 of 1%. Gain stability with variations in line voltage of plus or minus 10% and frequency of plus or minus 5% is kept to plus or minus 1%. Output voltage range of the instrument is plus or minus 28 VDC. Response time of the unit is 0.02 second.

Circle No. 229 on Subscriber Service Cord.

HYDRAULIC PUMP

A new variable delivery, variable pressure, hydraulic pump capable of pressures to 5000 psi has been announced by Vickers Inc. The pump has passed an Air Force 1000-hour qualification test (MIL-S-26874 and 26877) requiring operation at 5000 psi for more than 10% of the test time. During the test, the unit completed in excess of 23,000 duty cycles from zero flow to full flow.

The pump is designed to deliver 38.2 gpm at 3750 rpm and 3000 psi. Minimum life for steady-state operation at this pressure and flow is approximately 1335 hours. At 5000 psi and 3750 rpm, delivery



is about 38.2 gpm with minimum life of approximately 288 hours. Vickers reports very low internal pump leakage with high overall reliability as standard design components with proven long service records are used.

This new 5000 psi pump was designed for hydraulic test stand use, missile launching, jet engine starters, checkout stands, and mobile shop equipment that can advantageously utilize the high reserve power feature of the pump.

Circle No. 230 on Subscriber Service Cord.

COMMUTATOR SWITCH

Bendix Aviation Corp. has developed a complete line of newly designed, long-life commutator switches. The motor-driven units are used in telemetering, sampling and programming applications.

Especially designed for 500 hours minimum operation, and for switching of high and low impedance circuits in aircraft and missile applications, the com-

Circle No. 129 on Subscriber Service Cord.

AXFF3

mutators are available in a wide selection of poles and positions, and in speeds from 1/8 to 30 rps.

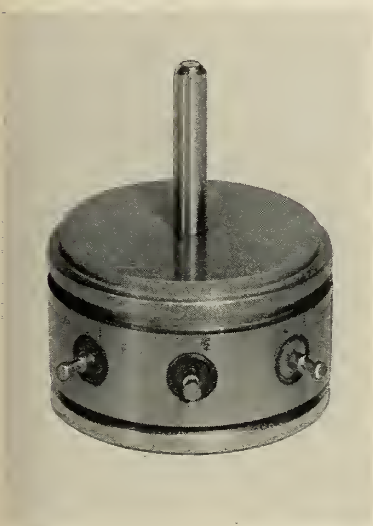
Circuits available are two independent switch sections per commutator on the model TSC-50, and three independent switch sections on the model TSC-51. Drive motors are available for operation on 115v, 400 cycles AC or 26.5v DC.

Rated performance is achieved at temperatures to 85°C and vibration of 25g to 2000 cps. Weight is less than 2 lbs., and power requirements are 10 to 20 watts, depending on speed and number of poles.

Circle No. 231 on Subscriber Service Card.

METAL FILM POTENTIOMETERS

A new type of metal film precision potentiometer is now being manufactured by the Magnetics Division of Servomechanisms, Inc. The resistance element of the potentiometer is made of alloys developed for this purpose, evaporated in high vacuum and deposited onto a ceramic disc. The process involves the carefully controlled transfer of the metal in its vaporized state to build up coatings of



desired shape on the prepared surface of the ceramic base or "substrate." Thickness of the coatings can be controlled to produce accurately the desired electrical characteristics. The entire process can be accomplished by the use of fully automatic equipment.

Made entirely of inorganic materials —ceramic and metal held together by molecular bond—the rugged construction enables the unit to withstand extreme tests of vibration, shock and humidity. Tests conducted to date indicate superior performance and dependability at temperatures of 150°C and higher.

The uniformly deposited resistance element offers substantially infinite resolution together with low noise and relatively small contact and end resistance, eliminating the problem of "hunting" in high-performance servo loops. Together with the patented contact brush, it assures long rotational life and continued low noise level. Although power rating is generally stated at 2 watts (with temperature of 150°C), both the brush and the resistance element are capable of dis-

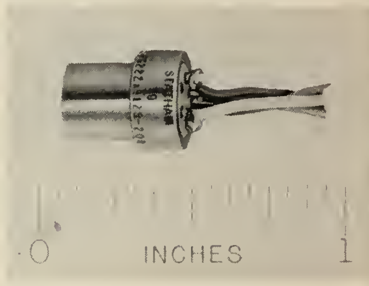
← Circle No. 152 on Subscriber Service Card.

sipating considerably higher wattages. The mechanical design of these metal film potentiometers permits ganging and phasing of 2 or more independent sections on a common shaft.

Circle No. 232 on Subscriber Service Card.

PRESSURE TRANSDUCER

A tiny flush-diaphragm pressure transducer approximately 1/8 the size of miniature instruments now in use has been developed by Statham Instruments, Inc. The unit has a diameter of 0.25", measures 0.47" in length and weighs 3 grams.



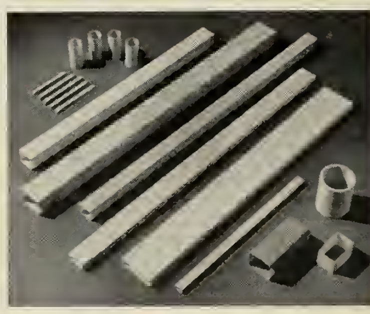
Due to the small dimensions, the model P222 pressure transducer is adaptable to many application possibilities in which the measurement of gage differential and absolute pressures are required.

Using the principle of the unbonded strain gage, the circuit of this subminiature instrument forms a complete bridge with a nominal resistance of 200 ohms. It has an output of approximately 15 millivolts full-scale open-circuit at 3 volts excitation. The wide ambient temperature limits of −100° to +275°F and the availability of pressure adapters for conversion to closed line applications extend the potential use of the instrument.

Circle No. 233 on Subscriber Service Card.

HIGH-TEMPERATURE CORE TUBES

Silicone Insulation, Inc., has developed new equipment producing rectangular and round high-temperature core tubes with a minimum of tooling costs. Class "H" tubes are of laminated silicone

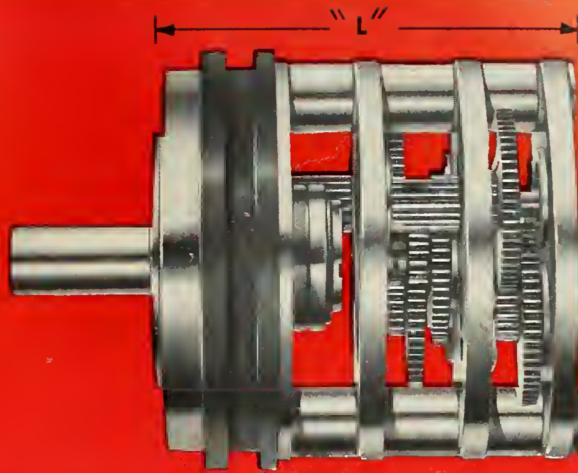


glass cloth. They are designed to meet the requirements of military specifications MIL-E-917B for electrical power equipment and MIL-E-16400A for electronic equipment. Class "B" tubes are of laminated polyester glass cloth or laminated epoxy glass cloth.

Semistandard sizes comprise rectangular tubes with both internal dimensions between ¼" and 2" and round tubes with internal diameters between ¼" and 2". The nominal wall thickness of these tubes

EDISON PRECISION GEAR HEADS

- Sizes 8 through 18 available in any ratio within 1%.
- Mount directly on all Edison and Bureau of Ordnance Motors without adapters.
- Adapters available to mount on any motor.



CHARACTERISTICS	STANDARD EDISON GEAR HEADS				
Size	8	10	11	15	18
Part Number					
Pinian Data: Number af Teeth Diametral Pitch Pressure Angle Pitch Diameter	12 120 20° .1050" +.0 −.0005	13 120 20° .1083" +.0 −.0005	13 120 20° .1083" +.0 −.0005	15 96 20° .1562" +.0 −.0005	15 96 20° .1562" +.0 −.0005
Gear Ratia to Length "L"	see below				
Moment af Inertia GM CM²	.01	.018	.02	.05	.08
Maximum Running Tarque in. az.	15	15	20	25	25
Maximum Stall Tarque in. az.	35	35	40	50	50
Breakdawn Torque in. az.	.01	.01	.012	.015	.018
Backlash maximum	30′	30′	30′	30′	30′

Gear Ratia to Length "L"

Ratio (8)	"L"	Ratia (10)	"L"	Ratia (11)	Ratio (15)	"L"	Ratia (18)
17	0.750	31	0.781	36	40	0.812	60
42	0.812	93	0.954	108	140	1.000	240
104	1.008	280	1.054	324	490	1.100	960
253	1.070	840	1.116	972	1715	1.162	3840
615	1.204	2521	1.266	2916	6000	1.328	15,360
1494	1.347	7565	1.409	8748	21,000	1.487	61,440
3629	1.421	22,696	1.500	26,244	73,500	1.600	245,760

Gear Tolerances: Precision Class 2 AGMA 236.02. *Bearings:* Stainless Steel ABEC Class 5 or better. *Shaft Radial Play:* .002"/inch length max. with 4 ounce gage load. *Shaft End Play:* .002" max. with 1 pound gage load. Friction Slip Clutch available on request. Designed to meet applicable paragraphs of MIL-E-5272.

Thomas A. Edison Industries
INSTRUMENT DIVISION
85 LAKESIDE AVENUE, WEST ORANGE, N. J.

McGRAW EDISON

Circle No. 41 on Subscriber Service Card.

is .030" and the standard length 25".

The new equipment can also turn out nonstandard sizes of tubes with heavier or lighter walls and lengths up to 72", as well as tubes with special contours. Special tooling has recently turned out tubes ranging from 20" I.D. x 144" length x 3/8" wall to one with a wall of .004".

Any of the tubes can be cut to specified lengths or fabricated with holes, grooves, or slots. Terminals and other hardware can be attached or markings applied. Laminated silicone glass cloth parts made by the company have been tested at 700°F for 300 hours and even higher temperatures and found satisfactory for their applications.

Circle No. 234 on Subscriber Service Card.

PRECISION ACCELEROMETER

A completely transistorized precision linear servo accelerometer, Model 4310, has been introduced by Donner Scientific Co. The unit is available in ranges from ± 0.05 g to ± 50 g. The maximum output is either ± 7.5 or ± 1.5 ma, eliminating auxiliary amplifiers required by other types of accelerometers. The Model

4310 is portable and can be operated from a simple battery power supply providing ± 15 v at 6 ma. Repeatability is 0.01% of full-scale and linearity is within 0.05% of full-scale. The entire unit weighs only 3.2 oz. When weight and space requirements are even more critical the acceleration pickup portion can be separated from the servo-amplifier part of the instrument and installed in a remote location.

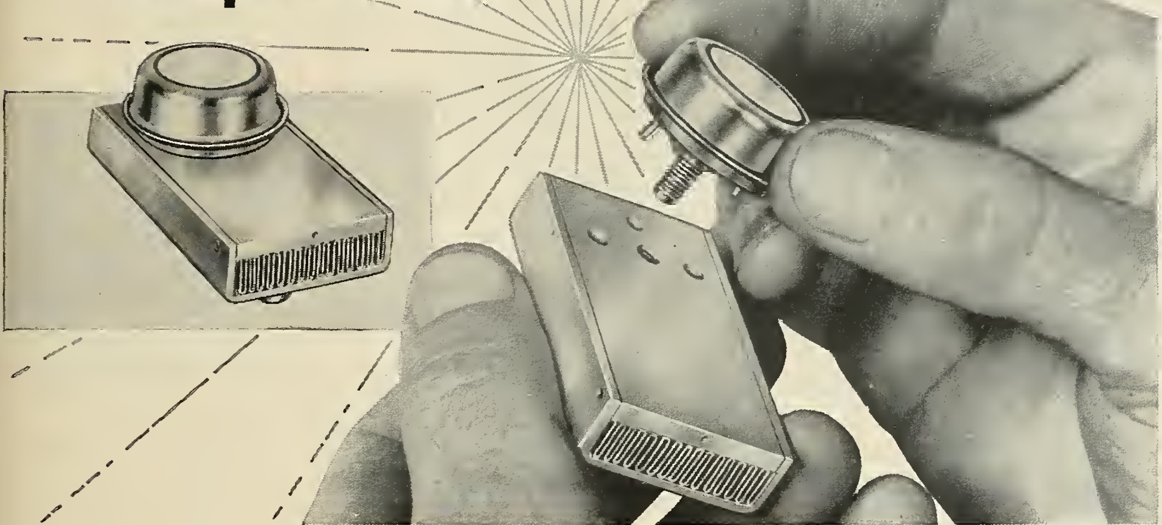
Circle No. 235 on Subscriber Service Card.

COUNTER-TIMER

Systron Corporation has introduced a single package in-line megacycle-microsecond counter-timer in its Model 1031, now in production. Providing flexibility and reliability for laboratory applications, it measures: frequency to 1 mc, time and period in 1 microsecond increments, phase angles in 0.1° increments, events to 7 digits, ratio of 2 frequencies, and acts as a secondary frequency standard.

The principal feature of the equipment is the in-line display of informa-

UAP COLD PLATE controls TRANSISTOR junction temperature!



minimizes transistor derating for thermal conditions . . .

UAP cold plate U-521330, designed for Collins Radio Company, dissipates heat generated by power transistors used in ground and airborne electronic circuits. The heat is transferred across a pressure thermal contact to cooling air. The cold plate controls the transistor junction temperature within operating limits compatible with the installation. Therefore, transistor derating is minimized.

The cooling air, which is forced through the cold plate, can be ducted from an air cycle refrigeration system; a ram air supply; an air manifold within the electronic compartment or a pressurized equipment package.

The aluminum cold plates are bonded by UAP's dip braze method which produces extremely lightweight assemblies with maximum heat transfer area within the core. Cold plates can be used individually or assembled in manifolded banks.

DESIGN PERFORMANCE CHARACTERISTICS OF U-521330 COLD PLATE
Air flow: 7 lbs. per hr.
Air pressure drop: 0.25" H_2O corrected to .0765 density
Temperature drop in cold plate: 1.5°C per watt dissipated
Weight: Approximately 1 oz.
Performance characteristics can be modified to requirements.

For complete information call the nearest UAP Contractual Engineering Office

CALIFORNIA.......................1101 Chestnut St., Burbank Calif., VI 9-4236
NEW YORK..................50 E. 42nd St., New York 17, N. Y., MU 7-1283
OHIO........................1116 Bolander Ave., Dayton, Ohio, BA 4-3841
CANADA...............United Aircraft Products, Ltd., 5257 Queen Mary Road, Montreal, Canada, ELwood 4131

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tion. The well-illuminated 1"-high numerals are clearly readable at distances up to 30 or 40 ft.

Outstanding features include: remote in-line indication, the use of the Burroughs beam-switching tubes for the counting decades with corresponding reduction of conventional vacuum tubes, and modular construction for all amplifiers and control circuitry.

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ADJUSTABLE CAM ASSEMBLY

Sterling Precision Corp. has developed an adjustable cam assembly designed

for use in servomechanisms where it is desired to actuate switches and similar devices at predetermined angular limits.

Two stainless steel cams may be rotated relative to each other to permit adjustment between rise from 0° to 180°. A balanced clamp secures the assembly to the shaft as well as locking the cams for the desired setting. Maximum diameter is 1 1/8" and hubs are available for 1/8", 3/16", and ¼" shafts.

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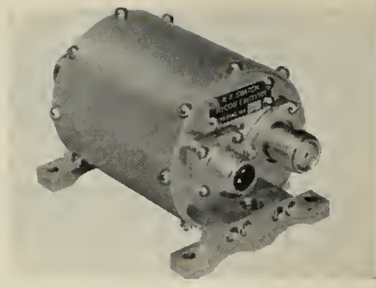
HIGH-POWER RF SWITCH FOR SEVERE ENVIRONMENT

Hycon Eastern, Inc. has introduced a high-power RF switch, type 1696, that will withstand the severe environment encountered in advanced missiles. The new component will switch a transmitter from one antenna to another at high-power levels without mismatching the transmitter. In other words, this unit may be safely switched under power.

Environmental specifications are:



shock to 100g; vibration 20g at frequencies up to 2000 cycles; temperature -40°F to +250°F; altitude unlimited because unit is pressurized.

Other specifications include: frequency range: 215 to 250 mc/s (other ranges on special order); attenuation: 0.25 db, maximum; power rating: 100 watts RF CW; VSWR: 1.2 maximum; switching: .15 sec. average; size: approximately 2½" diameter by 4½" long; weight: 2 lbs.; actuating power: 6 watts dc; cross-talk: 27 db down into unused channel; sequence: make-before-break.

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30 Channels — 10 Samples /Sec.

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- Meets all I.R.I.G. requirements, exceeds MIL E-5272A specification.
- Errors due to drift, cross-talk and non-linearity less than 0.50 percent under MIL E-5272A environment.
- Noise-free operation assured for thousands of hours without maintenance.
- Twenty-Seven (27) information channels, plus Master pulse.
- Unique limiting feature eliminates need for limiters elsewhere in system.
- Power Requirement: 150V DC at 12 ma.
- Size: 3" diameter x 5" long.
- Weight: Less than 2 pounds
- Extreme reliability is achieved through use of a simplified counter circuit in conjunction with an advanced-design silicon diode switching matrix.
- Design life expectancy is at least 5000 hours without maintenance of any kind.

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West Coast Industry

by Fred S. Hunter

The night shift is back in business at Rocketdyne's test facility in the Santa Susanna Mountains, and once again test firing have been booming out over the rooftops of the San Fernando Valley long after the sun has gone down. These midnight firings reflect an accelerated program on *Atlas* engines. The *Atlas* people are unusually busy these days since they have to complete their test firing program this year to provide the production articles due in 1959. The *Atlas* now also has an added responsibility: minus warhead, it's to be the initial boost stage of the four stages of the WS-117L, the earth satellite reconnaissance vehicle being developed for the Air Force.

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Temco's air-to-surface *Corvus* will equip the new low-level attack aircraft which Grumman is to build for the Navy, as well as the Martin P6M. Meanwhile, the Martin *Bullpup*, now being evaluated at Point Mugu and reported progressing satisfactorily, is to be used on attack-fighter aircraft such as the Douglas A4D. It may even be used on any propeller-driven ADs that may still be operational when the missile—radar guided—goes into service. Later on will come a more advanced air-to-surface weapon called the *Raven*, around which the Navy plans to design and build an entirely new aircraft. A contractor for the *Raven* may be selected shortly. Another new missile, a more sophisticated air-to-air bird called the *Eagle*, is reported also on the Navy schedule.

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The Navy regards its 19,000-acre portion of Camp Cooke, the West Coast ballistic missile facility, as being ideal for this scale of operations because of sea-facing deep canyons. Moreover, Cooke is said to be the only place in the United States where a satellite could be launched sea-wise in a N-S direction due to coastline curvature. This orbit is needed so the satellite can "see" different portions of the earth. The Pacific test range, to be established for operation by Point Mugu and Cooke, will make an excellent complement to Cape Canaveral. The vastness and emptiness of the Pacific will provide more flexibility in firing missiles.

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Marquardt Aircraft's new "Astro" division's activities can be expected to step up now that the new model test facility in the Newhall-Saugus area north of Los Angeles is complete. There's also some talk of a facility at Yucca Flat in Nevada. Marquardt has two nuclear projects in the shop now, one being a prime contract in the Air Force nuclear propulsion program. The other is a contract from General Electric for the development of a turbojet-engine control system designed for use with GE's nuclear power turbojet.

•

B. F. Coggan, general manager of the San Diego division, discloses that Convair is exploring the fantastic new field of antimatter. Physicists recently have shown that elementary particles, such as protons and antiprotons, release large amounts of energy on contact. It's possible that antimatter energy may be even more fundamental and powerful than nuclear fusion. Coggan suggests more knowledge about antimatter may supply the master key which will unlock many of the universe's innermost secrets—magnetic fields, aurora borealis, gravity. From this may come antigravity devices. And beyond this Coggan believes antimatter energy will be used in the future for propulsion to explore the universe.

World Astronautics

by Frederick C. Durant III

Optical tracking of earth satellites requires enthusiasm, technical appreciation, self-discipline and teamwork, in addition to simple but good optical and timing equipment. The Smithsonian Astrophysical Observatory (SAO) at Cambridge, Mass. has done an excellent job in staffing and outfitting the official U.S. Moonwatch tracking stations in many countries. Certification of competency of these teams in each country is made by a satellite coordinator appointed by the national IGY Committee. It takes dedicated effort to assure the complete manning, upon call, of the spotting 'scopes at dawn and dusk. Each team is comprised of 20 to 100 persons to compensate for fatigue, illness and those who may suddenly drop out for personal reasons.

A total of 205 Moonwatch teams in 11 countries were accredited and officially registered by last December. Of these, 114 are in the United States and 71 in Japan, 4 each in Argentina, Australia and the Union of South Africa, 3 in Chile, and 1 each in the Belgian Congo, Mexico, the Netherlands Antilles, Peru and Uruguay. The high interest in Japan was reported in m/r earlier (July 1957).

To date, the Japanese have responded to this scientific call in far greater numbers than any other foreign nation. The SAO recently issued a report of activities during the eight weeks after the launching of *Sputnik* I. During these first two months of the satellite era the Moonwatch teams of only four out of the 11 countries contributed to the 391 observations reported. The United States turned in 244 data reports of sightings, Japan, 128, Australia, 13 and Chile, one. The foreign sightings are particularly important because of their location in the Eastern and Southern Hemispheres. The Japanese made one-third of all the reports. Australia had the highest number of reports per team per country.

The Netherlands Antilles team has reported sightings since December. The major reason for holdup of Moonwatch operations in other countries has been delay in obtaining equipment. Ideally, an industrial sponsor is obtained to cover the cost of about $2000 to obtain basic equipment. There are no salaries.

The largest object, the final stage of the launching vehicle, was designated 1957 α_1; the satellite proper, α_2. These appellations follow astronomical practice. A third object, in all probability the protective nose cone, is designated α_3. Incidentally, it was a Japanese team that first sighted all three elements of *Sputnik* 1, although other teams subsequently reported similar sightings while α_1, α_2 and α_3 were still near each other. The U.S. *Explorer* satellite launched by the Army *Jupiter*-C became the first 1958 satellite, and thus, 1958 α_1, etc.

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Quite a spate of Russian books on space flight are available in the United States. Both paperbacks and hard covers may be purchased at the Telberg Book Co. and Four Continent Book Store in New York City. Although most works are in the original language, there is an excellent book by K. E. Tsiolkowskii translated into English.

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26 February to 1 March an astronautical meeting was held at the Loccum Evangelican Academy, at Loccum-Hanover, Germany. This is believed to be the first such extensive space flight discussion at a religious institution. Such well-known astronautical personalities as Dr. Eugen Saenger, Dipl. Ing. Heinz Gartmann, Andrew G. Haley and Dr. H. von Diringshofen were on the program.

Space Medicine

by Hubertus Strughold, M.D., Ph.D.

In addition to Col. Paul Campbell's Space Medicine Panel, as reported in my last column, there will be a panel on Simulated Atmospheres and Foreign Environments in Space Operations at the annual meeting of the Aeromedical Association, March 24-26, at the Hotel Statler, Washington, D.C. This panel will describe experiences in sealed gondolas with simulated atmospheres in recent ultrahigh balloon flights, in space cabin simulators, pressure suits and submarines. Other topics will be terrestrial microorganisms in a simulated Mars atmosphere and the medical significance of ozone. The writer will be chairman of the panel.

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The symposium on Physics and Medicine of the Atmosphere and Space, sponsored by the School of Aviation Medicine, will be conducted by the Southwest Research Institute of San Antonio. It will involve medical problems in aeronautics and astronautics, and will emphasize the Geophysical Year. There will be about 40 speakers on the program, eight of them from Europe. It is scheduled for November 11-14 at the Hilton Hotel, San Antonio.

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At the Annual Meeting of the Institute of Aeronautical Sciences held in New York City recently, a film was shown depicting Capt. Julian E. Ward (Department of Space Medicine, School of Aviation Medicine) drinking water in the gravity-free state during a ballistic curve in a jet plane. The use of a plastic squeeze bottle revealed no difficulties. However, drinking from an open container produced a mess of water bubbles in the face and surrounding area.

•

Dr. William M. Sinton of the Smithsonian Astrophysical Observatory recently reported on a new test to determine whether there is vegetation on Mars. This test is based on the fact that all organic molecules show strong absorption bands near 3.4 μ, the wave length of the carbon hydrogen resonance. Spectra of Mars taken during the 1956 opposition indicate the probable presence of this band. Although the lichen spectrum was used for comparison, the similarity between them, of course, does not imply that lichens are present on Mars; it indicates only that organic molecules are present. According to Dr. Sinton, it seems unlikely, however, that "organic material would remain on the Martian surface without being covered by dust from storms, or being decomposed by the action of solar ultraviolet, unless they possess some regenerative power." These studies, therefore, support the Martian vegetation hypothesis. A strong regenerative power was first postulated by Dr. E. G. Oepic in the Irish Astronomical Journal in 1950.

An outspoken promoter of the Martian vegetation theory is G. Tikhof of Russia's Alma-Ata Observatory, and a member of the Academy of Sciences in Moscow. Tikhof bases his opinion primarily on his findings regarding the ability of plants to survive in severe climates, such as in the subarctic, on the Pamir plateau, and to reflect and absorb infrared light in the blue-green areas on Mars. However, his scientific colleague, Olga W. Troizkaja, also a member of the Russian Academy of Sciences, in a paper published in 1952, expressed the opinion that only anaerobic, very cold-resistant microorganisms are conceivable in the severe Martian climate.

Another Russian astronomer, the well-known Professor W. G. Fessenkow, flatly rejects the whole theory of life on Mars in toto. There is apparently no party line in opinion so far as extraterrestrial cosmic matters are concerned.

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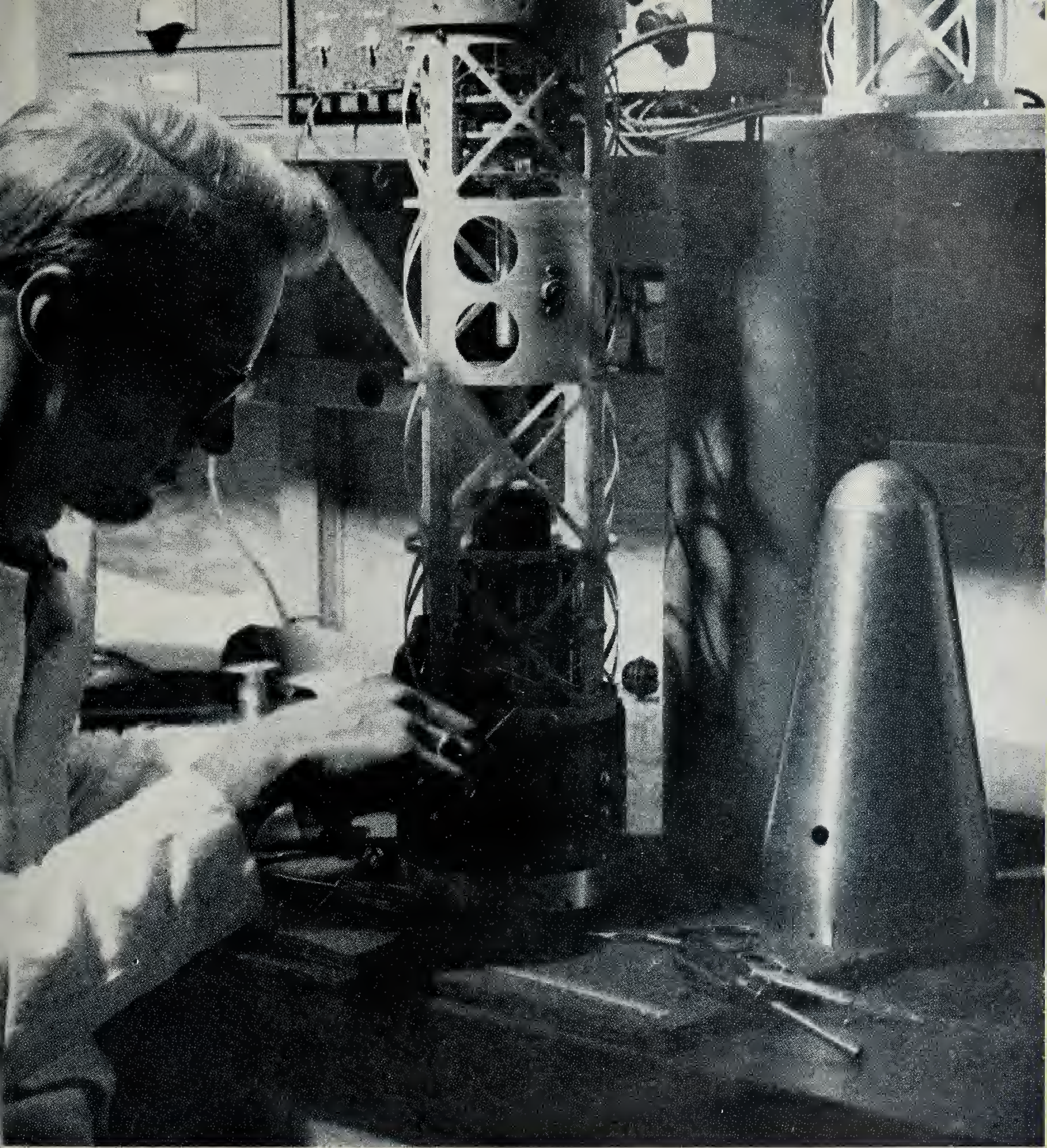

missile electronics

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MARCH, 1958

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TYPICAL SYSTEM MEASUREMENTS

	Input Voltage (Volts)	Input Current (Amps.)	Input Power (Watts)	Output Voltage (Volts)	Sensitivity (MV/deg.)	IMPEDANCE Input	IMPEDANCE Output	Phase Shift (deg.)	Remarks
Transmitter→Control Transformer	26	.111	.74	22.5	393	58 + j226	626 + j233	19	High impedance load on CT
Transmitter→Control Transformer	26	.111	.75	21.6	377	58 + j226		19	50° load on CT
Transmitter→Control Transformer	26	.110	.83	19.2	335	64 + j221		17	5° load on CT
Transmitter→Differential→CT	26	.134	1.78	19.5	340		748 + j364	40	Output to High Impedance
Electrical Resolver→Electrical Resolver	11.8	.115		7	120			52	Input to stator
Electrical Resolver→Electrical Resolver	26			15	260			53	Input to rotor

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LOOK TO *cppc* FOR SYNCHRO PROGRESS

Clifton Precision Products Co., Inc.

Clifton Heights Pennsylvania

Circle No. 68 on Subscriber Service Card.

missile electronics

vol. 1, no. 5

contents

missile electronics news

special features

cover picture:

Clifford J. Finnie of the Jet Propulsion Laboratory, Cal Tech, assembles interior instruments used in the Explorer *into the fibre-glass lattice sleeve which forms part of the satellite. The two transmitters used to telemeter information are on either end of the mounting sleeve. One transmitter was of relatively high power and lasted only 12 days, but the low-power unit has an estimated life of two to three months. The now defunct transmitter, operating on 108.03 mc, sent data on the skin temperature of the rear area of the satellite, internal temperature, micrometeorite impact and cosmic-ray counts. The low-power unit, operating on 108 mc, telemeters information on the skin temperature of the satellite forward area, the nose-cone temperature, micrometeorite impact and cosmic-ray counts. The transmitters were designed as independent units from batteries to antennae so that malfunction of one would not affect the other.*

photo credits: *ABMA, pp. 199, 200; Arnoux, pp. 201, 203, 206; Jet Propulsion Lab., Cover; Raytheon, p. 185; Sperry Gyro, p. 188.*

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Details of *Jupiter*-C Guidance System Revealed

by Raymond M. Nolan

NEW YORK, N. Y.—At a recent meeting here, scientists from the Guidance and Control Laboratory of the Army Ballistic Missile Agency discussed the guidance aspects of the *Jupiter*-C satellite launching vehicle.

Dr. Walter Heussermann, chief of the Guidance and Control Laboratory, demonstrated the orbit of the satellite with a world map and a transparent overlay. As he was speaking, he showed the exact position of the *Explorer*.

Questions brought out the fact that the *Jupiter*-C was stabilized in roll and yaw by an LEV-3 gyro system (see m/r February, "Workhorse of Inertial Guidance"). This probably means that the guidance system which put our satellite into orbit comprised an LEV-3 for roll and yaw, a Ford Instrument air-bearing gyro for the critical pitch control, and air-bearing gyro accelerometers for velocity and distance determination.

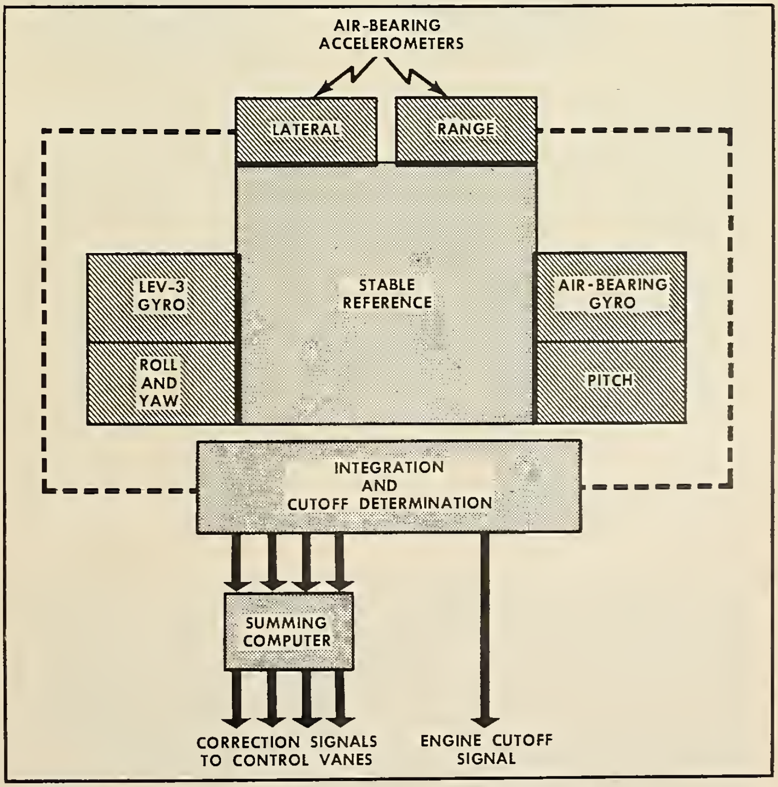
The use by ABMA of an LEV-3 in the system points to a decided difference in the *Jupiter*-C and the *Vanguard* programs. The LEV-3, a comparatively cheap device manufactured by the Waste King Corp., was developed by the same team that put up the *Explorer*—Dr. Wernher von Braun and associates—in World War II for the German V-2 missile. Development of the air-bearing gyros and accelerometers began even before that with early development work in the mid-1930's at Darmstadt Technical Institute.

In contrast, development of the guidance for the *Vanguard* presumably began in 1955 when the decision to drop Project *Orbiter* and proceed with *Vanguard* was made.

The guidance system of the *Jupiter*-C was in existence as a package for quite some time and required only installation and simple check-out when the word finally arrived that *Jupiter*-C could be launched.

Dr. Heussermann pointed out that, in spite of repeated criticism that the air-bearing instruments are delicate and difficult to produce, they are in fact extremely rugged devices and produce no more manufacturing difficulties than any reasonably complex instrument. No such criticism was voiced about the LEV-3 since it is obviously an easily produced, low-cost item.

An interesting statement made by Dr. Heussermann was that the guidance system on the *Sputnik* vehicles was probably more sophisticated than that on the *Jupiter*-C. He surmises this



Probable guidance and control system for the JUPITER-C first stage.

since we have to spin our final three stages for stabilization while the Russians presumably have some self-contained stabilization device for their final stages.

The *Jupiter*-C upper stages are spun because all stabilization is lost when the upper part of the vehicle is pitched into a position horizontal with the earth. This would tumble any sort of gyroscopic stable reference and require that further stabilization come from some other source.

Mr. Fritz Mueller, also of the Guidance and Control Laboratory, stated in answer to another question that the gyros were smaller than those ordinarily used in a *Redstone* missile (the first stage of the *Jupiter*-C). This could mean that they are of the same type used on the *Jupiter* missile since it was announced previously that the *Jupiter* guidance and control system was essentially a miniaturized version of that used on the *Redstone*. If so, this might mean that the *Jupiter* guidance problem has been licked.

Based on remarks by Dr. Heussermann and Mr. Mueller, the accompanying sketch shows the probable makeup of the guidance and control system in the *Redstone* missile, which formed the first stage of the *Explorer* launching vehicle. The system is pure inertial but might have had a radio link to accomplish the final tilt to place the last three stages in a horizontal position.

In operation, the LEV-3 and air-bearing gyros stabilize a platform on which the two accelerometers—for measuring range and lateral translation—are mounted. The accelerometers deliver signals to computers for further integration and summing. Final outputs of the system are the cutoff signal to the main engine and vane control signals.

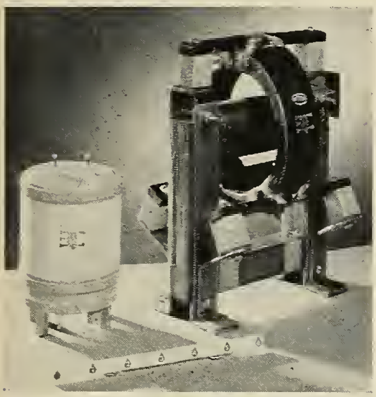
The only departure from the inertial systems used on the *Redstone* and *Jupiter* missiles (which use air-bearing gyros and accelerometers) is the inclusion of the LEV-3 as a stabilizing element. Since the LEV-3 has been available for such a long time, it is probable that the guidance system for the defunct Project *Orbiter* was identical or at least similar to the one used on the *Jupiter*-C.

New Cooling Techniques Lead to Miniaturization

Startling reductions in the size and weight of transformers through the use of new cooling and insulating techniques have been announced by the Raytheon Manufacturing Co.

The new techniques fall into two broad categories. In the first, heat resulting from unavoidable losses in cores and coils is carried away by the use of a volatile, heat-stable, fluorochemical liquid which boils on contact with heated areas. The vapor formed by boiling condenses when it contacts the cooler surface of the container, completing the cooling cycle. Heat transfer coefficients up to 20 times those attainable with conventional transformer oils are readily achieved.

The second technique makes use of stable fluorochemical vapors up to



Comparison of size between miniaturized transformer using air as a dielectric and new unit using heavy fluorochemical vapor.

50 times the weight of air. These vapors are characterized by excellent heat-transfer characteristics (equal to or better than oil), high dielectric breakdown strength (equal to oil at one atmosphere, better than oil at high pressure), and unequaled corona-suppressing properties.

Cooling effects better than those obtainable in oil are obtained by each of these two techniques.

Weight reduction in some cases has been as great as 75 per cent, an impressive figure in view of the amount of weight that transformers contribute to missile electronic equipment.

Norden-Ketay and Solar Aircraft Merge

The combination of Norden-Ketay Corp. of Stamford, Conn., a designer and builder of complex electronic systems and instruments, and Solar Aircraft Co. has been approved by the boards of directors of both companies. The transaction will be submitted to the shareholders at an early date, Paul Adams, chairman of the board of Norden-Ketay, announced.

The basis of the transaction would be the issuance of approximately 230,000 shares of Solar common stock, subject to contingencies. Norden-Ketay has approximately 1,300,000 common shares outstanding and is listed on the

American Stock Exchange. There are currently 700,052 Solar common shares outstanding, listed on the New York Stock Exchange.

Mr. Adams also released 11 months' figures for Norden-Ketay showing sales of $25,213,724 and a loss of $1,107,667 after interest expense and other deductions. The year-end audit is proceeding and further loss adjustments are indicated.

In a letter to Norden-Ketay stockholders, Mr. Adams stated: "Your company was hard hit by Government contract rescheduling and the receipt of virtually no new production business while the defense effort was being appraised. Serious reduction of working capital occasioned by the losses made it imperative that we seek substantial additional capital funds in order to preserve our status and maintain the potential of our company."

Solar's sales in the fiscal year ended April 30, 1957 were $83,118,500 and indicated sales of Norden-Ketay in the year 1957 were approximately $27,000,000. Solar is a major designer and manufacturer of products made from stainless steel and other hard-to-work metals. Products include aircraft and missile engine assemblies, airframe assemblies, small gas turbine engines, industrial expansion joints, and a variety of other military and commercial items. Norden-Ketay's output is largely used in aircraft and missiles, radar and fire control systems, and automation equipment.

Solar has plants in San Diego, Calif. and Des Moines, Ia. Norden-Ketay has plants and laboratories in several eastern cities and in California. The combined employment of the two companies approximates 6300.

NPN Computer Transistors Now Being Mass-produced

A new advance in production techniques resulting in the availability of substantial numbers of high-speed switching computer transistors was recently announced by Allan Easton, vice president of the marketing division of General Transistor Corp.

Mr. Easton said, "While we have been producing high-speed switching computer-types for a long time, no large-volume production was scheduled until we were making highest quality transistors with good yields." He went on to state that the increased availability is especially important because NPN computer transistors will now be available in large quantities.

In conclusion, Mr. Easton stated that he expected advanced development effort would bring similar results on newer transistor types.

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Sperry Shows Improved Type of Gyro Suspension

Sperry Gyroscope recently revealed details of a radically new form of suspension for integrating gyros. Rather than a pendulous weight (as in many precision accelerometers by offsetting the gyro rotor), the Sperry unit suspends the sensing element in a silicone fluid and then spins sensor and fluid while the accelerometer is operating.

Three small metal cylinders, self-contained, form the device. Smallest internal cylinder is the floating sensor or acceleration-sensitive element. This is immersed in a silicone fluid inside the next larger cylinder, which in turn is supported by bearings within the outer shell or case.

Inside the silicone fluid, the sensor would normally rise to the top of the liquid, except that the middle cylinder is spun at 1000 rpm by a small external motor. This rotates the silicone fluid as well, and produces hydrostatic forces that exactly center the inner sensor away from adjoining walls without any bearings at all.

Because the sensor is supported only by a spinning liquid, no static friction remains and the slightest component of acceleration along its longitudinal axis moves the sensor along this axis for precise electronic measurement.

As fluid is displaced from one end to the other by a piston-like action of the sensor, it exerts a viscous restraint on motions of the sensor. The use of special bypass tubes eliminates the possibility of variations in this restraint as the float moves. This combination cushions fore-and-aft movement in a manner that produces internal velocity which is exactly proportional to external accelerations.

Weight of the unit is one and one-half pounds; the size is illustrated by the accompanying photograph. Accuracy was conservatively quoted by W. G. Wing, head of components engineering at Sperry as "within hundredths of one per cent." He stated that threshold sensitivity was better than 10^{-5} g's or 100,000th the force of gravity. An example of this is the ability of the new

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accelerometer to detect the gravity force produced by tilting its sensitive axis as little as 2 seconds of arc—approximately the angle you get by raising a one-and-one-half-mile-long rigid pipe only one inch at the farther end.

Mr. Wing sees immediate application for long underwater voyages such as those preparatory to firing a *Polaris* missile. This might mean that the accelerometer would be used in a version of the Sperry SINS (Shipboard Inertial Navigation System) now in use on the USS *Compass Island*. The SINS was originally developed for the fleet ballistic missile version of the *Jupiter* missile and is presumably being used for the *Polaris*.

Simplified Data-handling for Wind Tunnel

A new data-handling system, capable of handling information from a total of 300 strain gauges and 100 thermocouples with an accuracy of better than 0.25 per cent of full scale, has been put in operation for wind-tunnel testing by the systems division of Beckman Instruments.

In high-speed automatic scan, the system samples 400 transducers at a basic rate of 400 per second. It is possible to vary the sampling period from one complete scan per second to one per 100 seconds.

In single-scan operation, the system makes a complete scan only in response to the operator pressing a button. Another feature is the capability of selecting any one of the 400 transducers and obtaining a graphic plot of the individual channel.

Input circuitry of the system has several unusual features. Transducer inputs are multiplexed into 10 per amplifier so that 40 amplifiers are used rather than 400, reducing the maintenance problem. Synchronized electronic and mechanical switching is used, including oil-immersed stepping switches capable of more than 300 million operations before failure. Solderless wiring and gold-plated contacts are used to eliminate noise and thermal effects from the low-level signal paths.

Extensive modular construction is used to aid in servicing and minimize down time. Input amplifiers are all plug-in units and the high-speed electronic commutator is easily removed for service.

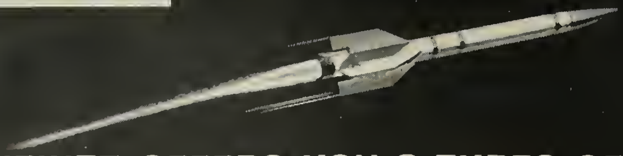
The system uses an analog-to-digital converter to change transducer outputs into computer inputs. The converter compares the analog trace to a linearly changing voltage which calibrates itself against internal reference voltages 1000 times per second, the digitalization time.

The digital information is stored on magnetic tape and transferred to punched cards by means of a transistorized tape-to-card converter. Besides test data, all identifying information such as the date, time of sampling and the channel group number is recorded. Also, an analog signal is available for use with an X-Y plotter.

Neatest feature of the system is a servo control "gun" for rapid balancing of the strain-gauge transducers. The operator places the end of the "gun" over each balance control knob and the device automatically rotates each knob in search of a null position which balances the strain-gauge network. The trigger of the "gun" automatically switches the balancing circuit to the next network.

A system such as this points to the trend to a larger number of data channels, say engineers of the systems division, and additional multiplexing of amplifiers may be the answer. Future demands for systems capable of operating at the rate of 10,000 to 20,000 channels would require rack arrangements of tremendous size, but further advances in the art of solid-state amplifiers will probably be responsible for a total size within reason.

Missile Designers:



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Short-Duration Flights: J&H *thermal lag* generators are capable of delivering full-rated output throughout flight without benefit of cooling.

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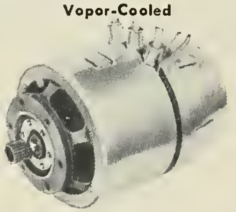

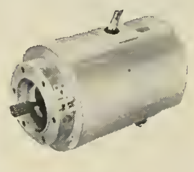

	Vapor-Cooled	Oil-Cooled	Thermal Lag
J&H Model	G188-5	31190-005	31186-001
Nominal Rating (kva)	30	40	10
Duty	continuous	continuous	intermittent
Volts	120	120/208	120/208
Speed (rpm)	12,000	6,000	12,000
Phase	3	3	3
Frequency (cps)	400	400	400
Power Factor (minimum)	.8	.75	.9
Weight (lb)	66	75	29.5
Length (in.)	13	9	10
Diameter (in.)	9	9.75	7

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AIRCRAFT SYSTEMS AND EQUIPMENT

Circle No. 73 on Subscriber Service Card.

Astrionics

by Henry P. Steier

Latest round of satellite-scurrying occurred just before the Army put up its *Explorer* satellite. Last minute additions to the Minitrack tracking stations were needed. A few days prior to the event, word went out to prepare for installation of special recording equipment to handle signals from the *Explorer*. This was needed for a different mode of signal from Army's "Microlock" position-fixing system developed by Jet Propulsion Laboratory some time ago for Army satellites.

•

Despite our success in getting a satellite up, a very important part of the program is still dragging its feet—installation of tracking cameras. From these was supposed to come the really precise observation of satellites, and accurate data on what they were doing. So far only two of 12 planned cameras are available. One is at White Sands Proving Ground, the other is en route to the Union of South Africa. Industry sources say mechanical problems are delaying production.

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Optics job for the cameras has been called "one of the most difficult optical production jobs ever attempted." However, this work is on schedule. Optical design calls for a 31-inch Schmidt-type mirror and three aspheric corrector plates. Perkin-Elmer Corp., Norwalk, Conn., has contract for this work.

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Real breakthrough which permitted start of radar detection system for ICBMs was development of high-powered transmitters, according to Lt. Gen. Donald A. Putt, Asst. Chief of the Air Staff for Development. A $721-million program involving Radio Corporation of America, General Electric Co. and Western Electric Co. was revealed by Putt in testimony before the House Appropriations Committee. Detection radar configuration is still cloaked in security. The other radar, for tracking after target acquisition, is similar to the Millstone Hill, Mass., radar prototype now being operated by Lincoln Laboratory of MIT.

•

Heart of the radio frequency power system employed in the tracking radars is said to be 11-foot klystron tubes which supply signals to the 84-foot-diameter parabolic reflector used. Tube is believed to be the X626 ceramic-metal tube built by Eitel-McCullough, Inc. It delivers 1¼ million watts peak power and 100 kilowatts average power. Frequency of the system is believed to be near the lower end of the spectrum usable for radar.

•

Detection radar must be a whopper from hints dropped by Putt in the testimony. Radar antennas must be located at some distance from the power-generating plant. It was implied that strong interference generated in the powerplant's vicinity would interfere with radar's operation.

•

Primary job of the ICBM detection system will be to make rapid computations of the missile's trajectory and find the predicted impact point. Computer will be of small size and transistorized. Sylvania Electric Corp. revealed it is a major subcontractor of RCA for the super radar, and will be responsible for the data-processing phase of the warning system. According to estimates, 15 minutes warning time is about what the system will give. That's not enough to evacuate many people, but ought to be enough to get an anti-missile missile on-course for interception.

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metal sputtering by ion bombardment

basic research
for tomorrow's metals

by G. K. Wehner

WHEN METEORS go hurtling through space and collide with a planet, they leave huge craters on the planet's surface. And when sandblasting is used to clean the grimy surfaces of metropolitan buildings, particles of the surface being cleaned are knocked loose along with the grime.

In each case, a solid surface is altered by the *impact* of the "particles" striking it.

Likewise, the basis of *sputtering*, as the term is used by physicists, is the alteration of a solid surface caused by the impact of striking particles. In the study described here, the bombarding particles are ions of mercury gas which are made to strike a metal surface. The impact causes surface atoms of the metal under study to be ejected. Under prolonged ion bombardment metals literally are disintegrated.

One of the objectives of working on sputtering in the laboratory is to set up and investigate conditions similar to those which exist in outer space. In this outer space an object like a satellite encounters collisions with free-wheeling atoms and molecules. Such collisions are capable of knocking loose atoms of even the best metals we now have. This is one of the reasons why the sputtering investigations are significant—in providing basic data in the search for materials that will withstand the atom and ion bombardment at high velocity flight in the ionosphere and in outer space.

These conditions generally can be duplicated by putting the target metal in a chamber which contains an ionized gas at reduced pressure. The ions, accelerated under the influence of an electric field, bombard the target surface and sputter the target metal.

Dr. Wehner is associated with the General Mills Electron Physics Laboratory.

To one unfamiliar with this work, the equipment used for these sputtering studies appears to be a complex arrangement of glass chambers and tubes.

The phenomenon of sputtering by ion bombardment has been known for a long time. It was first recognized on cathodes in gas discharge tubes and mentioned as cathode sputtering in an English publication as early as 1852. Current work was started at Wright-Patterson Air Force Base, Ohio.

Besides paving the way for the development of metals for high velocity flight, the purpose of the project is to understand the sputtering phenomenon thoroughly, providing necessary data for further work in such fields as gas discharge studies, crystallography, surface physics, metallography, etc. In other words, the work fits the category of basic research—creating basic scientific knowledge for use in a potentially great number of applications.

Until recently one of the major obstacles to detailed sputtering work was that the mean free path of the bombarding ions was too short. (The "mean free path" can be defined simply as the average distance that the ions travel without hitting anything.) That is, when the bombarding ions were released from their source and directed toward the target metal, many of them struck gas atoms and were reflected off in various different directions.

To make headway in learning about sputtering, it is necessary to know the exact bombarding energy that the ions impart when they strike the metal, and the angle at which they strike. This is impossible when many of the ions are bouncing from one gas atom to another in the chamber rather than traveling a direct route from the source to the metal.

To lengthen the mean free path of the ions, therefore, the obvious answer is to reduce the gas pressure (increase the vacuum) in the chamber so that there are fewer gas atoms to collide with the ions in their flight to the target metal.

Reducing the gas pressure also solves another problem. That is, at the *higher* gas pressure, many of the atoms that are sputtered from the surface of the target metal collide with gas atoms and are reflected back to the target metal. With this happening there is no way of knowing accurately the *rate* of sputtering, and the yield of sputtered atoms deposited on the chamber wall is greatly reduced. Indeed, it seriously interferes with learning how a certain metal withstands ion bombardment.

To eliminate such problems, the gas pressure is decreased to a level (10^{-3} mm of mercury or less) where by the sputtered atoms are allowed to travel freely from the metal to the collector, or the chamber walls. At this level, the *unobstructed* flight distance of the ions going toward the target metal is greater than the dimensions of the chamber. Sputtering then becomes independent of the tube geometry and gas pressure.

To provide the bombarding mercury ions with the essential high velocity, it is necessary to impose an external potential difference between the mercury ions and the metal target. In the present studies the target metal is given a negative potential to attract the positively charged bombarding mercury ions.

A difficulty which has had to be solved in this research is that oxide layers of some metals are more resistant to sputtering than others. Even when they are thoroughly removed before the metal is placed in the sputtering chamber, oxide and other such layers may be reformed continuously during the sputtering process. This occurs either through impurities diffusing from the bulk of the metal to the surface or because of impurities from the gas settling down on the metal surface. Even with the pressure of impurities in the tube at an extremely low level (10^{-6} mm mercury) a complete layer one atom thick would be formed on the surface of the metal in one second if every atom of the impurities stuck to the surface. Therefore, the ion bombardment would have to compete with the formation of such interfering surface layers.

Obviously, if oxide layers were allowed to build up on the metal, they would complicate the sputtering conditions. It would be impossible to get precise, clear-cut data on pure metals.

So, a basic requirement for reliable sputtering measurements is that the density of the bombarding ion current be high enough to overcome the formation of surface layers. Ion beams in a high vacuum are normally limited to a very low current density. Under such conditions each surface atom of the target metal receives only one impact every 100 seconds.

In the work at General Mills, a method employing a *vacuum arc discharge* has been developed which increases the current density by more than a thousand times—about 10 impacts per surface atom per second—even at a low gas pressure. At such high current densities weighable amounts of metal can be sputtered off in a reasonable time even when ions are striking at relatively low speeds. Thus it is possible to collect reliable sputtering data in the region of low velocities of the bombarding ions (30 to 400 electron volts), a region which has never been thoroughly investigated.

An analogy might serve to illustrate why this low velocity region is of much interest: If a slate wall is "bombarded" with bullets, it is chipped, pitted and otherwise marred in a rather haphazard fashion. But if the wall is eroded by the lower velocity of wind-driven sand, for example, the gentle erosion or etching pattern reveals structural details quite clearly.

A certain minimum velocity of the bombarding particles is necessary before sputtering will occur. In fact, charged atoms, or ions, are used rather than neutral atoms because ions can be more easily accelerated to the required velocities.

In an effort to simplify sputtering conditions in the current work, metal single crystals, rather than polycrystalline metals, are used as targets. (Metal single crystals are metals "grown" in such a way that the arrangement of the atoms is regular and identical throughout the whole piece. Polycrystalline metals consist of microscopically small crystallites which are randomly oriented.)

The use of metal single crystals as targets revealed the surprising discovery that when metal atoms are sputtered they are not ejected from the surface randomly but leave in certain directions determined by the *arrangement* of the atoms in the crystal. In other words, the atoms of the target leave the surface of the crystal in directions of closely packed rows, or lines formed by atoms lying directly against each other.

Heretofore it was widely held that sputtering resulted from heat caused by the impact of ions on the metal atoms. (Surface atoms of metals *can* be ejected by heat. This is called evaporation, or sublimation, and is not to be confused with sputtering.)

It has also been shown in the present work that sputtering will not occur unless the bombarding ions have a critical minimum kinetic energy—threshold energy—for any one metal.

In studying the threshold energy requirements for many different metals, a surprising result is that the velocity of sound in the metal comes into play. That is, the threshold energy for a given metal is related to the manner in which the metal transmits sound energy vibrations from one atom to another. Thus, it turned out that threshold measurements provide a simple method for measuring sound velocities in metals.

It can readily be seen that sound velocities are important in sputtering when one considers that surface atoms are ejected by a vibration from *within* the target metal. The momentum of the impact of an ion is directed to the interior of the target metal. This momentum is then *reversed* in a certain way by the bulk of the target metal, and travels most efficiently along a row of closely packed atoms to the surface where it ejects the surface atom at the end of the row.

Other interesting, applicable results of sputtering are the etch effects observed on target metals after ion bombardment.

As a tool in studying structures of metals, controlled sputtering has the advantage over chemical etching of being equally applicable to almost all metals. Also, it involves only two parameters—kinetic energy of the bombarding ions and target temperature.

The naturally occurring arrangement of the metal atoms into a perfect lattice becomes deranged because of slight impurities, and heating, molding and machining of metal processing. When these out-of-place atoms are jarred free by sputtering, some of them, along with other loosened atoms, find their way back into the natural lattice, or pattern, of the metal.

When the ion velocities used in

the present work are converted from electron volts to miles per hour, it may be seen that the region of the lowest velocities studied here is of the order of the velocity necessary to hold an earth satellite in its orbit. Also, the density of the gas at altitudes above 100 miles is so low that the mean free path of the gas atoms is very large. These atoms and molecules actually bombard the satellite surface with the flight velocity of the satellite. For many metal and gas combinations this velocity is above threshold, especially at the sides of the satellite "target" where the incidence is oblique and the thresholds are low. Under such conditions the sputtering rate should increase with the fifth power of the velocity.

Hence, such sputtering effects should be much more pronounced and even detrimental at those velocities suggested for interplanetary "spaceships" of the future.

Although many details of the sputtering process need further clarification, it can be assumed that the basic picture is about as follows: The atomic weight, kinetic energy and angle of incidence of the target atoms determine the amount of momentum and energy that is transferred to the surface atoms of the target. The momentum pointing to the inside of the target must be reversed in direction in order to account for sputtering. This reversal takes place inside the target and a sound pulse travels from the place of impact most efficiently along closely packed atom rows. In this part of the process the sound velocities come into play.

Finally, a surface atom receives an impact from one of its close neighbors underneath, with the momentum directed to the outside. If the energy of this impact is sufficient to overcome the binding energy of this atom, and if neighboring atoms do not interfere with the direction of ejection, the target atoms clear the surface and are sputtered. The process is markedly different from evaporation and the influence of the target temperature is of only a secondary nature.

Efforts in General Mills' present sputtering work are now concentrated on:

1. Collection of more yield and threshold data, especially for gases other than mercury.

2. Continuation of ejection studies from metal single crystals.

3. Simulation of erosion conditions arising in high-velocity flight in the ionosphere and in outer space.

The final goal is to arrive at a thorough understanding of the basic phenomenon of sputtering.★

Gene Schott, Flight Controls Department Manager, right, talks over results of a recent test with design engineer Carlos Avila.

the new look in gimbal systems

internal gimbaling tailormade for ballistic missiles

by F. K. Mueller

Ed. Note—*Recently published pictures of* Thor *and* Jupiter *stabilized platforms (m/r, February) point to a basic difference in concept. The* Thor *platform, like most units with unlimited travel in all three degrees of freedom (as in aircraft, land and sea applications), is gimbaled from the outside in, while the* Jupiter *platform departs from convention by gimbaling on a central core (from the inside out). Here, the Deputy Director for Guidance and Control, ABMA, gives some of the reasons why ABMA chose to develop this type unit. The May issue of m/r will carry an article written by AC Spark Plug engineers detailing their reasons for using the externally gimbaled platform.*

WHEN GYROS were first employed for attitude reference in navigational systems, gimbal suspensions were built to satisfy the requirements of the airplane, ship or land vehicle on which the reference was to be used. None of these vehicles presented operational stresses to the gyro support systems much more stringent than the stationary condition. However, as a disadvantage, they had the requirement of unlimited maneuverability in one or more of the three coordinates. The designers' answer was to arrange two or three gimbal rings around the gyros, and thus the classic external gimbal illustrated in Fig. 1 came into being.

Ballistic missiles upset this neat arrangement by posing a whole new set of problems—weight, high linear acceleration with its vector changing direction and magnitude (presenting in turn the problem of isoelasticity), and vibrations of undetermined frequencies and magnitudes.

During World War II, the inertial guidance system, development of which began with the A-5 missile in 1937 in Peenemunde, was improved for use on the V-2 missile in order to replace the V-2's original autopilot and missile-fixed integrating accelerometers.

The stabilized platform for this guidance system consisted of three gyroscopes, two integrating accelerometers and two plumbline detectors, supported by a conventional external gimbal system. Although the platform had to operate only during the propulsion period—slightly longer than one minute—all the other typical ballistic missile criteria had to be met.

Early in the development stage it became apparent that a high percentage of overall platform weight would have to be allotted to the gimbal structure to cope with stresses due to vibration and linear accelerations in the order of 6g. So, an important problem was to find the most favorable gimbal ring structure. Investigations resulted in the decision to build hollow steel gimbal rings formed from sheet metal and welded together as shown in Fig. 2.

The hollow box frame gimbal was found to be superior to solid aluminum-alloy rings not only in the matter of weight, but also in respect to yield under stress.

This design, after completion and successful flight-testing, was the first stabilized platform specially designed and built in large quantities for a ballistic missile. The completed unit still featured the traditional external gimbal system. This was a workable, reliable system but studies throughout the

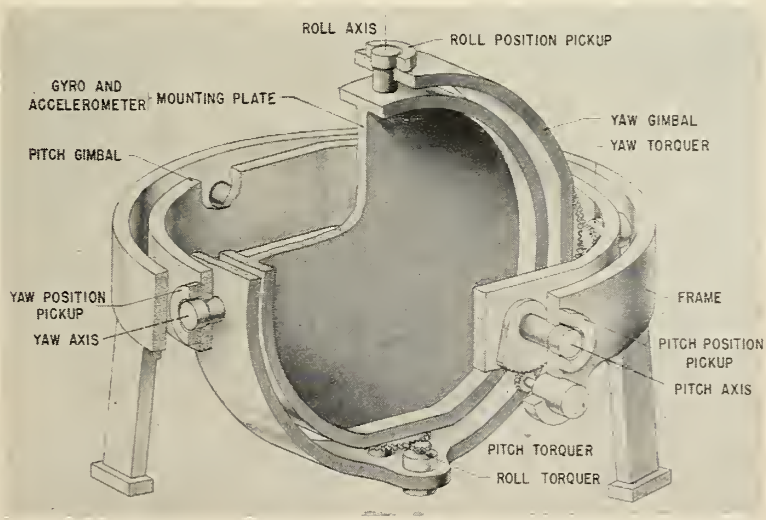

Fig. 1—External Gimbal System. Outer gimbals enclose gyros, accelerometers and other sensing elements.

Mr. Mueller is the deputy director of the Guidance and Control Laboratory, Army Ballistic Missile Agency.

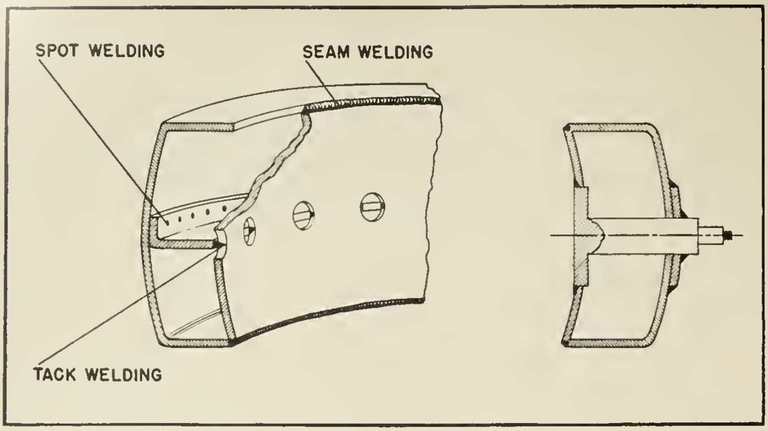

Fig. 2—Gimbal Ring Section. V-2 missile used stabilized platform fabricated in this manner.

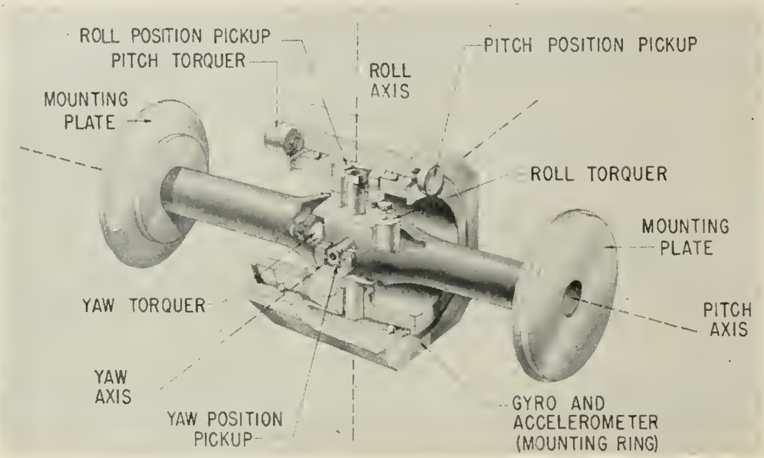

Fig. 3—Internal Gimbal System. All sensing elements are mounted on the outer gimbal ring.

years showed that, while the weight-efficiency ratio was acceptable, it would have to be improved for faster and higher-flying missiles.

A stabilized platform normally carries three types of sensors—gyros for stabilization, accelerometers (or integrating accelerometers) for guidance information and plumbline detectors for prelaunch alignment. Considering the gyros, accelerometers and plumbline detectors as the sensing components and all the other remaining elements such as gimbal rings, torquers, housing, etc., as structural components, a weight-efficiency ratio can be established:

$$\frac{\text{weight of sensing components}}{\text{weight of structural components}}$$

This ratio provides a convenient basic criterion to judge the suitability of a stabilized platform for a ballistic missile. In the case of the V-2 stabilized platform, a weight-efficiency ratio of 1:4.2 was achieved. Modern missiles with higher linear accelerations and more severe vibration can be expected to decrease this ratio even further. The size and the weight of the sensing components are mainly determined by accuracy requirements: the logical way to improve the ratio is to reduce the size and weight of the structural components.

The realization that a more favorable suspension mode was necessary provoked a long series of design and development studies by Army Ordnance and the Army Ballistic Missile Agency. These studies resulted in the internal gimbal system, tailormade for ballistic missiles. The internal gimbal system breaks with the tradition of building the gimbal around the gyroscopes and instead concentrates the kinematic features of the three-axis gimbal system into the smallest volume possible and places the sensing components on the outermost gimbal itself as illustrated in Fig. 3.

By this method stabilized platforms were produced for conditions more severe than those of the V-2, but actually attained weight-efficiency ratios of 1:1.4. After the first system of this type was built, further studies and tests, including flight tests, confirmed most of the anticipated advantages.

The overall weight and space requirements of a stabilized platform with an internal gimbal system can be kept smaller than one with external gimbals using sensing components of comparable size and weight.

The arrangement of the sensing components on the outermost gimbal makes them very accessible for calibration and maintenance and permits easy exchange of components.

The internal gimbal system features relatively rugged parts with small lever arms which results in relatively small elastic deformation under stress. This results directly in higher natural frequencies.

The simplicity of the gimbal parts permits a design of utmost isoelasticity. The importance of isoelastic features is clearly indicated by the relation for a disturbance torque, T, created by nonisoelasticity:

$$T = m^2 g^2 y \left(\frac{X-1}{Y}\right) \sin 2\alpha$$

where the mass m of the sensing components and the acceleration g appear in the second power. X and Y represent the yields in the direction of the axes of the gimbal system and α the angle between the direction of acceleration and direction of the gimbal axes. The rectifying effect of the g^2 term makes the vibration forces especially difficult to cope with. Such torques caused by linear acceleration and vibration have to be compensated.

The inner gimbal configuration results in a relatively small inertia around the stabilized axes. The ratio between this moment of inertia and the angular momemtum of the gyro influence the configuration of the servo loops. (See "How Industry Solved the Air-bearing Gyro Stabilization Problem," m/r, February.) The smaller moment of inertia permits simpler servo loops and smaller torquers.

The internal gimbal system has limited freedom in two of its axes and permits 360° freedom in one axis only. However, limited freedom in two axes is not a limitation in common ballistic missiles which require 360° freedom in one axis only.

The system is not suited to accommodate direct or ungeared torquers but again, this is not a disadvantage. On the contrary, an optimized gear ratio with its associated small torquer, amplifier and power supply can be built with only a fraction of the weight of its counterpart, the ungeared with its amplifier and power supply.

The internal gimbal system can be applied to save considerable weight and space in any vehicle which tolerates limited gimbal freedom in two axes.★

soldering in the missile age

modern applications cause new look at old techniques

by Alvin B. Kaufman

WITH TODAY'S technology advancing by leaps and bounds, the subject of solder connections is largely taken for granted and rarely accorded the importance that it deserves. The engineer is thus overlooking an important reliability parameter.

It is conventional practice among engineering writers to review the "literature" when compiling and writing a text or article to clarify or advance the "state of the art." Careful perusal of all available MIL specifications, handbooks and trade journal literature has revealed an abundance of material on soft (tin-lead) solders.

Unfortunately, review of this multitude of material has indicated redundant data which is incomplete insofar as supplying the engineer with environmental limits of the solder materials and terminal connections with which he must work.

The literature is also meager on the subject of soldering fluxes and soldering techniques. In general, however, certain publications appear to outline accurately the uses of various solders and fluxes in the electronic field. For this reason, very little mention will be made here of basic solder-flux data and soldering techniques.

Rather, this article provides for the solder user a sound and factual background underlying the fundamentals of "environmental limits" as applied to the realities of solder usage.

The environmental parameters with which the engineer must be concerned, surprisingly enough, are much broader than mere temperature or tensile strength limits. Additional parameters are methods of wire or component-solder termination or configuration, vibration, shock and effects or combinations of these conditions.

Solder fluxes are tested for cor-

The author is Chief, Development Engineering at Arnoux Corp., Los Angeles, Calif.

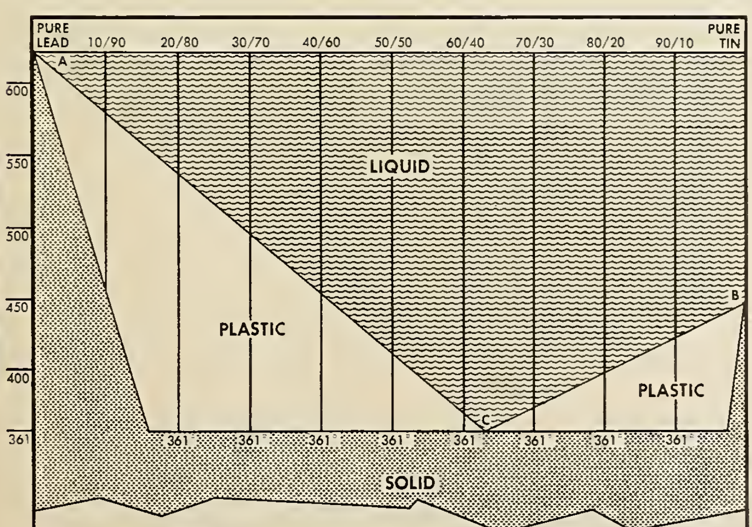

Fig. 1—Tin-lead fusion diagram.

rosion and fungus resistance per MIL-S-6872 and MIL-E-5272 respectively. The solder or its connection receives "environmental test" only incidentally during the test of equipment, as solder procurement specifications require composition and plastic or melt point certification only. Climatic environmental conditions are normally evaluated by test per MIL-E-5272A.

This specification includes testing for items such as sand and dust which are not applicable for solder reliability tests. Other parameters such as humidity, temperature, and salt spray are dubious in value. Temperature in particular is a factor in which adequate control has not been made.

Components are rated per MIL specification for environmental temperatures of 85°C with little attention paid to the associated solder connection with which the component is held in place. Additionally, I^2R heat generated in, or radiated by components may well bring solder connections close to the solder "plastic" range. Military specification MIL-R-26B indicates that power resistors at full ratings may have surface temperatures of 200-350°C (392-662°F) in free space and still air. Coupled with this is the possibility of higher than ambient internal air temperatures due to enclosure of an assembly in a rack panel or in its placement in a marine or airborne vehicle.

For the reasons indicated above, careful empirical tests to evaluate the "connection" or the use of higher temperature soft solders is advisable. It can thus be seen that cooling of equipment or solder connection parameters must now be considered as a prime design requirement, and electronic equipment must be thermally designed as well as electronically designed.

In either case, the use of an eutectic alloy solder where practical is desirable. An eutectic alloy solder is one in which there is no appreciable "plastic" or semimolten state; *i.e.*, a few degrees of temperature separates its solid and molten state.

This solder has an advantage in preventing a "cold" solder joint such as will occur by accidental mechanical movement of a lead wire while the solder is cooling down through its "plastic" range. The non-eutectic solder may have a plastic range of 50 to several hundred degrees (Fig. 1). This type of solder is commonly known as a "wiping or body" solder. As such it has many uses not connected generally with electronic soldering.

Fig. 2 indicates the comparative strength of tin-lead solder vs. alloy ratio. Note that at the 50 to 60 per cent tin ratio to lead, the highest strength alloy occurs.

These solders, however, are not

necessarily as strong as other solders at elevated temperatures, as shown in Fig. 3.

Although certain material and word of mouth indicate that 230°F is the limit of a soft (tin-lead) solder connection, no published data has been found to substantiate this claim. Fig. 3 clearly indicates the tensile strength of soft and low-temperature silver solders at various temperatures.

This data in itself is not enough to indicate a "safe" solder-termination temperature. According to one reference, "the alloy attachment lies in the this film of solder between the two metals joined together." In addition, the reference indicates that it is advisable to make a mechanical joint for strength, using the solder mainly for electrical conductivity.

At one time the author would have agreed with this statement without exception and under certain high temperature conditions this statement may still be correct. However, with the introduction of shock and vibration parameters, the picture is radically changed.

A termination, in which the component lead is held to its associated binding post by solder alone, has proven superior in resisting vibration and shock and in ease of component replacement. The test parameters included the use of tin-lead solders of various ratios, but unfortunately did not include tests of the solder joint above 200°F. This is approximately 161°F below the plastic point of tin-lead solders.

The plastic point is considered by the author to approximate zero tensile strength. With a solder joint at 200°F, considerably lower environmental temperature would have to be assumed for anything but a passive or low level power device. The solder in such a termination, at this moderate temperature, would still have approximately a 3000 psi tensile strength. For commonly used 50-50 solder, this corresponds to a 50 per cent decrease of tensile strength.

At a 300°F joint temperature (combination of 85°C (185°F) environment temperature and I^2R from a power resistor) such solder has decreased in tensile strength to about 1100 psi.

It is obvious then that, depending on component-terminal geometry, a mechanical connection or a higher temperature soft solder becomes essential at this time. The mechanical connection however does not allow the solder joint to be taken to the "plastic" solder temperature. Under vibration, at some point, solder integrity would fail due to stress transfer or outright "throwing" of solder. In addition, more rapid failure under vibration stress would occur. It appears that the solder-held termination is still superior, although it introduces a requirement in some cases for the higher temperature soft solders.

The tensile strength data shown in the graphs is not assumed to be highly accurate. Solder-alloy tensile-strength data available to the author shows a correlation of approximately 20 per cent.

Variation in this data will be found from source to source due to measurement technique variation and impurity variation between test samples. Also, tensile strength may be based on strength of the solder alone or its holding strength in relation to copper, tin or various solderable elements.

The high-temperature limitations presented above may also be altered by another effect. Certain material indicates that alloy composition changes with a temperature gradient. Correlation of this effect with tensile, bending or torsional stress is not known.

As of this time its significance to the soldered joint has not been de-

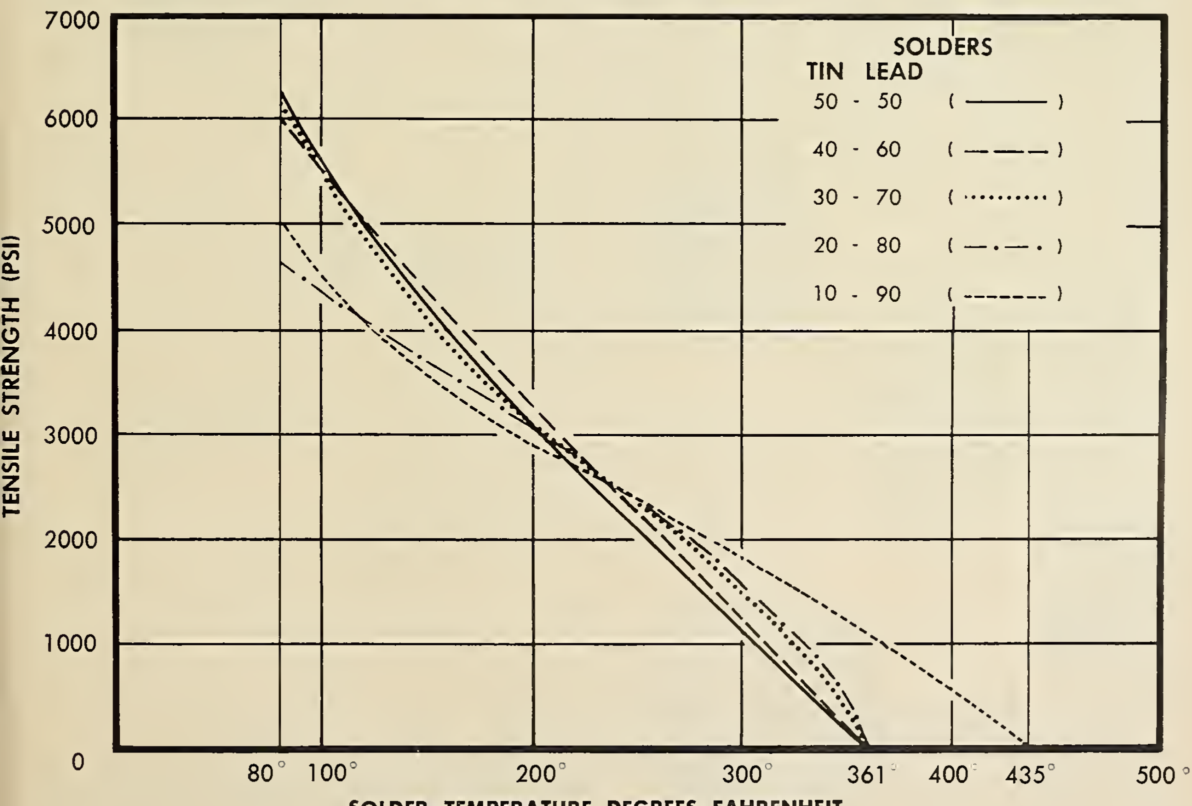

Fig. 2—Comparative strength of tin-lead solder vs. alloy ratio.

Tin-lead Solders—Tensile Strength (psi) vs Temp.

Solder*	80°F	200°F	300°F	°F psi Plastic	°F Liquid
95-5	——	——	——	361	432
90-10	——	——	——	361	415
80-20	=5900	——	——	361	390
70-30	=6150	——	——	361	367
63-37§	=6273	——	——	361	361
60-40	=6300	——	——	361	370
50-50	6273	3090	1150	361	414
40-60	6030	3320	1275	361	460
30-70	6176	3120	1495	361	496
20-80	4640	3043	1518	361	536
10-90	5017	2917	1863	435	576
5-95	4190	2965	1782	522	597

* Tin (Sn) first figure; lead (Pb) second figure.

§ Eutectic alloys do not have a plastic range, but have a sharp and distinct melting point; *i.e.*, there is little or no distinguishable difference in temperature between the solid and liquid point.

veloped. It is well, however, to keep this parameter in view in regard to its possible ultimate effect in changing solder environmental limits.

Much attention has been paid to the upper environmental temperature limits. The lower or colder environmental limits also deserve their share of attention. Experience with solder in arctic areas has indicated that solder connections maintained for long periods at cold temperatures are subject to failure. This is due to the tin content in the solder.

Push temperature down and lead's strength goes up, with little loss in its ductility. Not so with tin. Below −18°F tin may suffer its allotropic transformation, to a brittle element. The lead-tin soft solder alloy becomes gray and crystalline in form with resultant open or erratic conductivity. Recent research shows that lead-tin solders tend to split the differences noted above in rough proportion.

A 50-50 solder, for example, produces joints with higher tensile strength at −75°F than at room temperature. But it is more brittle. At −75°F the solder is still stronger than the joined metals. At colder temperatures the solder is weaker.

Increasing the lead content of a solder lowers the temperature at which joints retain good ductility. Ease of soldering decreases, however, and the strength does not increase as rapidly as temperatures go down. Up to 15 per cent tin content has little effect on ductility. Beyond 15 per cent the loss in ductility and the lowering of impact and fatigue resistance should be considered when specifying a solder for "cold" environmental applications.

Although antimony and other elements are generally considered worthless or accidental impurities of virgin metal solders, 0.2 to 0.5 per cent antimony in 40 to 70 per cent tin vs. lead solders inhibits the allotropic change. Higher values of antimony create a hard and brittle solder.

Of course one easy way to forestall this problem is a change to a lead-silver or other higher temperature soft solder alloy; providing its higher melting point and greater difficulty of application (with non-corrosive rosin flux) is acceptable.

The use of soldered connections close to liquid oxygen or helium tanks (such as in missiles) poses a severe problem as indicated above, if long-term connection stability is required. Environmental temperatures of −297 to −453°F respectively, may be encountered on the surface of such tanks. Air environmental temperatures close to such tanks may reach −100°F or colder.

In a recent typical missile system, with which the author was concerned, components were required to operate in a −200°F air environmental temperature. The use of high-temperature soft solders was indicated in the preceding paragraph but is not the only alternate possible.

Crimped, silver solder or welded connections are also feasible for some connections. Potting of components and terminal connections, especially where internal assembly heat is developed, may negate the requirements of special solders or techniques.

The use of tin-lead soft solders internal to liquid or gaseous oxygen tanks is not suggested. A number of tin-lead alloy solders have been tested and found sensitive to impact when in contact with liquid oxygen.

At present, if a tin-lead solder connection must be made in the vicinity of liquid oxygen, it is recommended that it be sheathed in teflon tubing to prevent direct contact with the liquid or that other alloy solders be used. Note that an impact is required as the "ignitor" to cause an explosion, and that this is not too probable in most installations. In addition, some teflons

have been found sensitive to impact under the same conditions. More specific data is not available to the writer at this time.

Although temperature vs. tensile strength of solders has been thoroughly

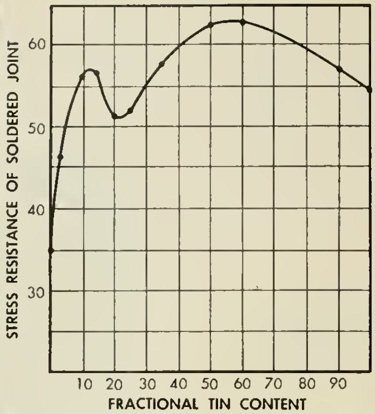

Fig. 3—Stress resistance of soldered joints vs. fractional tin content.

covered, it is not intended to infer that these are the only parameters involved in selecting a solder. The overall quality of a solder is governed by numerous factors. These are speed of alloy formation, flow (or wetting) of solder, chemical stability of the soldered connection, soundness and porosity of the joint, and physical resistance to shock, strain and stress. In addition, the requirement that corrosive-type fluxes be used with some solders may rule out their use, even though excellent in all other respects.

The primary purpose of the solder is to unite two or more metals in continuous metallic contact under environmental conditions as previously noted. Tensile strength in itself is not necessarily a complete index of quality, although Fig. 2 indicates a close corollary.

Other parameters of possible value are: Brinell hardness, elongation; torsion, bending, and compressive strength. Simulated bending-torsional stress or vibration-shock life tests will certainly have to be correlated under various environmental conditions to secure comprehensive design data for possible use in the future.★

The data in this article is not as comprehensive as could be presented, but it is hoped that it will contribute something of importance to the design engineer and additionally be a spur to greater investigation by other research agencies.

people

Rear Adm. Jackson S. Champlin, USN (Ret.) has been appointed assistant to the director of DataTape Division of Consolidated Electrodynamics Corp.

A. C. Labrie has joined the consulting firm of Thomas Wilcox & Associates in Washington.

Myron G. DeFries has been named head of the chemistry group of Atlantic Research Corp., Alexandria, Va., and **Kenneth D. Johnson** has joined the firm as staff assistant to Vice President **Keith E. Rumbel.**

Richard N. Goldbach has been appointed to the newly created position of vice-president in charge of marketing for the semiconductor division of Hoffman Electronics Corp.

Dr. Theodore K. Steele has been named vice president of research and engineering and **Oscar Brockmeyer** has been named vice president of engineering sales for Bulova Research & Development Laboratories.

E. U. Da Parma has been appointed executive vice president of Sperry Gyroscope Co. He formerly was vice president for operations.

D. M. Heller and **R. E. Whiffen** have been appointed assistant general managers and **W. P. Bollinger** has been named director of engineering of the products division of Bendix Aviation Corp.

A. R. Teasdale has been named to the newly created post of director of advanced technology at Temco Aircraft Corp. He formerly was chief of avionics.

James S. Arnold, a physicist at Stanford Research Institute, has been elected vice president of the Northern California section of the American Rocket Society.

Five persons have joined the staff of recently formed Data-Control Systems Inc. in Danbury, Conn. **F. E. Farris,** now assistant to the president of the firm, was formerly with Philips Electronics Inc. as assistant sales manager. Others are **David Zeller** and **Joseph H. Marchese,** research engineers; **Owen J. Ott,** senior research engineer; and **Clark A. Denslow,** industrial engineer.

Charles H. Kenerson has been appointed eastern district customer relations manager in charge of Marquardt Aircraft Co.'s Dayton office. He succeeds **Paul J. Papanek,** who becomes assistant director of customer relations at the firm's main office.

Col. Frank M. Fazio has assumed command of the Air Research and Development Command's liaison organization.

Herbert C. Langmore has been named manager of special products for North American Aviation's missile development division. He has been project engineer for the X-10.

E. A. Bellande has been placed in charge of foreign operations and support services for the Garrett Corp.

Dr. Louis N. Ridenour, head of research for Lockheed missile systems division, has been appointed to the Air Force's Scientific Advisory Board.

Sud-Aviation Corp., a U.S. firm representing the French aircraft/missile manufacturer, has the following officers who are also directors: **Claude J. Teyssier,** president and treasurer; **Alexis C. Coudert,** vice president; and **George F. Mason, Jr.,** secretary.

George M. Ballee has been appointed vice president and director of sales for the Electro-Snap Switch & Mfg. Co.

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missile miscellany

Washington's beginning to come to life again: Army's General Daley recently quipped that "Now we've got a missile with a range of 400,000 miles a day." Jupiter-C, of course, and its Explorer payload. And Defense Secretary McElroy, in appointing GE's Roy Johnson to head up the new Advanced Research Projects Agency, said that he saw no reason for Johnson to sell his GE stock; that he couldn't see any conflict of interest. With hundreds of millions of dollars in defense contracts, of which a healthy hunk is missile and space-flight related, this page wonders just how Mr. McElroy would define "conflict of interest."

Then, there's usually cogent Assistant Navy Secretary for Air Garrison Norton, who recently told Congress that Jupiter-C was "very, very expensive and rather inefficient." If Vanguard manages to get its scheduled six 20-inch spheres into an orbit—which isn't at all certain yet—each will have cost the American taxpayer an absolute minimum of $18.3 million each. And, when we're all through, there isn't any other practical use for Vanguard. Any thought of using the complex beast as an IRBM is preposterous to contemplate.

In contrast, Jupiter-C was developed and paid for as an essential tool in the development of the intermediate-range ballistic missile, Jupiter. Similarly, AF had the X-17 for its Thor and Atlas development work. Jupiter-C as a satellite launching vehicle was a pure bonus to the taxpayer—its research and development cost having all been written off previously for military work. The bare bird itself—one Redstone plus 15 Scale Sergeants plus special engineering on the fourth stage—could not have cost more than $1 million, which seems to dump Norton's cost claims.

As for efficiency, the record speaks for itself. Vanguard is a two-and-a-half-year-old project. When Explorer went into orbit it was, as a satellite project, less than three months old. How do you define efficiency, Mr. Secretary?

If you've ever wondered really whether the missile business was big business or not, perhaps this little statistic will be a helpful indicator: Redstone Arsenal, Huntsville, Ala., used 7,531,258 kilowatts of electric power during December 1957.

Then, there was the case of Senator Irvin listening to General Schriever who finally stopped the ballistic missile general with: "Pardon me, General, but this sounds like unscrewing the inscrutable."

One authoritative estimate concludes that within 10 years Russia will have to launch 50,000 nuclear warheaded missiles at varying ranges in order to knock out all the West's retaliatory bases, assuming a 10-megaton H-bomb in each missile. Only a fraction of these would so poison the air with radioactivity as to destroy the population of the Soviet Union—and everybody else in the world as well.

And now quick and fast—Wandering about with Lockheed Missile Division engineers, this page learns that Thiokol, as well as Aerojet-General, will share in production of solid-propellant motors for Navy's Polaris fleet ballistic missile; that 16 will be carried in each submarine . . . Army's angling to build an ICBM based on an improved Jupiter . . . AF's in the mood to build a solid-propellant ICBM, perhaps using Thiokol Big-B technique to make a single-motor first stage . . . Astrodyne (Phillips-Rocketdyne) has sent a proposal to the AF to build up production of an improved MB-1 rocket to hundreds of units a month . . . The weight of destruction from missile nuclear warheads is now down to a point where it's less than half a ton per megaton.

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PNEUMATIC VALVE. Dual-lever emergency pneumatic valve operates on an inlet pressure of 3300 psi and applies differential pressures from 0 to 1000 psi, depending on the force exerted through each of two operating handles. Weight is 2.4 lbs. Walter Kidde & Co., Inc.
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FLEXIBLE COUPLINGS. Connection provides flexible coupling for miniature electromagnetic clutches and brakes. Made in 2 stock models and in 2 sizes for each model ranging from 15/16" o.d. to 1 5/16" o.d. for shaft diameter from 1/8" to 1/2". Dial Products Co.
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HYDRAULIC TEST STANDS. Series KC-300 universal hydraulic test stands, providing performance data for all types of hydraulic system components and accessories, has been developed and is being produced by Kahn & Co., Inc.
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AUTOMATIC COATING. Maximum control of heater wire coating used in the manufacture of electronic tubes is afforded by an automatic machine which controls the thickness of insulated coating applied to heater wire. The developer of the machine, Sylvania Electric Products Inc., is using it in production.
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TRANSISTOR SOCKET. A new Teflon-insulated transistor socket for missile guidance and electronics applications is now available. The sockets, of compression-mounted design for assembly time and cost saving, are also suitable for subminiature tubes with in-line leads and are applicable to printed circuits. Fluorocarbon Products, Inc.
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DIGITAL RECORDER. A digital recorder printing 11-column digital information at rates to 5 prints per second has been introduced. Primarily designed to make permanent record of electronic counter readouts, the device is also usable with two or more counters simultaneously, digital voltmeters, time recorders and flowmetering equipment and systems such as telemetering installations and engine test stands. In addition to the printed tape record, the instrument, model 560A, provides an analog current or voltage output to drive a galvanometer or potentiometer strip chart recorder or to provide a servo control. Hewlett-Packard Co.
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PRINTED CIRCUIT CONNECTORS. PC board receptacles of one-piece body construction available in either type GR and MFE mineral filled phenolic, MDG diallyl phthalate or CFG general-purpose phenolic. Receptacles have new contact design to prevent board-to-contact damage. H. H. Buggie, Inc.
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BALANCING MACHINES. A new line of Rava electrodynamic balancing machines has been introduced for production and short-run balancing. The machine employs en electrical measuring system end both the angle and amount of imbalance are determined by adjustment of electrical controls. Tinius Olsen Testing Machine Co.
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MONITORING SYSTEMS. Remote-area monitoring systems are described in a 4-page bulletin covering basic units in the systems and giving specification data on ranges, response, accuracy, stability, dimensions, weights and suggested uses. Victoreen Instrument Co.

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LITHIUM. Facts and figures on lithium and other alkali metals are available in a 24-page brochure featuring charts and other illustrations. Covers principal sources, developed and undeveloped, in the world. Current prices, principal uses and producers are also covered. Montgary Explorations Ltd.

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FOAM METAL. Development of techniques and equipment which produced a satisfactory metal foam for sandwich construction is described in this three-part report for the Air Force, just released for industry. Entitled "Foamed Metal Low Density Core Material For Sandwich Construction," the publication is available through the Department of Commerce's Office of Technical Services.

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HIGH-TORQUE MOTOR. Design features, specifications, dimensional drawings, photos and exploded views of a new high-torque motor, described in a data sheet, are now available. Motor operates over a temperature range of −100° to 500°F at 60 or 400 cycles ac or pulsating dc. Starting and stopping time is a microsecond and starting torque is equal to running torque. Viking Tool & Machine Corp.

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DIAL SCALE CATALOG. An illustrated catalog showing different types of dial scales and related accessories and specifications covering dial graduations, capacity, platform dimensions, and other data has been published by the Howe Scale Co.

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INSTRUMENTS. Phase meters, impedance, vacuum tube voltmeters, amplifiers and numerous other instruments are described in a brochure covering the complete line of instruments produced by Acton Laboratories, Inc.

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POWER TRANSMISSION. New concept in power transmission is detailed in a brochure citing it as being particularly suited to design requirements of linear actuators, hermetically sealed pumps and valves and large-ratio speed-reduction devices. Technique is believed to be the first to utilize a controlled deflection wave for positive transmission of power and information. Numerous applications described. Research Division, United Shoe Machinery Corp.

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TAPES AND RESINS. Application information and specifications for pressure-sensitive electrical tapes and epoxy resins for electrical insulations are listed in a 32-page guide book and catalog. Contains physical and electrical properties, suggested applications and application procedures, data for choosing correct product, recommended tests for corrosion, guides for choosing electrical tapes, temperature limitation charts, and other data. Minnesota Mining and Manufacturing Company.

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PNEUMATIC TRANSDUCER. Operation of the pneumatic transducer, an electromechanical device for instantaneously converting 3-15 psi input pressures into ac signals, is explained in a catalog sheet published by Fischer & Porter Co.

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PRINTED CIRCUITRY. Brochure on printed circuits containing full descriptive data on materials, specifications, design tolerances and application information. Printed Electronics Corp.

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HIGH-PURITY METALS. Information on ordering and purchasing ultrahigh-purity materials for semiconductors and soft-solder preforms for automatic soldering is contained in a booklet published by Alpha Metals, Inc.

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FLUID POWER DIRECTORY. The 1958/59 edition of this directory is available at $6.50 in five sections covering fluid power components, trade names, manufacturers' catalogs and sales outlets, fluid power design and local fluid component suppliers. Industrial Publishing Corp.

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BLIND RIVETS. A 16-page catalog and three bulletins describing applications for a new line of drive-pin blind rivets are now available. The low-weight, high-strength rivets are used to solve blind-side clearance problems in fabrication. The illustrated 2-color catalog presents technical data, typical design applications, dimensions and weights for the full line of stainless-steel rivets produced by the Deutsch Fastener Corp.

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METALLIC POWER RECTIFIERS. An illustrated 32-page guide to metallic power rectifiers, utilizing germanium, silicon and selenium semiconductors, has been published. The guidebook covers applications for rectifier equipment such as anodizing, battery chargers, electrocleaning, electroplating, ground power supplies and complete semiconductor power conversion systems for the operation of electrolytic cells. Sel-Rex Corporation.

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