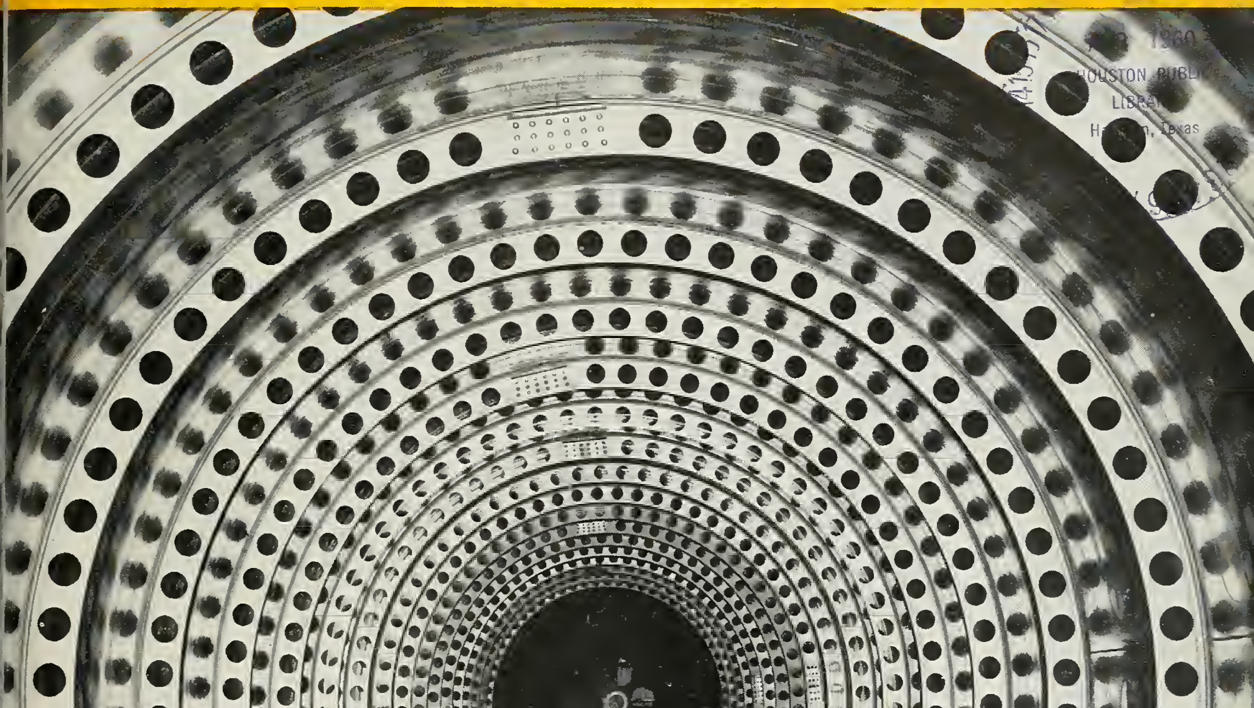
April 18, 1960

missiles and rockets

THE MISSILE/SPACE WEEKLY



Inside a *Saturn* Outer Lox Tank

Another M/R Exclusive:

Saturn Fabrication . . . 16

AN AMERICAN AVIATION PUBLICATION

THE MISSILE/SPACE WEEKLY

missiles and rockets

April 18, 1960 Volume 6 No. 16

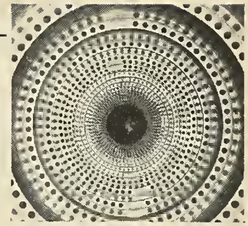
Published each Monday with the exception of the last Monday in December by American Aviation Publications, Inc., 1001 Vermont Ave., N.W., Washington 5, D.C.

Wayne W. Parrish, President
Leonard A. Eiserer, Exec. Vice President
Fred S. Hunter
Vice Pres. and Editorial Director

Printed at the Telegraph Press, Harrisburg, Pa. Second Class postage paid at Washington, D.C., and at additional mailing offices.

Subscription rates: U.S., Canada and Postal Union Nations—1 year, $5.00; 2 years, $8.00; 3 years, $10.00. Foreign—1 year, $10.00; 2 years, $18.00; 3 years, $26.00. Single copy rate—$.50. Subscriptions are solicited only from persons with identifiable commercial or professional interests in the missile/space industry. Subscription orders and changes of address should be referred to Circulation Fulfillment Mgr., M/R, 1001 Vermont Ave., N.W., Washington 5, D.C. Please allow 4 weeks for change to become effective and enclose recent address label if possible.

THE COVER



A partly assembled Saturn *outer LOX tank viewed from inside. Stiffening ringframes are spot welded into cylindrical sections before tank is welded. See exclusive story, p. 16.*

APRIL 18 HEADLINES

ASW ENGINEERING

ELECTRONICS

PROPULSION ENGINEERING

ADVANCED MATERIALS

INTERNATIONAL

PRODUCTS AND PROCESSES

DEPARTMENTS

31,400 copies this issue

letters

Astrolexicon?

To the Editor:

The missile and rocket field—being such a new, complex, and technical field—has spawned many new additions to the language. Exotic terms, highly technical phrases, and more highly abbreviated abbreviations of organizations, committees, etc., meet one's eye from about every other sentence of your fine publication.

Might I suggest as a special section to a forthcoming issue, a glossary of such terms and abbreviations, and that it be kept up to date in much the same manner as the Astrolog. Thank you for your consideration and for an outstanding magazine.

Robert W. Wempe, Ensign, USNR
NAMS
Little Creek, Norfolk, Va.

Real Patriots Lacking

To the Editor:

In your April 11 Letters, Ted Wallace's "The Gap—Another View" is certainly one of the most realistic and intelligent viewpoints on this subject I have heard, and it more and more proves the fact that those who are in a position to really do a job for "their country" and "mine" are still too much concerned with their own selfish personal gain. It's a terrible tragedy that today's generations have placed self far above country . . . Oh, for just a few real patriots in the right places.

M. L. Carlisle
Washington, D.C.

Sanity in Space

To the Editor:

I want to congratulate you on your editorial in the March 7 issue ("Let's Be Daring But Not Ridiculous"). I certainly think it is most appropriate.

I am reproducing the editorial in order to give a copy to each of our project engineers.

George W. Howard
Technical Director
U.S. Army Engineer Research and Development Laboratories
Fort Belvoir, Va.

Fuel Cell Best Seller

To the Editor:

Your cooperation is desired in correcting a situation growing out of information given in Letters section of the April 4 M/R.

It is regretted that the Army Research Office, Office of the Chief of Research and Development, Department of the Army, is unable to provide copies of ARO Scientific Report No. 1, "Status Report on Fuel Cells," as stated in the Editor's reply to an inquiry.

Initial distribution to official agencies concerned was made by the Army Research Office. Since that time, this office has not stocked copies to meet additional requests. The report *is* available to any institution, industrial organization or individual interested, upon written application to the Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C. The price is $1.25 and the order number is PB 151804. The report has enjoyed a record sale and is now in its fourth printing.

Robert W. Struder
Lieutenant Colonel, GS
Chief, Research Support Div.
Army Research Office
Washington, D.C.

Welcome for ASW Section

To the Editor:

I have been receiving your magazine for a month now, but wish it were a year. It is an excellent magazine, and I am looking forward to the AntiSubmarine Warfare Engineering Section.

There has been need for publications covering this field for some time. Congratulations on establishing this section; I am sure it will be representative of your other fine sections already established.

R. B. Wright
Dev. Engineer
Goodyear Aircraft Corp.
Akron, Ohio

To the Editor:

As a regular subscriber to M/R, I have read with great interest the treatment of ASW matters in your April 7 issue.

I consider that your treatment of the subject was outstanding, covering as it did the technical hurdles and the factual budget-submission breakdown which is the real key to the character and scope of the ASW effort.

I will be most interested to follow the output of your new department—and on the basis of the general excellence of your other reporting and analysis, I would expect it to be a very sound and helpful output.

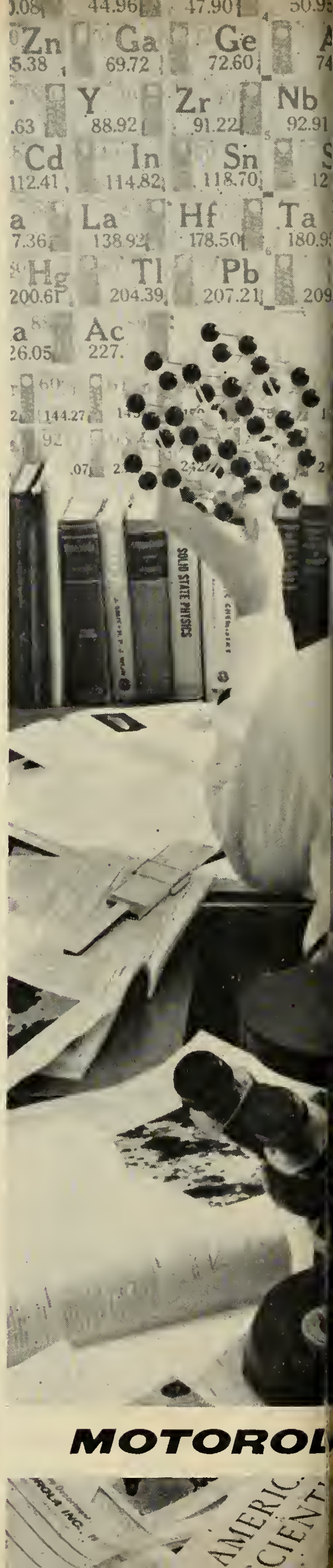
Robert B. Carney
Admiral, USN (Ret.)
Washington, D.C.

New Cover Pleases

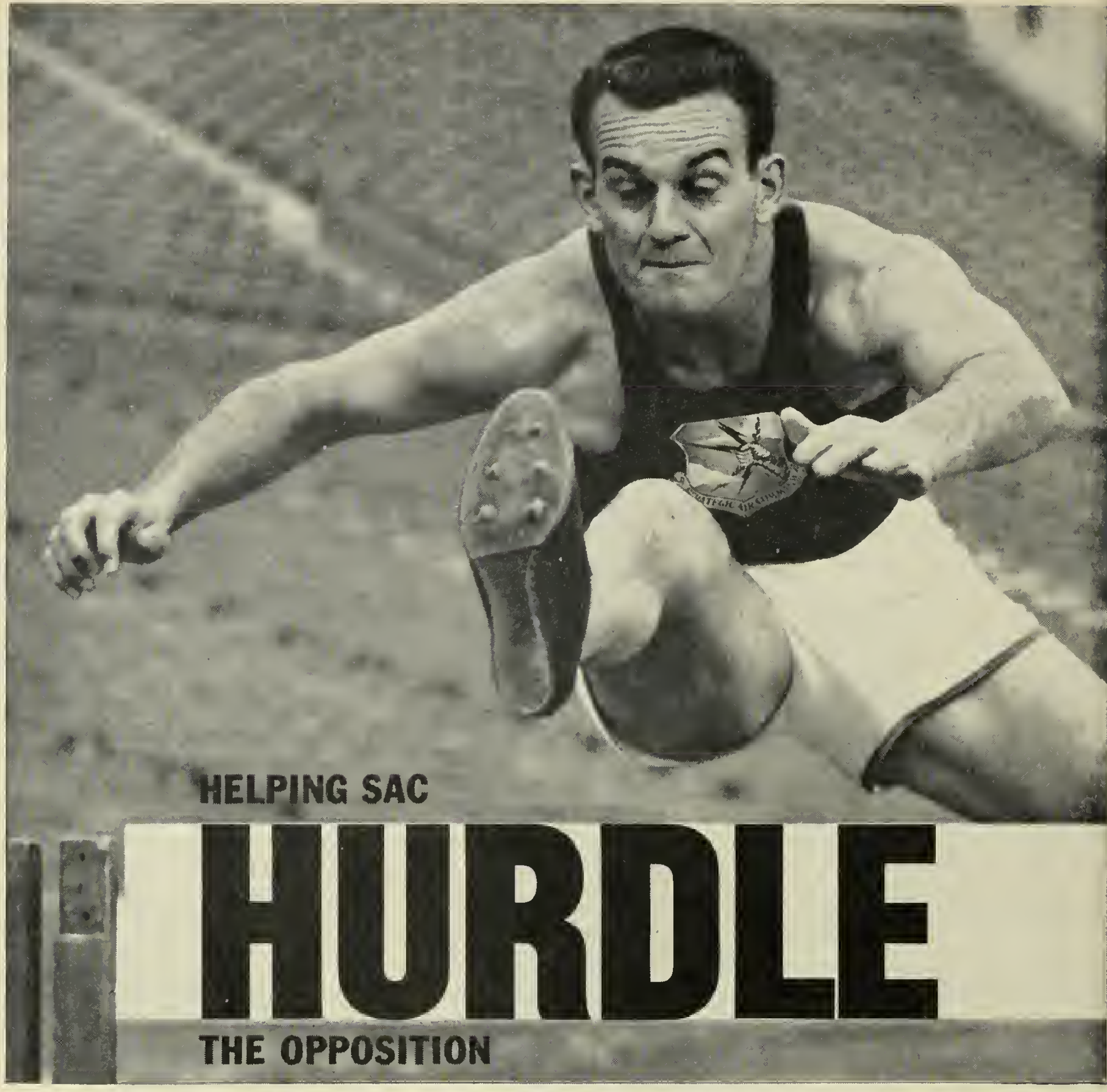
To the Editor:

The new M/R cover is quite impressive. It is causing quite a lot of favorable comment.

David B. Juenke
Assistant to the President
Rocketdyne Division
North American Aviation, Inc.




ilitary Electronics Division



SAC is now off and running with its new Hound Dog missile. With the supersonic GAM-77 missile, the B-52 bomber can more easily hurdle ground defenses on the way to a target. In the short span of just 30 months, the Hound Dog air-to-surface missile grew from the drawing board to a powerful member of SAC's deterrent team.

Silencing enemy ground defense centers while the mother ship speeds on toward the main target is just one of the jobs of the versatile GAM-77 missile. Slung beneath the swept-back wings of a B-52, a pair of GAM-77's can either clear a path for the bomber, or be sent right in on the main target itself. This triple-threat capability lets a single B-52 command a target approach corridor over a thousand miles wide.

To further confuse the enemy, these inertially-guided missiles can feint at pseudo-targets before turning toward their real objectives. Speed and altitude variations can also be programmed into the GAM-77's target approach.

The Hound Dog missile greatly extends the useful life and striking power of SAC's B-52 bombers—the backbone of America's strategic power. The GAM-77 is being produced by the Missile Division of North American Aviation.

MISSILE DIVISION
NORTH AMERICAN AVIATION, INC.
Downey, California

Washington Countdown

IN THE PENTAGON

Warheads can be switched . . .

on the latest generation of *Sidewinders*. One warhead provides infrared guidance, the other radar. They are called Ira and Sarah.

• • •

Dyna-Soar tests . . .

during the next 13 months will include intensive work on materials and structural shapes. The Air Force is asking for $50 million in the new fiscal year for work on the *Dyna-Soar* glider and faster work on the *Dyna-Soar* booster.

• • •

Pint-size ICBM's . . .

are already considered feasible by top Pentagon officials. The ICBM would weigh between 20,000 and 25,000 pounds.

• • •

Some top ASW code names . . .

and the official programs behind them:

. . . *Atlantis*—A 1959 study aimed at determining the feasibility of developing a large ocean surveillance system.

. . . *Trident*—The Bureau of Ships exploratory R&D program aimed determining by experiment if the conclusions of the Atlantic study are valid.

. . . *Artemis*—R&D work on a deep-water, long-range, fixed antisubmarine detection system.

• • •

Julie and *Jezebel* . . .

are two of the Navy's new sonobuoys. *Julie* uses an explosive sound for echo ranging. *Jezebel* is a passive buoy.

• • •

A double life for BMEWS . . .

is envisaged by the Pentagon. Not only will it provide early warning of an ICBM attack, the big radar network also will be capable of detecting all polar orbiting enemy satellites.

• • •

Shopping suggestion . . .

for the missileman who has everything: A complete *Jupiter* missile is reported to be on a scrap heap at Redstone Arsenal waiting for a buyer. But no warhead.

AT NASA

NASA Chief Glennan may quit . . .

early in order to allow NASA Deputy Administrator Hugh Dryden to hold the top NASA post before the next Administration picks its own man. Dryden, a 40-year veteran of government service, is the former chief of the old NACA out of which NASA was organized.

• • •

More red tape . . .

is the description being pinned by many NASA officials on the new Aerospace Activities Control Board. They see the board as merely a sop to congressmen who opposed the elimination of the ineffectual Civilian-Military Liaison Committee.

• • •

Saturn production . . .

according to insiders, could be increased to 10 to 20 a year within the next four years. At present, NASA plans only to build 30 *Saturns* during the 1960's.

INTERNATIONAL

The French IRBM-ICBM . . .

program is undergoing a big speed-up as a result of the success of French A-bomb tests. The French are calling their ballistic missiles *SSBS's*—for Sol Sol Balistique Strategique.

• • •

Swedish *Falcons* . . .

will soon be pouring off the production line. The Swedish are making a deal with Hughes to produce the air-to-air missiles.

• • •

Security worries . . .

plagued NASA before they released the pictures of earth taken by *Tiros I*. NASA feared their pictures might be too good—thereby giving Russia an opportunity to make "spy in the sky" charges just before the Summit Meeting.

the missile week

Industry Countdown

MANUFACTURING

First *Titan* is being . . .

installed in the silo launcher at Vandenberg AFB. The bird won't be used as a flight vehicle—just as an R&D tool to check out launch instrumentation.

• • •

Look for *Pershing* . . .

production to begin this summer. Thiokol now has 120-day Army funding to complete development of continuous mix solid-fuel process at Longhorn Ordnance Works in Marshall, Tex. Propulsion unit production will be semiautomated.

• • •

Missile industry employment . . .

is now pegged at almost 400,000 by the Labor Department. The agency surveyed 482 plants and found the heaviest concentration of missile work in the Los Angeles-Long Beach area. Latest survey indicates a 60% rise in employment in the field in two years, which probably is misleading since the department previously had restricted its inquiry largely to the aircraft industry. The latest survey includes all missile producers listed by DOD as having more than 200 employes.

• • •

Payload vibrations . . .

transmitted from the solid-propellant X248 final stage are delaying the next *Atlas-Able* moon probe until August or later. The difficulty is forcing NASA into a complete redesign of the payload package structure.

• • •

Next big missile/aircraft . . .

producer to begin an aggressive diversification program will be McDonnell Aircraft. The corporation's stockholders will vote April 29 on increasing the authorized common stock from 2 million to 8 million shares. They are also expected to approve a change in the certificate of incorporation to permit the company to diversify.

PROPULSION

Martin has unofficial go-ahead . . .

to redesign the *Titan* to use Aerojet-General's storable liquid (N_2O_4-N_2H_4) engines. Contract signing is expected soon, with the first flight test in about two years.

• • •

R&D contract for 30 KW ion . . .

engine will be awarded shortly by NASA. The bidders: Ramo Wooldridge, Raytheon, Rocketdyne, Goodrich, Pratt & Whitney, Convair, General Electric, Aerojet-General, Hughes, Curtiss-Wright, Armour Research Foundation, and ITT Labs. Bids are now being presented orally and will be followed by evaluation and negotiation.

• • •

NASA also is evaluating . . .

bids on the liquid hydrogen Project *Rover* nozzle. Bidders are Rocketdyne, Aerojet-General, Pratt & Whitney, Reaction Motors, Bell, Martin and General Electric.

ELECTRONICS

"Projectitus" is a disease . . .

threatening the U.S. space program, in the opinion of Dr. Lloyd V. Berkner, president of the Associated Universites Inc. Berkner makes the point that engineers are diffusing effort in jamming a number of conveniently available experiments into every space vehicle just before it is launched. He says all the various projects should be replaced by one logical long-range program in which each launching is a step toward a goal of planetary exploration.

WE HEAR THAT

Major space system . . .

contract may go soon to the Electric Boat Division of General Dynamics, which has a 750-man R&D lab already working on several advanced systems . . . Melpar Division of Westinghouse Air Brake is laying off about 200 engineers with the expiration of some GSE contracts . . . The Washington office of General Motors' new defense products division is being increased . . . The General Accounting Office is getting ready to expand its auditing investigation of the *Polaris* missile system, which is being built largely under negotiated contracts.

Typhon System Shown by Navy

New Westinghouse radar plus existing birds will have two-way capability

by **Richard van Osten**

Los Angeles—Details of a new shipboard weapon system employing advanced versions of two existing missiles and a new long-range radar under development by Westinghouse Electric have been disclosed by the Navy.

The system, intended to back up the strategic offensive power of *Polaris* submarines, is scheduled for installation aboard more than 50 ships in the 1965-70 period.

(This development was first reported in M/R, Sept. 21, 1959, p. 24.)

Named *Typhon*, the system will have both defensive capabilities against enemy aircraft and missiles and offensive capabilities against enemy fleet units and shore targets.

The Navy says it is capable of "long-range" shore bombardment.

The system's antiair capabilities extend from very short to very long slant ranges and to extremely high altitudes.

Typhon incorporates two missiles, the Super *Tartar* and Super *Talos*, now designated as Medium Range *Typhon* and Long Range *Typhon*, respectively. No hardware is yet in flight stage.

Key to *Typhon* rests in the radar concept developed by the Applied Physics Laboratory, Johns Hopkins University, according to Capt. E. B. Jarman, head of the ship-launched weapons program, Naval Bureau of Weapons.

A $38.5-million contract for development, design and production of a prototype for long-range *Typhon* radar has been awarded to Westinghouse Electric. The system as conceived by APL will incorporate high data rates and extremely high power features far in advance of present shipboard radar designs. Exact details are classified, although the Navy says it will be a phased array radar "with no ball bearings." However, monopulse and low frequency techniques are very likely under serious consideration.

Requirements for longer range and detection of extremely small targets forced a major boost in radar power.

• **Better and smaller**—Another Navy problem it is hoped *Typhon* will solve is a lack of shipboard space for equipment that can perform multiple tracking functions. *Typhon* is specifically designed to handle a very large number of targets and to process target data at rates far greater than similar existing equipment.

The proposed radar will outperform any shipboard radar in its class presently available, and will be considerably smaller and lighter to fit "our small amount of real estate," the Navy says.

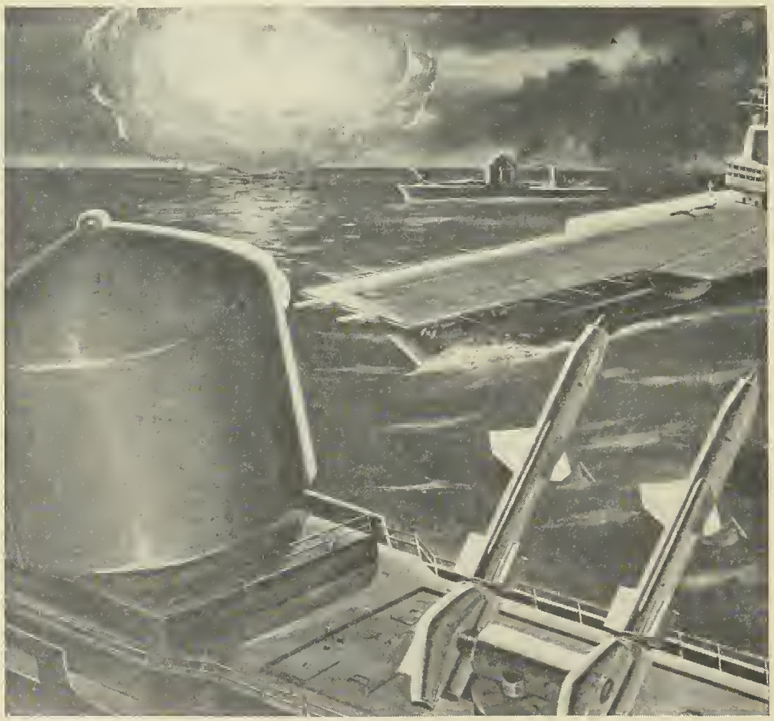
First complete *Typhon* system will probably be installed on a relatively large Navy vessel for further development—with emphasis on studies of the system's long-range capabilities with both radar and missiles. Eventually, it is hoped to fit all large class Navy ships with *Typhon*—destroyers, frigates, cruisers and aircraft carriers. There has also been some consideration of utilizing *Typhon* radar concepts on a single ship of a small fleet. The *Typhon*-equipped vessel would serve as a command ship and fire missiles from other ships in its immediate task force. In present state of development, however, *Typhon* is not tied to any specific ship in Navy programs.

• **Discrimination** — Although the Navy says *Typhon* is not parallel to antimissile capabilities of *Nike-Zeus* and it should not be termed an antimissile system, officers say they would "like to have discrimination" when asked if the radar portion can "separate" outgoing and incoming ballistic warheads.

Work on research missiles is going ahead at APL. Long Range *Typhon* (Super *Talos*) will be smaller and lighter than present *Talos*.

With so much emphasis on the Westinghouse radar, it is reasonable to assume *Typhon* missile development may have to wait for further development of the radar portion. Just how well this works out may determine exact configuration of the missiles and what equipment will be required within each missile.

The *Typhon* system is related in a very general way to APL's past work on the Navy's *Bumblebee* project from which came *Terrier, Tartar* and *Talos*.



ARTIST'S CONCEPTION of *Typhon* in action. Missile cruiser is shown with dome of new type of radar antenna which can keep track of several missiles at one time.

The new system, however, will be a major break with the *Bumblebee* concepts—particularly that part affecting weapon control.

• **A big step**—Pointing out that work on *Bumblebee* is dropping off rapidly, the Navy says *Typhon* is a major "step" to take advantage of new technology rather than an "inching towards improvement."

In addition to its capabilities against sea and air targets, *Typhon* may also be used against land targets within the system's range. Existing launching systems for *Talos* and *Tartar* can be used for *Typhon* weapons. The system has no application for ASW, according to Navy statements.

It seems likely also that both Convair-Pomona, now producing *Terrier* and *Tartar* missiles, and Bendix, producing *Talos* at its Mishawaka, Ind. plant, could figure prominently in *Typhon's* future. Both plants are Navy-owned—a fact that might help in keeping missile costs down.

Typhon is assumed to have nuclear warhead capabilities, but a Navy spokesman declined to verify this. At a press conference, however, it was pointed out that "$38.5 million is a lot of money just to toss TNT into the air."

The system is named after a legendary monster with 100 fire-spitting heads.

NASA Nears Decision on Plasma Device Study Awards

The National Aeronautics and Space Administration is making final evaluations of bids on two proposals for feasibility studies on pulsed plasma propulsion devices.

Both contracts, expected to be awarded within the next few weeks, call for one-year studies. A decision will be made at the end of the year on whether to carry development further.

One of the two is a small device drawing up to one kilowatt, which would be used for attitude control of a satellite or space vehicle. The other, drawing 30 KW, could power deep space missions from a low orbit. Both devices would operate up to 60 days. Eleven companies bid on the 1 KW unit and eight bid on the larger one.

The 1 KW device might be powered by a solar-cell device such as is to be developed under Project *Sunflower*. The 30 KW unit could use the power from a SNAP-8 nuclear reactor.

Cost estimates for the first year are $200,000 for the 1 KW device and slightly under $500,000 for the 30 KW device.

Bidders on both contracts were Westinghouse, Rocketdyne Division of North American Aviation, Republic Aviation, Avco, General Electric Co., Aerojet General Corp., Plasmadyne Corp. and Marquardt Corp. Additional bidders on the 1 KW machine were Curtiss-Wright, American Machine and Foundry, and Convair Division, General Dynamics.

Nuclear Stage for *Saturn* by '68-'69

An upper nuclear stage for the *Saturn* vehicle is planned with a 1968 or 1969 launching date, Dr. Wernher von Braun has told a congressional committee.

A *Saturn*-nuclear vehicle could deliver a payload of 72,000 lbs. to a 300-mile orbit, Von Braun told the House Appropriations Subcommittee considering the National Aeronautics and Space Administration budget. The testimony, given in closed session March 16, was made public last week.

Von Braun compared payloads with the C-1 and C-2 *Saturn* configurations. The C-1 configuration consists of the 1½-million-lb.-thrust booster, a hydrogen-oxygen second stage with 80,000 lbs. thrust and the *Centaur*, with 40,000 lbs. thrust, as third stage. In the C-2 configuration, the second stage would be a cluster of four 200,000-lb.-thrust hydrogen-oxygen engines and the third stage would be a single such engine. Fourth and fifth stages might be added to the C-2 according to the mission.

The three-stage C-1 can put 4500 lbs. in a 24-hour orbit or make a soft lunar landing with about 2400 lbs. The first two stages can put 22,000 lbs. in a 300-mile orbit.

The three-stage C-2 can put 45,000 lbs. in a 300-mile orbit, 9000 lbs. in a 24-hour orbit and can land 5000 lbs. on the moon.

With a nuclear upper stage, Von Braun said, the payload would be 72,000 lbs. in a 300-mile orbit, 32,000 lbs. in a 24-hour orbit and 14,800 lbs. for a soft landing on the moon.

He declared the nuclear rocket "makes it definitely possible to fly a portion of this back to earth so you can bring samples back from the surface of the moon."

• **How to launch?**—Von Braun appeared to side with Harold B. Finger, NASA chief of nuclear engines, in the dispute over orbital or ground launching as the first flight test of the Project *Rover* nuclear rocket. He said:

"In principle it is possible to fly this right from the ground, but there are certain disadvantages to it. First and foremost there is the problem of tremendous radiation in the vicinity of the launching site. This runs at 1000 megawatts and you would have gamma radiation in the vicinity requiring very thick concrete shielding for the crew and probably within a mile or two miles from the takeoff nobody can stay because there would be a radiation hazard.

"In addition, if the thing aborts in the pad area we might as well evacuate the pad and forget it for the rest of our lives and build another one because of the contamination of the area."

Col. Jack L. Armstrong of the Atomic Energy Commission favors a ground launching as the first test of *Rover*—possibly by 1964 or 1965. Others who support a ground launching are Dr. Raemer E. Schreiber, who heads the nuclear rocket development program at Los Alamos Scientific Laboratory, and Krafft Ehricke, who heads the *Centaur* program at Convair Division of General Dynamics Corp.

NASA plans to contract with an industry study team for a complete examination of the pros and cons of all launch methods. Finger said bids on the study will be circulated soon.

Firestone May Eliminate Or Cut Back Missile Work

Firestone Tire & Rubber Co. is reducing the level of its missile division's activity to that involving current projects. The company gave no indication as to the future of the group after the *Corporal* system requires no further support. In addition to the cutback, certain supporting facilities may be sold outright.

Requirements for support of the *Corporal* assures operation of the organization for "a considerable length of time," according to Hugh I. Gibson, general manager. The cutback of operations in the Los Angeles plant is accompanied by a reappraisal of Firestone's engineering laboratory in Monterey, which may be sold. If a decision is made to sell this laboratory, it will be done so as to keep the lab operating as a unit.

Gibson said the cutback and reappraisal do not affect the other defense activities of Firestone.

Navy Presses *Polaris* Sub Test Shots

Members of Congress who witness trials of launching systems demand increase in number of subs

by James Baar

GROTON, CONN.—The nation's first two *Polaris* submarines are undergoing intensive testing of their launching systems as congressional pressure mounts for big increases in the *Polaris* submarine construction program.

In the last week, congressmen proposed increasing the number of *Polaris*-launching submarines in the FY 1961 budget anywhere from three to seven. They called for a total force ranging from the 40 plus sought by the Navy to more than double.

President Eisenhower's original budget provided for construction of three *Polaris* submarines and the purchase of long-lead-time items on three more. The President has now agreed to add long-lead-time items to still another six, bringing to nine the number for which long-lead-time items would be purchased.

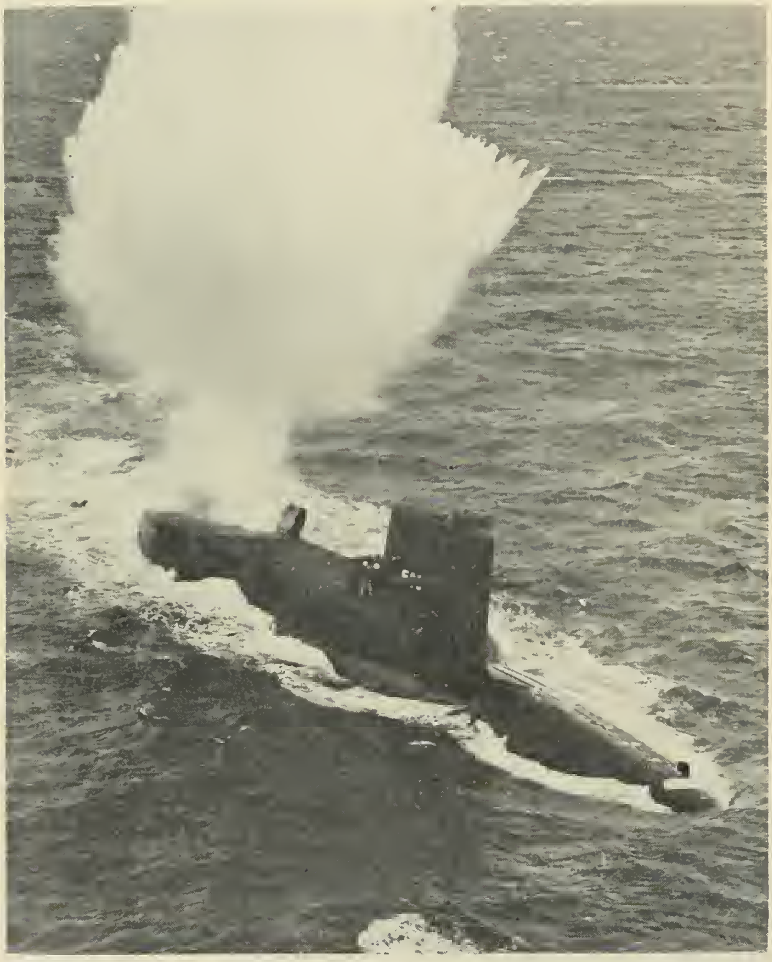
• **More subs demanded**—However, a number of powerful congressmen made clear that they wanted more money for more submarines as quickly as possible—not long-lead-time items for submarines at some future date.

Sen. Clinton P. Anderson (D-N.M.), chairman of the Joint Congressional Atomic Energy Committee, said after an overnight cruise on the *Polaris*-launching submarine George Washington that he favored "doubling the order" for construction of subs. That would boost the number in the budget from three to six. Anderson said he favored a total fleet of about 45.

Sen. Henry Jackson (D-Wash.), a member of both the Senate Armed Services and the Joint Atomic Energy Committees, said he wanted seven more subs in the budget, boosting the total in the budget to 10. He said he wants a total force of 100. Jackson and other Joint Committee members accompanied Anderson.

The Navy itself has proposed adding six more. The total package would cost close to $1 billion.

On the other hand, the Administration proposal would be much cheaper. Long-lead-time items—mainly nuclear reactor components—cost about $20 million for each ship.



SURFACE FIRING of a 2500-pound slug and two and a half tons of water from a tube of the *Polaris* Submarine George Washington near the Connecticut shore.

• **Training shots**—The George Washington during the next few months will continue to launch from submerged and surfaced positions both *Dolphins*, dummy operational missiles, and *Sabots*, missile slugs.

The Lockheed *Dolphins* are instrumented dummy *Polarises* that duplicate the operational missile both in shape and weight. The Westinghouse *Sabots* are 2500-pound short cylinders that are fired from the *Polaris*-launching tubes along with two and a half tons of water.

The George Washington launched 10 *Sabots* while the Joint Committee was aboard. One *Sabot* was launched at the surface near the mouth of the Thames River about a mile from the Electric Boat shipyards at Groton. The other nine were launched from beneath the surface of the Atlantic off the New England Coast.

Congressmen and high-ranking Naval officers stood by the George Washington's tall sail while one of the great missile tube doors swung back. The *Sabot* roared skyward in a mushroom-shaped geyser of water and was recovered by a tug.

The Patrick Henry—second of the 5700-ton class of *Polaris* subs—had already headed for open water after commissioning ceremonies at the Electric Boat pier.

The Patrick Henry will begin launching *Sabots* later this month while lying along her pier. She will begin firing *Dolphins* next month.

Both submarines—first the George Washington, then the Patrick Henry—are scheduled to be on station with their missiles by the end of the year. Rear Adm. L. R. Daspit, commander of the Atlantic Submarine Force, said during the commissioning ceremonies that the Patrick Henry would go on station in December.

Navy Refutes Charges That It Neglects ASW Proposals

Rear Adm. Rawson Bennett has brushed aside charges from some industry officials that the Navy is disregarding many new proposals for combating the growing submarine threat.

Bennett told the House Military Appropriations Subcommittee in newly released testimony that between Jan. 1, 1958, and Dec. 31, 1959, the Navy received 486 unsolicited ASW proposals.

He said 386 of these included cost information; the other hundred did not. He said that 48 of the total number of proposals were offered at no cost to the government.

Bennett said that over the period the Navy has obligated about $26 million for 155 of the total number of proposals. He said 24 of the no-cost proposals also have been accepted; 17 rejected; and seven remain under consideration.

As for criticism of the Navy's handling of ASW proposals, Bennett said:

"You have to recognize it is a great American right to be a little upset if someone doesn't buy your own particular product."

news briefs

FIRST NAVIGATION SATELLITE—The nation's first R&D navigation satellite *Transit 1B* soared an approximately 400-mile circular orbit. The 265-pound ARPA Navy satellite was launched from Cape Canaveral at 7:02 A.M. EST April 13 by the Air Force's latest space booster, the two-stage *Thor Able-Star*. The Aerojet STL's *Able Star* had a start-restart engine that hurled the satellite into a circular orbit from the elliptical into which it originally was launched. The satellite carried two ultrastable oscillators within its 36-inch diameter operating over four bands. Six ground stations were set up to pick up the satellite's signals. Navigational fixes will be obtained from the signals by measuring the Doppler shift. *Transit 1B* is essentially a repeat of the first *Transit* shot last September 14. The first *Transit* failed to get into orbit. One of the prime uses for *Transit* will be to serve the Navy as another navigational check for *Polaris*-launching submarines. The operational system will use four 50-pound satellites.

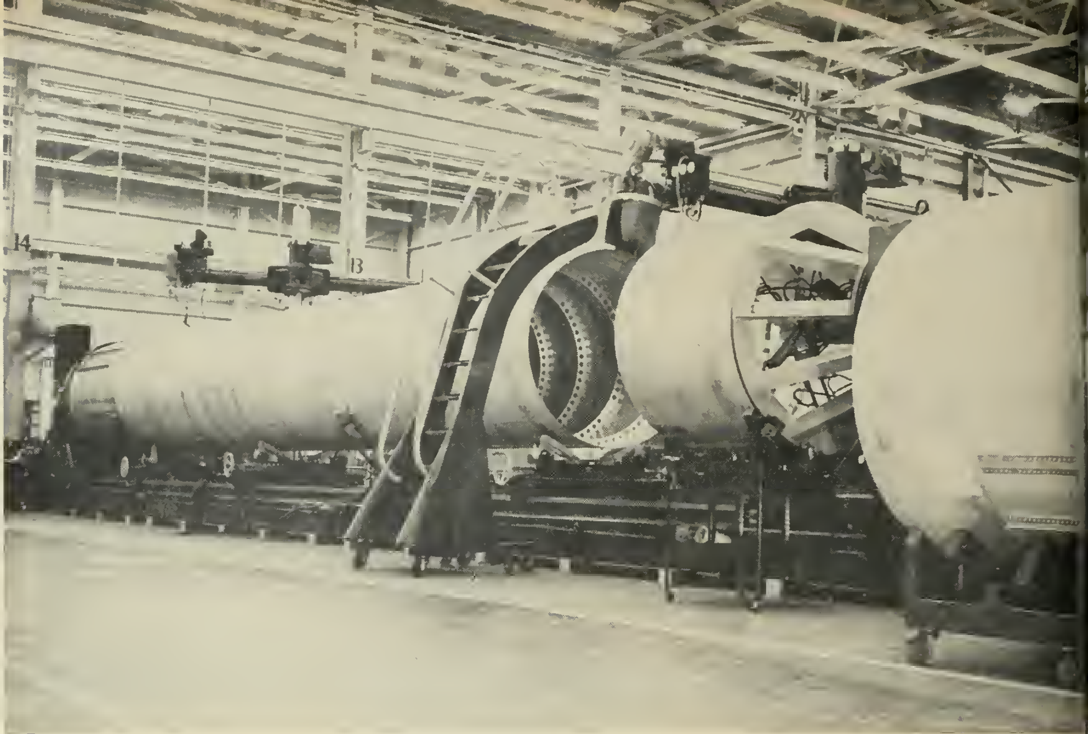
BRITISH CUT MISSILES—In a major defense shift, Britain is reported ready to cancel its *Blue Streak IRBM* and antiaircraft *Super Bloodhound* missile as a first step toward buying missiles from the United States. More than $280 already has been spent on the *Blue Streak*. Government officials were said to feel the British economy could not support large-scale missile development and that it would be more economical to procure needed weapons from other countries.

***SAMOS* R&D $200 MILLION**—The Air Force is budgeting $200 million for the development of the *Samos* Television reconnaissance satellite in Fiscal 1961. Another $12 million is earmarked for re-entry vehicle studies, penetration aids, storable noncryogenic fuels and silo-type launcher studies for *Atlas*, *Titan* and *Minuteman*.

STL TO GET $44 MILLION—Space Technology Laboratories would receive $44 million for research consultative services for the Air Force under the 1961 Budget. The Air Force also plans to pay Rand Corp. $13.5 million; Lincoln Laboratories $21 million; Mitre Corp. $20 million and ANSER $1 million in the coming fiscal year.

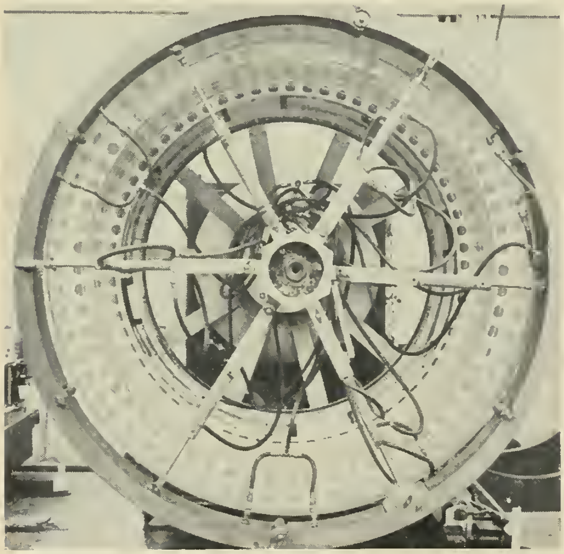
A Clear Middle Eastern View from Tiros I

PHOTOGRAPH WAS TAKEN by *Tiros I's* wide-angle camera from 450 miles over the Red Sea on April 4. Map at left helps to identify the dark strip to the west as the Nile River. The Sinai Peninsula is flanked by the Red Sea to the west and the Gulf of Aqaba to the East. In upper left corner is the Mediterranean Sea.



an M/R exclusive . . .

Saturn Fabrication: Spectacula



DETAIL OF circumferential welding machine for outer tank welding shows internal back-up bar arrangement. The "Serpentine Design" can be collapsed and expanded by pneumatic action, provides clamping pressure and precision fit of joint.

by Hans H. Maus*

HUNTSVILLE, ALA.—On July 27, 1959, a small, yet significant, ceremony took place in Building 4707 of the Fabrication and Assembly Engineering Laboratory, Army Ballistic Missile Agency, at Redstone Arsenal. It marked the completion of the last *Jupiter* type airframe to be fabricated by the Agency. Immediately thereafter the Master Mechanic Organization took over and retooling of the shops for the *Saturn* project began with all possible speed.

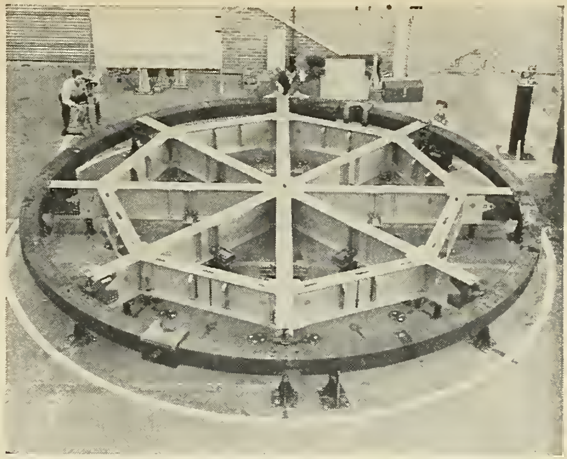
A full-size outline of the *Saturn* booster diameter which had been painted on the end wall of the building by the tool designers served as a continuous reminder of the new and challenging assignment and of the schedule which was to be met.

It was half a year later—on Feb. 1, 1960, and coincidental with the fourth anniversary of the Army Ballistic Missile Agency—that the first *Saturn* booster tank cluster could be displayed to the public.

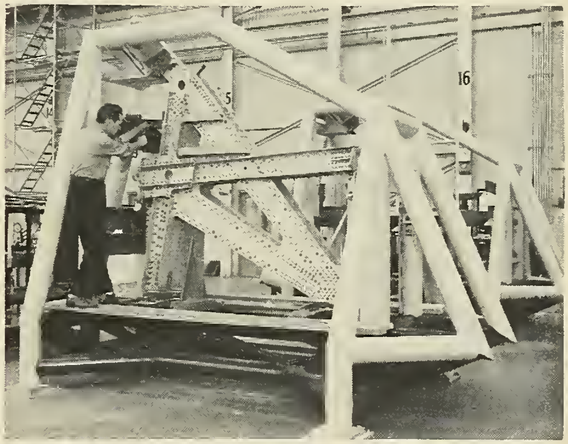
What had been accomplished during a relatively short period of time by dedicated tool engineering and production personnel of the Agency and by equally dedicated personnel of numerous companies supporting the project can be seen, to some extent, from this pictorial report.

**Chief of the Fabrication and Assembly Engineering Laboratory, George C. Marshall Space Flight Center, Huntsville, Ala.*

ASSEMBLY of 70-inch diameter tankage is done on circumferential welding machine from cylindrical sections and bulkhead sections preassembled on other tooling. For joining, tank sections are rotated under stationary welding bead. While tank lengthens by sections which are added, one at a time, tail stock of fixture travels over entire length of tool base.



"SPIDER BEAM" assembly, part of adapter section, being aligned on locating fixture. Tool ring, later used for handling and transportation of booster, is assembled on same fixture. Structural members are from 7075 aluminum.



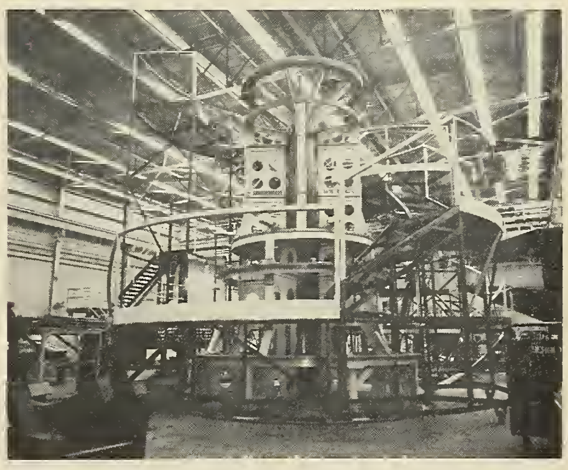
OUTRIGGER SUPPORT frames are assembled separately before being joined to tail. Huckbolting is used for assembly. Four inboard and four outboard supports are required for a single booster tail section.

uccess Story

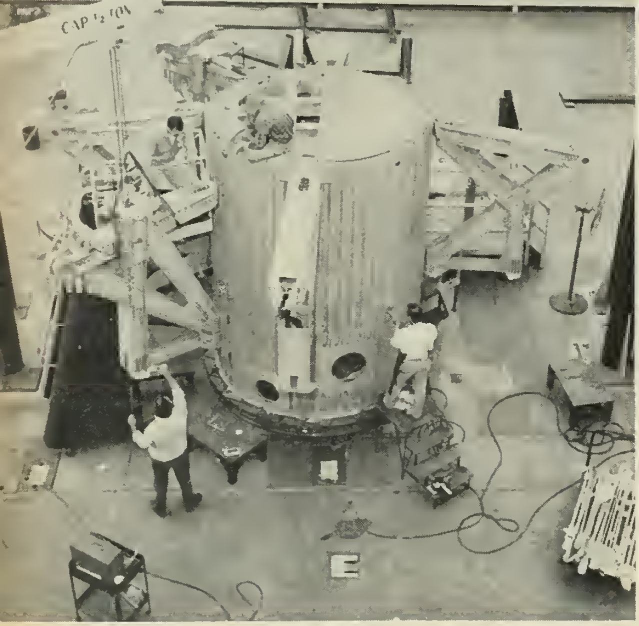
• **Basic description**—Basically the *Saturn* booster airframe consists of one large center tank of 105 in. diameter around which eight outer tanks of 70 in. diameter are clustered. The front tie of the tankage is furnished by the "Adapter Section" which also creates the base for the upper stages to be carried by the booster. The rear tie of the tankage is accomplished by the "tail section" which supports the eight rocket engines which power the vehicle.

The tank diameters have been chosen to permit the use—in part at least—of tooling which had previously been developed for the *Redstone* and *Jupiter* programs. Considerable modifications were required, however (as could be expected), and many additional pieces of tooling were needed. This was true particularly for the adapter section, and for the final asesmbly of airframe and booster vehicle.

In the fabrication of the tankage, specific emphasis is placed on reliability. With a few exceptions the tanks are fabricated from 5456 aluminum alloy. Skin sheets are milled to a pattern in the flat condition (which is done for weight savings) then rolled and joined to cylinders by automatic fusion welding. Ring frames, spot-welded inside, complete

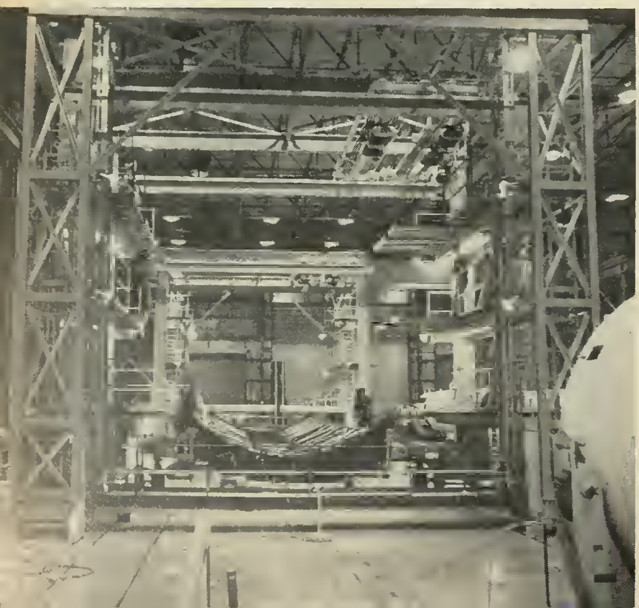


VERTICAL FIXTURE which facilitates assembly of tail barrel. Component parts such as thrust rings, longerons, shear panels, etc., are handled on separate tooling.



PREASSEMBLED OUTRIGGERS and tail barrel are joined on optical alignment stand. Turntable permits precision location and installation of support frames and of mounting brackets for outer tanks, rocket engines and engine swivel actuators. Tail barrel has same diameter as center tank, is later bolted to it. Main columns of stand are filled with oil.

BOOSTER FINAL assembly station shows part of assembly tool in center. Full adjustability is provided in positioning stands operated from a central location outside the station. Movable service structures are equipped with hoists and elevators, making it possible to conduct assembly at three elevations.



the cylindrical sections.

Bulkheads are formed from one piece of material in a combination shear-spin-machining operation, and chemically milled in certain areas for weight reduction. They are joined to the cylindrical sections by internal fillet welds. Dimensional accuracy of components parts is achieved by routing the skin sheets to lengths and by parallel trimming of the tank sections.

• **Optical alignment**—The overall assembly fixture, on which the individual cylindrical sections and bulkhead sections are joined into a tank, provides for alignment of the component parts by built-in optical equipment. The fixture incorporates provisions for test-weld specimens to be welded under identical conditions immediately preceding the production weld. Machine welding is applied.

Radiographic inspection and hydrostatic testing are used, after the tanks are completed, to check for weld quality and soundness.

Major structural items such as adapter section and tail section, as well as shrouding are fabricated from preassembled component parts joined on special alignment fixtures. Most of the tools designed for these items serve a multitude of operations.

• **Final assembly**—The final assembly of airframe and booster vehicle is handled on the *Saturn* Booster Assembly Station. The station consists of the assembly fixture proper (with fully adjustable cradle supports, tool rings, etc.), and of scaffolding structures which can be closed in to provide access to the booster. The structures are provided with hoists and elevators and allow parallel assembly operations at three elevations.

Two large tool rings are used to place the booster on the fixture. They tie in to the eight "spiders" of the adapter section in front and to the out-rigger support frames in the rear. The tool rings are segmented for ease of installation. Once assembled to the booster they form an integral part of it without which it cannot be handled or transported. They are disassembled, finally, after the booster has been shipped to the firing site and has been moved to the launch site.

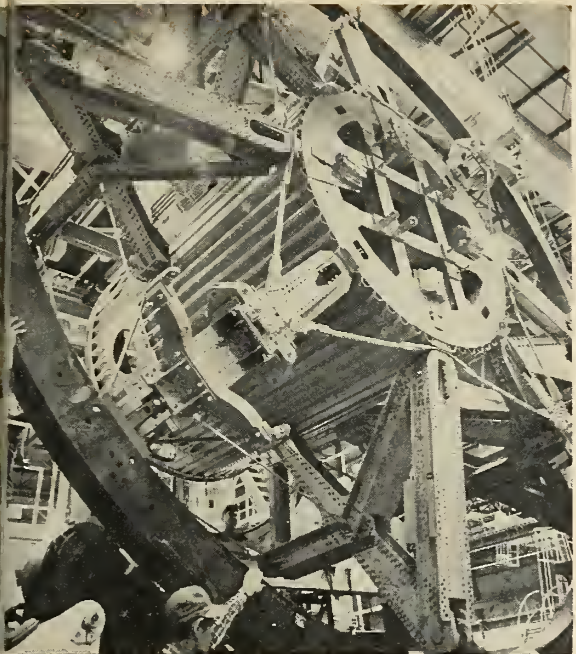
The assembly of the tank cluster is handled in a simple manner: The tail section is moved in first and the center tank connected. Then the adapter section is added. Next, the outer tanks are filled in from above, one at a time, while the fixture is rotated.

• **Special features**—A number of special features are incorporated in the assembly tool which allow for alignment, weighing, and determination of center of gravity. The alignment is accomplished by optical means and by push-button remote control located on an elevated platform in the rear of the station. Weight and center of gravity are determined by precision load cells and optical measurement.

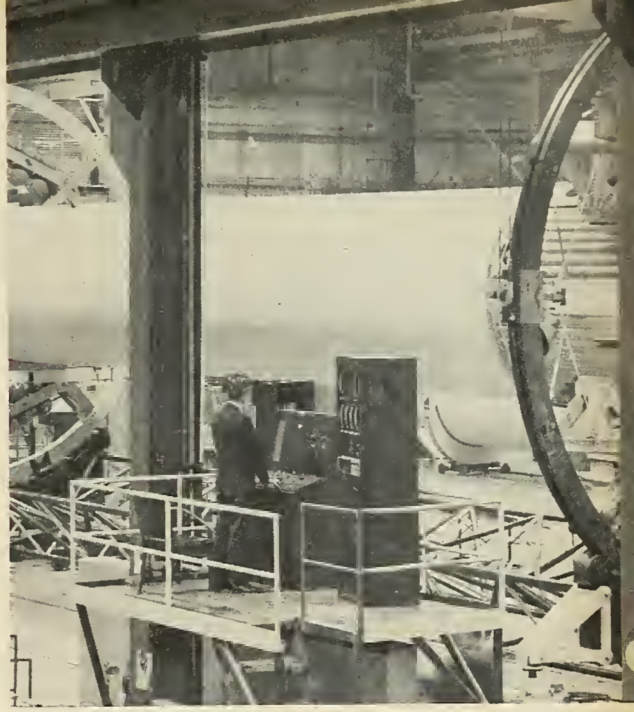
After the booster is assembled all special equipment is disconnected from the tool and the basic elements (rings, cradles and trusses) are converted into a transportation vehicle. For this purpose the assembly tool is jacked-up hydraulically on four points and front and rear "walking gears" are moved under. The walking gears consist of tandem wheel arrangement which can be steered separately for transportation.

In this fashion the assembled booster can be transported to functional check-out and captive testing and in the same manner will finally be transferred to the river dock and onto a barge for shipment to the launch site.

Editor's note: The Saturn *tank cluster shown in some of the pictures does not carry the adapter part (of the adapter section) with which the booster connects to the upper stages. Likewise, engines and shrouding are not yet assembled.*

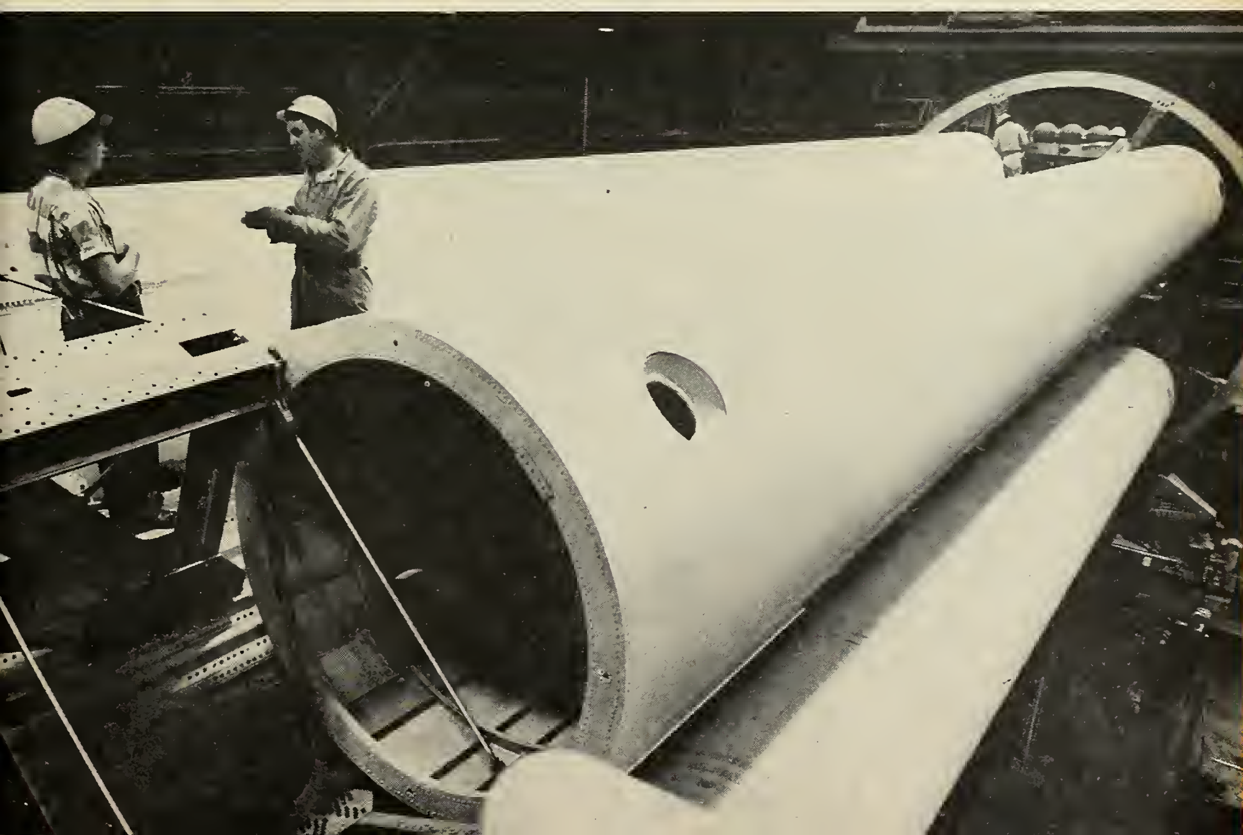


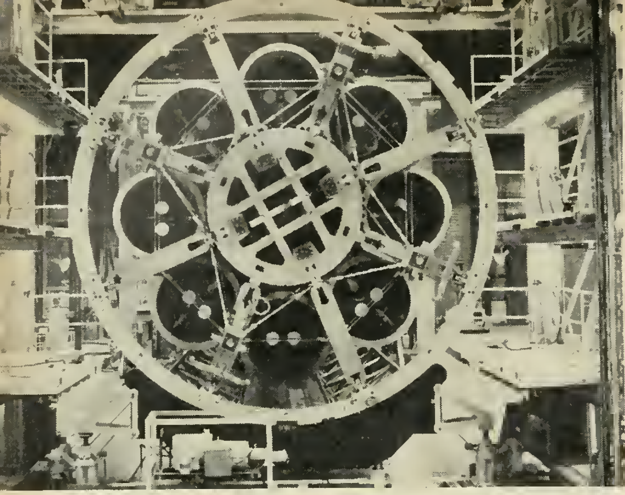
COMPLETED "TAIL SECTION" subassembly, the 24-foot-diameter tool ring assembled to it, is hoisted on rear cradle support of *Saturn* assembly station. In a succeeding operation, the large center tank will be moved in and connected.



TRANSDUCER READOUTS and push-button remote controls are used to maintain precision alignment. Same equipment permits rotation of entire fixture for assembly of outer tanks, engines, shrouding, etc.

TOP VIEW OF assembly station shows four outer LOX tanks installed. In following operation, the outer fuel tanks will be assembled. Fixture stands three stories high; distance between tool rings is 63 feet.





REAR VIEW of partially assembled booster shows tail section in foreground. Four outer and four inner thrust pads are installed; engines will be mounted on them. The large tool ring connects to eight outrigger support frames to allow rotation.

EDITOR'S NOTE

Preliminary design on the 1.5-million-pound-thrust Saturn *booster was started at ABMA about April, 1957. This early configuration would have used four Rocketdyne E-1 engines developing 330 K each.*

In July, 1958, this proposal was submitted to ARPA. ARPA specialists suggested using eight Jupiter *engines instead of four E-1 engines in order to save some $50 million in engine development money which was not available.* Saturn *finally was approved by ARPA and funded by $10 million to demonstrate the feasibility of a cluster.*

The original ARPA-ABMA program would have flight-tested the booster in late 1960; with operational flights following in 1962-63. After one year, however, the project faltered because of inadequate funding.

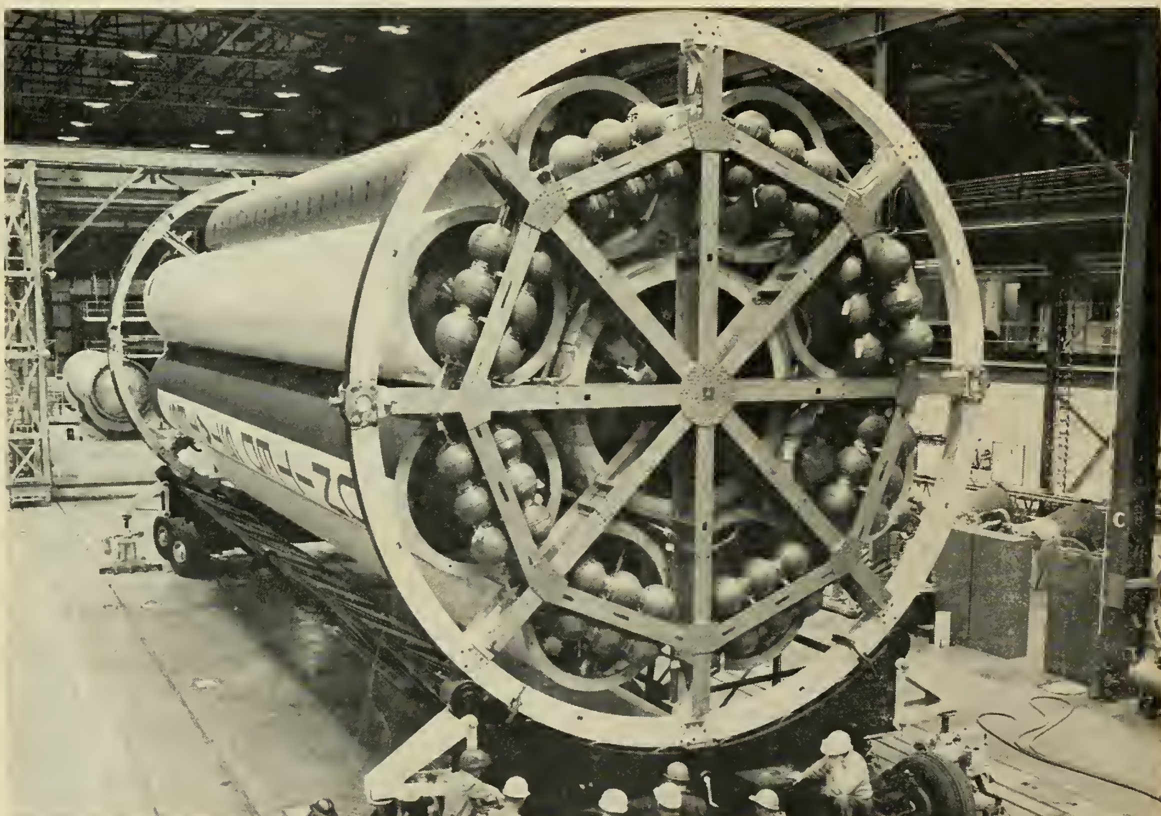
In FY 1959, $34 million was requested by the Saturn *team and $34 million was received. The second year (FY 1960) $140 million was requested, but only $70 million was received. The third year (FY '61) the team requested $250 million. The ARPA budget called for only $140 million.*

Also jeopardizing Saturn's *future in 1959 was an arbitrary DOD ruling that no military missions existed beyond 600 miles. At one point, according to recent testimony by ex-ARPA director Roy Johnson, DOD R&E chief Dr. Herbert York had ordered the* Saturn *project cancelled.*

Late in 1959, the President ordered Saturn *and the Development Operations Division of ABMA transferred to NASA. NASA asked that the* Saturn *funding be increased for FY '60 from the $140-million DOD-ARPA figure to $246 million—just $4 million short of what the* Saturn *team had asked. NASA threw in another $8 million out of its liquid propulsion budget for good measure.*

After announcement of the intended transfer, NASA and the Saturn *team quickly arrived at a decision to use liquid hydrogen-oxygen engine clusters for* Saturn's *upper stages, and invitations to bid were sent to industry.*

Present estimates of Saturn's *schedule are close to the original schedule worked out in 1958 with the first full static test in 1960 and the first flight test in 1961.*



"WALKING GEARS" designed and supplied by Systems Support Equipment Laboratory, ABMA, are being installed on the fixture. They provide for transportation of the booster on the basic assembly tool without need for reloading. Front and rear wheels can be steered separately for ease of maneuver.

Optics Play Large Part in DAMP

Program uses unique optical instruments designed to investigate re-entering missiles

Data from optical instrumentation aboard the recently modified Army Ordnance range ship USAS American Mariner (M/R, Feb. 29) will play an important part in design of future anti-missile systems.

Part of ARPA's Downrange Antiballistic Measurement Program (DAMP), the range ship and a teammate C-130 aircraft gather optical data on re-entering missiles for Project *Defender*. The floating and flying Laboratories carry a number of precise and unique optical instruments to photograph, measure, and record physical phenomena surrounding re-entering bodies.

Optical measurements cover the light spectrum from far infrared through ultraviolet. Data recording and reduction facilities translate this information for use in research on missile defense.

During an operation, the American Mariner—and the aircraft—are spotted downrange near the expected impact point. On board the ship, tracking radars acquire the re-entering nose cone and the optical instruments, slaved to the radar, begin their photographic and recording functions. In case the radars are unable to acquire the target, the optics may be controlled by both or either of two optical directors.

Instruments in the C-130 are manually aimed and operated on the basis of visual acquisition and tracking.

On completion of a mission, film is processed and copied, and chart and oscillograph records tabulated. Film and original recordings are sent to Stamford, Conn., for further reduction and analysis.

• **Shipboard instrumentation**—A wide variety of optical instruments have been designed or adapted for use aboard the DAMP ship.

Special ballistic cameras provide a spectral record of the re-entry phenomena as a function of both range time and spatial orientation.

Spectral sequence cameras provide an instant-by-instant record of the spectra of the re-entering bodies through the ultraviolet, visible, and near infrared.

A four-barrel photometer provides absolute calibration points in the spectra shown by the photographic recording instruments. Each barrel of the photometer uses a photomultiplier tube equipped with a filter passing the narrow regions of the spectrum of special interest.

Measurements in the intermediate and far infrared are provided by radiometers. One is a wide-angle instrument and the other a high-precision, high-sensitivity, small-field-of-view instrument with 12-inch optics.

A high-resolution cine camera provides accurate information on the make-up of the re-entry complex. This instrument uses a 40-inch lens and 70-mm film to provide high-quality, high-magnification motion-picture records of the re-entry bodies.

A 30-element infrared scanner makes instantaneous radiation measurements on the individual bodies of the re-entry complex simultaneously, covering a 5° by 15° portion of sky on a 30-channel oscillographic recorder.

In addition to these instruments, separate 35-mm boresight cameras, with a variety of lenses, are available for installation on hand-tracked instruments or on remotely controlled pedestals.

Data-recording equipment, timing units, audio tape recorders and control switches are located below decks along with checkout, repair, and electronic calibration facilities.

The common Atlantic Missile Range timing code is generated aboard ship and supplied to the optical instruments in the form of one pps coded GMT grad. Also available are 0.1, 0.01, and 0.001-second timing pulses, but these are not used with current instrumentation.

Meteorological data from radiosonde balloon flights—taken before and after each test—are furnished for the reduction of the optical data.

Following each test, radar trajectory data—slant range, azimuth, elevation, velocity, acceleration, altitude, and aspect angle—are supplied for the optical data processing.

• **Airborne instrumentation**—Instruments aboard the aircraft are limited to a 70-mm cine-spectrometer, a 2-barrel photometer, a R-4K1 radiometer, and a boresight camera. Addition of ballistic trajectory cameras is currently being investigated.

• **Motion-picture cameras**—Four motion-picture cameras are used to photograph the re-entry complex. Three of these are Flight Research Corp. 35-mm Model IV C mounted on slave pedestals 1, 3, and 4, where they function as boresight cameras for the other instruments mounted on these pedestals. Two of these cameras have 6 in. focal length f/3.5 lenses (8° x 10° field of view) and the third a 3 in. focal length f/2.3 lens (16° x 20° field of view). A reflex sight with an illuminated reticle is mounted in front of each camera to provide a boresight grid at the film plane. Range time is recorded in the form of coded one pps marks on both edges of the film (one ahead and one following the exposed frame).

The fourth camera is a Flight Research 70-mm with a 40 in. focal length f/8 Zoomar lens. With a 2¼ x 2¼ inch film format, this instrument has a field of view of 3.2° x 3.2°. The 40 in. lens is being used in an effort to evaluate the limit imposed by shipboard environment. If results are favorable, higher resolution systems—possibly even such instruments as the ROTI, IGOR or SMT high-resolution cameras—may be installed later and used for the provision of higher-resolution photography.

• **Ballistic cameras**—In its simplest form, the ballistic camera consists of a photographic plate at the focus of a wide-field lens equipped with a shutter. It is pointed at some predetermined azimuth and elevation. The shutter opens before the target moves into the field, and closes after the target moves out of the field or disappears. A bright, essentially point-source target—such as a missile in launch or in re-entry—will be recorded as a streak across the photographic plate.

By the addition of a chopper which obscures the lens or closes the camera at some known rate, relative time and, hence, target velocity can be determined from the simple streak record.

Aboard the American Mariner, two ballistic camera arrays are installed. Each array consists of a cluster of four cameras mounted in such a way that heir individual fields of view (37° x 15°) can be oriented to cover a rectangle of the sky 90° x 74°, or practically any other combination of the four individual fields of view.

These cameras are not stabilized but are mounted on a heavy tripod bolted to the deck. An azimuth adjustment head allows the entire array to rotate through 360°.

The individual cameras are Fairchild K-19B aerial reconnaissance cameras modified for this special application. Lenses are 12 in. focal length. The photographic plates are 8 x 10 inches. Film can also be used.

One array of four cameras is used undispersed; the other array is fitted with transmission gratings in front of the objectives. These gratings have a ruled area of 153 x 128 mm with 300 lines/mm and are blazed for 6000 A. The dispersion is about 110A/mm in the focal plane, and the resolution at full operation is about 10 A in the center of the field and about 15 to 20 A at the edge of the field.

• **Spectral sequence camera**—One drawback of the ballistic camera is that it cannot resolve any target structure in the direction of target movement. For example, if a target is leaving an appreciable trail, whose geometric and spectral features are naturally of great interest, these features cannot be obtained from the ballistic camera record. Similarly, two targets, one immediately behind the other, cannot be resolved and may, indeed, obliterate the timing marks unless there is sufficient lateral camera motion to separate them.

Resolving target structure along the line of motion requires a "snapshot" picture, and for this purpose two cine spectrometers have been provided on the slave pedestals aboard the American Mariner. These cameras have relatively narrow fields of view and must therefore be pointed close to the target to be effective.

The cameras used for this purpose are Hulcher 70 mm rapid-sequence cameras provided with Bausch and Lomb replica transmission gratings.

A four-channel photometer system monitors simultaneously the intensity of one-re-entry object in four narrow wavelength bands in the region from 2000 A to 8000 A. Each channel consists of an f/4.6, 4-inch diameter crown-glass objective lens, a crown-glass field lens, an iris to provide an adjustable field of view, a filter and a photomultiplier tube. Presently used spectral regions are:

1. 114 A wide centered at 5896 A
2. 120 A wide centered at 7636 A
3. 37 A wide centered at 6718 A
4. 34 A wide centered at 4609 A.

Each photometer channel is linearly recorded on two Sanborn channels, one normally at full gain (i.e. the gain is set so that system noise just shows) and the other at a gain reduced by a factor of 20 or 10 depending on anticipated intensities. This dual-channel recording provided increased dynamic range. Two four-channel recorders and four dual-channel amplifiers are required for the installation.

• **Infrared radiometers**—The Model R-4K1 Radiometer was designed to meet the requirements for making radiation measurement of small, remote and fastmoving targets against a variety of day and night backgrounds. Special features were incorporated to make it effective and flexible in this application, where conventional radiometers were incapable of providing the desired functions and data. One example is the incorporation of a field of view which can be made as wide as three degrees.

The problem of background radiation was solved by the use of a space-filtering reticle, instead of the total-radiation chopper generally used in radiometers. In this instrument, space-filter chopping rejects uniform background signals by a ratio of 10,000 to 1, providing a radiometric contrast measurement of the target.

In addition to the wide-field radiometer DAMP required a research radiometer system with maximum obtainable sensitivity and with a field of view

Lightweight Maser Developed

A NEW RUBY maser amplifier, developed for U.S. Army by Hughes Aircraft, is said to be the smallest and easiest-to-operate of its kind and can extend by 10 times the range of many Army electronic systems. The "super-detector" amplifier weighs only 25 pounds and uses a 12-ounce magnet costing only $10. It was designed for an Army portable radar receiver for combat use. Such highly sensitive amplifiers also find use in space communications, ballistic missile detection, and radio astronomy.

in the order of ½° to 1°. Other basic requirements for this radiometer were ease of interchanging detector and filters. The R-12A1 Radiometer was selected because it has all of the desired characteristics. The R-12A1 radiometer system consists of two optical heads, four plug-in detector packages and two sets of electronics. It is essentially a two-channel system.

The optical system was designed to provide extreme radiation collecting power with the largest possible field of view. This was obtained through the use of a Pfund pierced-mirror optical system. This arrangement comprises a paraboloidal mirror 12 inches in diameter plus a large pierced flat mirror placed at 45° to shorten the optical path. The resulting system has an effective focal length of 14.4 inches and a focal ratio of f/1.2. The obscuration is less than 5%, and the field of view can be made as wide as ½° to 1°.

• **Infrared spectrometer**—One possible technique for distinguishing the various bodies in the re-entry complex is by means of spectral differences in their radiations. For example, the aerodynamic properties of the nose cone may result in a spectrum which is relatively rich in some wavelength range.

In order to determine the spectral characteristics of the re-entering complex, Barnes designed an infrared spectrometer to be mounted on a radar-directed pedestal. Its field of view is a 1/3° square, established by a field stop in the focal plane of a 6 in. diameter Cassegrain collection system.

• **Multi-element scanners**—One important item to be investigated in the course of Project DAMP is the radiation-time history of each of the object in the re-entry complex. In an attemp to obtain this information, a thirty-element lead sulfide scanner was rebuilt.

The optical system consists of a (in. aperature Cassegrain primary an flat secondary mirror which is oscillate from side to side to provide the scanning action. The image is swept acros a thirty-element lead sulfide detecto array placed in the focal plane of th optical system. The 30-element arra subtends a 5° vertical field with 3 mil liradian resolution, and the secondar mirror sweeps a 15° horizontal field.

Currently under modification fo shipboard use is an Eastman Kodak 50 element PbS Scanner with improve resolution. This instrument scans a field of view 3° high by 12° wide wit an instantaneous detecting element o 1 mil.

How Hawaiian Station 'Hula' Tracks Orbiting *Discoverer*

SIGNALS SENT from Kaena Point, Hawaii can change orbital period on *Discoverer* satellites. Tracking station is one of six used in program.

Discoverer satellites, in polar orbi around the earth, take their order from a tracking station called "Hula" located on a high bluff at Kaena Point Hawaii, 35 miles from Honolulu Signals sent from Kaena Point car change the programer aboard the satellite to correct its orbital period. The space vehicle then sends back a message signalling acknowledgement and compliance with the order.

During a *Discoverer* launch and orbit, the Lockheed/Air Force Kaena Pt. station—one of six AF instrumentation facilities in the program—is used to track and collect data from the satellite as well as serve as a control center for orbit correction.

The station is manned some two hours before launch time. The equipment is checked out and calibrated and voice and teletype communications are established with the Satellite Test Center in Sunnyvale, Calif.

At T minus 10 minutes, Kaena ties in to a direct voice line to the Vandenburg blockhouse to listen to the countdown and lift-off of the *Thor-Agena* vehicle.

After lift-off, launch and orbit injection data are computed by Lockheed's Scientific Research Laboratory at Palo Alto. Acquisition data is then fed to STC which sends it out to Kaena, Vandenberg, and Kodiak.

At Kaena, the tri-helix acquiring antenna is aimed by the received information and awaits appearance of the satellite. A few minutes after Kodiak announces acquisition, the *Discoverer* races into range of the Hawaiian tracking station. The tri-helix picks it up and the 60-foot TLM-18 antenna locks on the satellite. A verlort (very long-range tracking) radar, slaved to the big dish, begins tracking.

During the following hours, while

the satellite is within range, it is tracked, necessary programing commands are given, data are received.

• **Hawaiian eye**—About 26 hours after launch, Hawaii becomes the center of attention as the *Agena* completes its sixteenth pass and heads around the earth on the 17th when an attempt will be made to recover the capsule contained in the nose.

Recovery forces have been deployed. The Joe E. Mann telemetry ship is spotted at a point between Hawaii and Alaska, the RC-121 radar planes and the C-119 aerial recovery aircraft are cruising their assigned stations, and the USS Haiti Victory and Dalton Victory are patrolling the area for backup.

After crossing over Kodiak, the capsule separates and the retro-rocket fires, slowing down its orbit speed to allow it to enter the earth's atmosphere in a gradual curve. The Joe E. Mann monitors the capsule separation and retro-rocket firing with its telemetering gear. The TLM-18 antenna at Kaena picks up the capsule upon re-entry and parachute deployment and notifies the Hawaii Control Center which is directing the recovery force. With their radar, the RC-121's vector the C-119 aircraft which home in on the capsule's radio beacon. Aerial pickup can be made with trapeze-like nets suspended from the C-119's which snag the parachute with the attached capsule and reel it into the plane.

Several firsts have been accomplished with the program:

1) Launch and orbit of large, heavy satellite vehicles;

2) Attainment of polar orbit;

3) Ability to maneuver a satellite in orbit;

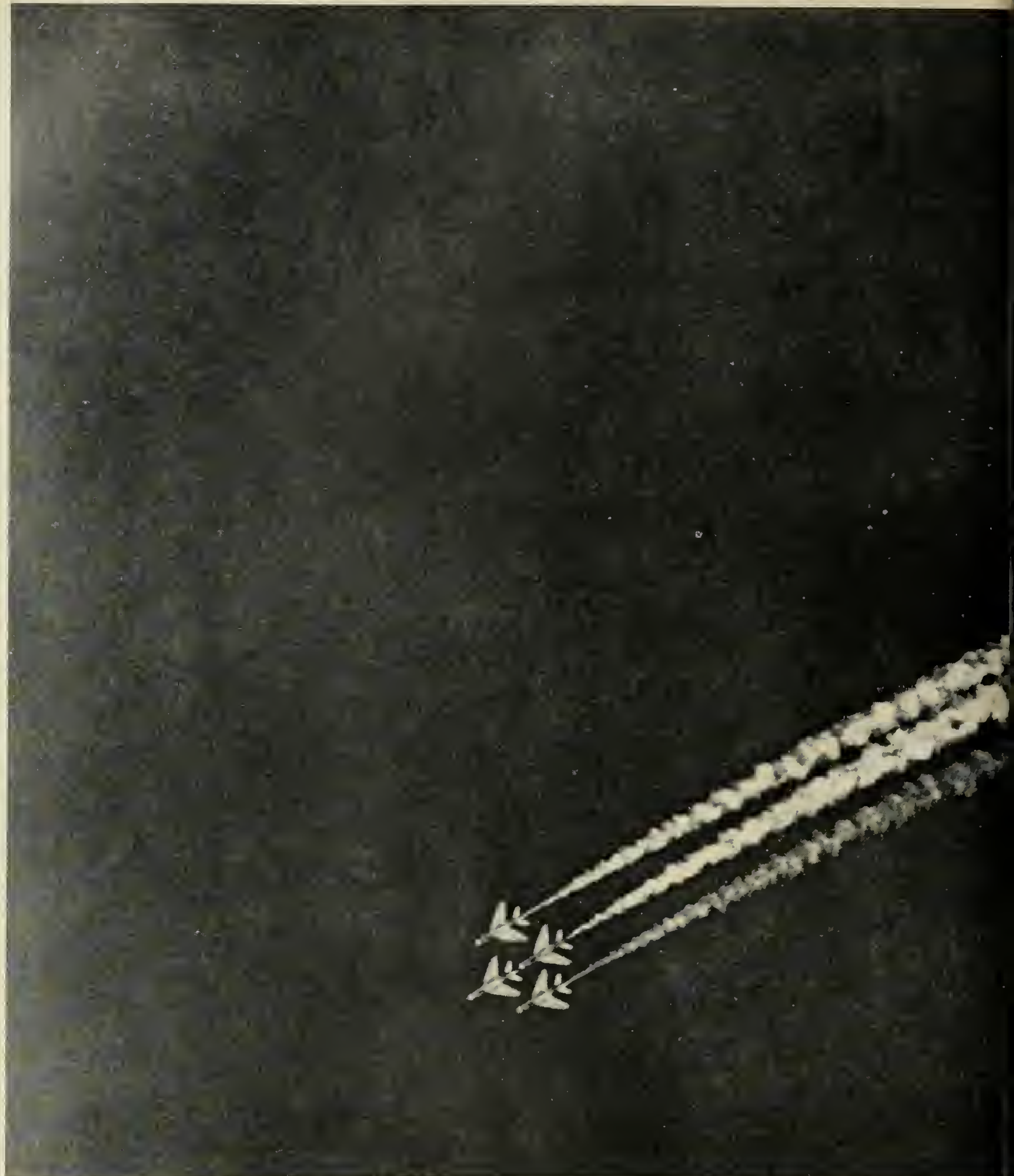
4) Stabilization of a space vehicle before and after change in attitude;

The project also claims more successful orbits than any other program and the first capsule ejection and reentry.

Discoverer Operating Facilities

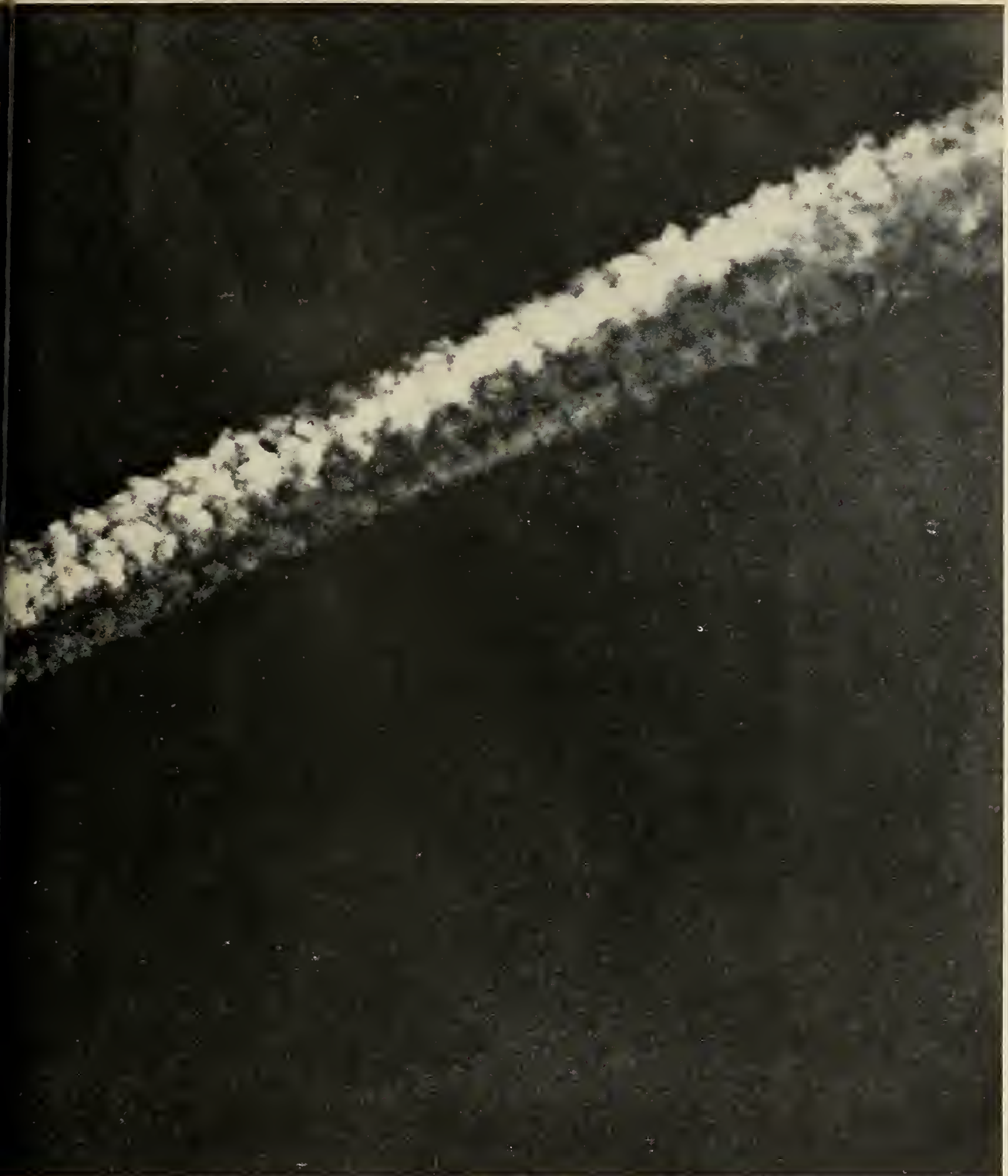
Command, control, and direction—**Satellite Test Center, Sunnyvale, Calif.**
Launch—**Vandenberg AFB, Calif.**
Tracking and Acquisition—**Vandenberg AFB, Calif.; Kodiak, Alaska; Point Mugu, Calif.; Kaena Pt., Hawaii.**
Data Processing—**Lockheed Scientific Research Laboratory, Palo Alto, Calif.**
Recovery—**Hawaiian Control Center; Kaena Pt., Hawaii; C-119 Test Squadron, Hickam AFB, Hawaii.**
Telemetry ships—**Pvt. Joe E. Mann; Kings County.**
Sea Recovery—**Haiti Victory; Dalton Victory.**

Circle No. 5 on Subscriber Service Card. →



electrical energy for the needs of motion

While the prime moving forces change as ma moves his vehicles from the highway to the sk and on into space, the all-important auxiliary powe continues to be electricity. Jet, rocket and missil contractors who are in need of reliable units fc the accurate release, transformation and contr of vital electric energy can turn to Delco-Rem for certain on-time delivery, whether the quantit be measured in tens or ten thousands.



Thiokol Details Continous Solids Mix

by Jay Holmes

MARSHALL, TEX.—Thiokol Chemical Corp. last week unveiled a continuous solid-propellant mixing process it said is capable of on-site loading of rockets weighing up to 10,000,000 lbs.

The process was developed at Longhorn Ordnance Works, which Thiokol operates for the Army near this East Texas city. Army Ordnance Missile Command this month approved a 120-day funding for final statistical checking of the process to qualify it for operational use. The cost of development to date has been about $600,000.

Apparently, the continuous mixing process will become operational this summer, about the same time the Army prepares to start producing motors for the 500-mile-range *Pershing* divisional artillery missile at Longhorn.

Thiokol has worked on continuous mixing for about three years and at an intensive rate for a year and a half. At a pilot facility here, live propellant was poured for the first time Feb. 12 into an M7 *Honest John* spin rocket. A week later, a different formulation was run through and poured into an M58, 6000-lb.-thrust *Falcon* motor. At a classified demonstration for 60 representatives of the military and prime contractors on March 30, dummy propellant was poured into the case of an XM10 *Lacrosse* motor. The pilot plant has a capacity of 1200 lbs. an hour.

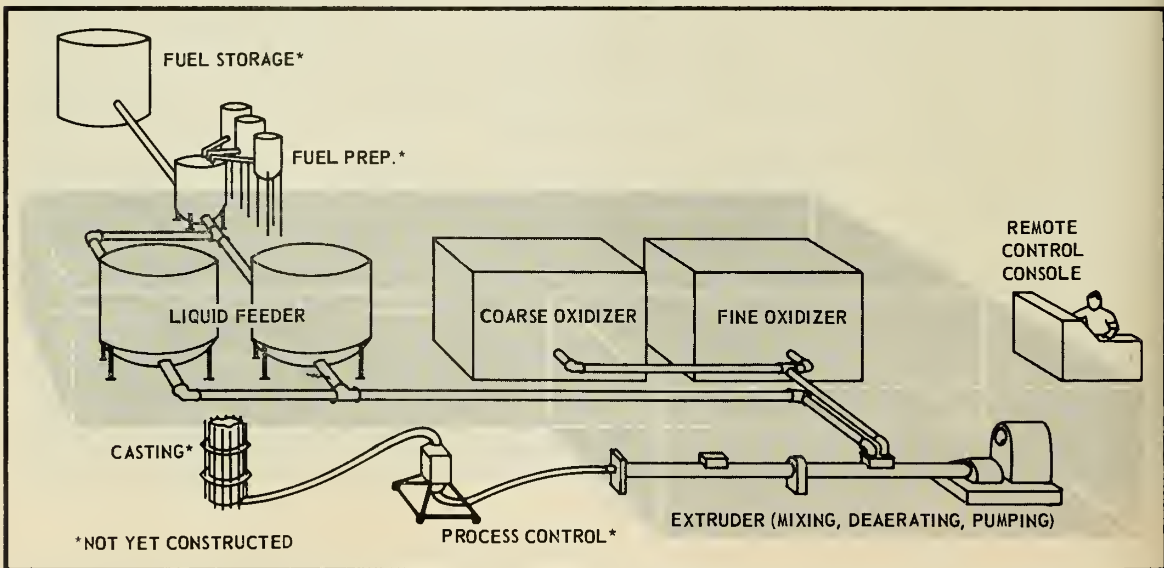
• **Extra advantages**—Everyone in the solid propellant business agrees that continuous mixing saves money, reduces hazards and improves quality control. "In mass production, the savings could pay back the cost of development within a year," says R. A. McElvogue, general manager of Thiokol's Longhorn Division.

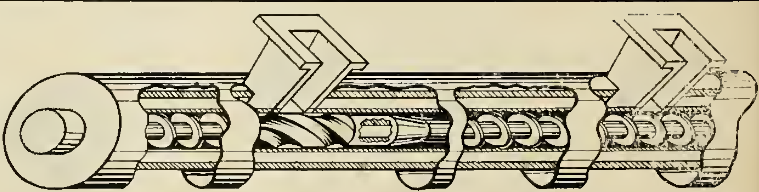
"But we see two additional advantages of continuous mixing," McElvogue adds. "First, it improves our ability to utilize high-energy propellants that are being developed. Second, it makes possible on-site loading of very large booster rockets."

Dr. H. W. Ritchey, Thiokol vice president, rocket operations, declared that continuous mixing is the key to an almost limitless expansion of solid rocket production.

• **Implications for 3059**—Although the process was developed under Army auspices, its announcement had significance in the spirited competition for the contract to develop the Air Force's Project 3059 booster of 100 million pound-seconds total impulse.

The six competitors have divided on how they would go about building such a huge rocket, which will be too large to transport from factory to launch site by rail or truck. Three companies—Aerojet-General, Grand





CONTINUOUS PROCESS developed at Longhorn Ordnance Works will start from fuel storage vat at upper left, lead into building outlined in gray. Oxidizer and fuel are mixed by extruder in second room. Extruder, consisting of variable screws, is shown in detail at right.

Circle No. 7 on Subscriber Service Card.

Central and United Technology Corp. —proposed to overcome this difficulty by casting and constructing the big rocket in segments, which would be assembled on the site.

Thiokol and Rocketdyne, however, proposed on-site loading. It could not be learned which approach was favored by the sixth competitor, Hercules Powder Co.

Both Rocketdyne and Aerojet also are developing continuous processing methods. Rocketdyne announced the concept, which it calls "Quickmix" last fall. The Navy reported the Aerojet work earlier this month.

• **Segmenting background**—Bryce Wilhite, technical director at Thiokol's Rocket Operations Center, Ogden, Utah, said Thiokol had established eight years ago, during work on the *Loki* missile propulsion system, that segmented casting was feasible. The *Loki* was built in 1952 in two segments: a cylindrical portion and a head end. He said further studies conducted in 1956 proved that several cylindrical segments could be used to build larger rockets. A rocket measuring 6 ft. in diameter was cast in a segmented case and static-tested in 1956, he added.

However, for rockets in the 2,000,000-lb. weight class, Wilhite said, the problems associated with handling each segment as a separate rocket and insulating and protecting the joint surfaces seemed to indicate that on-site loading would be more favorable.

• **Mating to come**—Ritchey said Thiokol is developing a portable on-site manufacturing plant, which is scheduled to become operational in mid-1961. The facility will be built around the continuous mixing process developed at Longhorn.

Actually, a completely continuous process is envisioned for casting on site. Nearing completion as components of the system are automatic in-process control, casting techniques and continuous pre-preparation of propellant ingredients.

The continuous mix pilot facility is in Longhorn's Bldg. 68G, a reinforced concrete three-room structure amid scrub pines in a remote section of the 855-acre reservation.

Propellant ingredients are fed into the machinery in one large room. The actual mixing takes place in a second large room. These two rooms are separated by a heavy concrete wall to protect equipment in the feeding room in the event of fire or explosion.

The process is controlled from a console room at one end of the structure. A sandbagged wall separates the console room from the operations rooms. No one is in the operation rooms during mixing. It is not considered hazardous for control personnel to be in the console room because only a very small amount of propellant is in the mixing machinery at any given time.

William E. Gravlee, process development engineer, explained that fuel, oxidizer and metal powder are loaded into the large feeds in batches at present, while the process is being developed. Soon, however, the material will be piped into the feed room automatically from remote storage facilities. Inside equipment consists of Omega-feeders bought from the Omega Division of BIF Industries.

• **Fourth feeder?**—At present, there are two solid hoppers and one liquid feeder. If the facility is set up to handle polybutadiene acrylic acid (PBAA) propellant, a fourth feeder will be installed. Polysulfide fuel and aluminum powder are mixed before arriving at the mixing room. A small rotary feed may be necessary for pre-mixing fuel.

The heart of the process is the mixing bay, a long cylindrical extruder containing a screw with three stages of threading. Fuel mix, a liquid, and oxidizer, a mixture of ground and unground solid crystalline matter, feed by pipes through the concrete wall.

The mixer, a modified rubber extruder, was built at Thiokol specifications by the Modern Plastics Co. Mixing takes place in the first stage of the screw, which gradually compresses material. The bore provides a back-feed that improves the mix. The mixed material then passes through a seal into a shallow-thread vacuum stage that removes tiny air bubbles that could constitute imperfections in the grain structure. After passing through another seal, the third stage pumps the mixed material into a rocket motor.

"We never doubted we could mix with this machinery," Gravlee said. "The question was whether we could mix to specification."

Doubts on this score were removed, he said, when statistical studies were made of the static-firings of the first two live runs. Ballistic data from these runs fell just outside military requirements. This means that with a very slight improvement of quality control—what amounts to a final trim of the process—the product can be brought within the standards for operational motors.

• **Simple expansion**—Development work during the final four months will concentrate on testing the system with other propellant formulations and expanding it at front and back to make it completely continuous.

For a different formulation, it is merely necessary to change the screw. Different taperings are required to allow for different feed rates for ingredients.

Expanding the system at the front is also relatively simple. It will require the installation of automatic feeders and connection with oxidizer grinders and fuel mixers. This equipment will be separate from the main mixer building.

At the rear of the system, the mix is to be led into a process control. Work on this component is moving rapidly, Gravlee said. The mix will be sampled and checked chemically, by X-ray fluorescence and by nuclear spin resonance. The slightest deviation of the product from specifications will actuate a feedback that will adjust ingredient feed rates.

The final step will pipe the mixed propellant slurry to the rocket case, where it will pour in and be cast.

The continuous process brings solid rocket manufacturing a long step closer to the current industrial goal of completely automatic production, untouched by the hands of fallible and mortal man.

To Hear the Roar

TINY MICROPHONE—about the size of a letter of type in this photo caption—is used to study the sound of rockets and jet engines at the Massachusetts Institute of Technology. MIT researchers, in a study sponsored by the National Aeronautics and Space Administration, have devised small instruments that add known sounds to streams of air. The microphone then picks up the sounds added because of flow instabilities. Additional basic knowledge on the nature of jet streams is expected to result from the study.

NAA Renews Orbital *X-15* Proposal

Crossfield hopes for government support; Reaction Motors engineers detail performance gains from switch in fuels

North American Aviation last week revived its proposal for an advanced version of the *X-15* rocket aircraft, eventually aimed at putting one in orbit.

Scott Crossfield, North American's chief engineering test pilot, told the national aeronautic meeting of the Society of Automotive Engineers that his company is optimistic about receiving government support.

The present *X-15* program ends this summer with the delivery of three test aircraft to the National Aeronautics and Space Administration. The first step in the new program would be the development of a Mach 10 version that could be drop-launched from a *B-52*.

The way to do this he said would be to shift to higher-energy fuels and to structural materials capable of handling higher re-entry velocities.

In another development, two engineers for Thiokol Chemical Corp., which is developing the *X-15* engine, suggested the use of an advanced *X-15* as a reliable, low-cost method of putting a man into an earth orbit.

The proposal by G. R. Cramer and H. A. Barton of Thiokol's Reaction Motors Division was made at a secret session of the SAE. However, an unclassified version of their paper was made available to MISSILES AND ROCKETS. They said the XLR-99 engine, which Reaction Motors has just delivered, could be scaled up for an orbital *X-15* with these three steps:

- Adding auxiliary droppable fuel tanks.
- Switching to a more energetic propellant combination, and
- Lifting the vehicle with a big booster rocket.

The current version of the XLR-99, which uses a LOX-ammonia propellant combination, is rated at 50,000 lbs. thrust. Assuming specific impulse of 290 seconds, 19,000-lb. propellant supply thus is able to maintain an average thrust of 50,000 lbs. for about 110 seconds.

The actual thrust performance is classified. However, Thiokol has said the engine will burn for about 90 seconds. This indicates an average thrust of about 61,000 lbs.

Cramer and Barton reported that, keeping a constant thrust-weight ratio, terminal velocity can be increased 35% by adding droppable fuel tanks.

They chose four representative higher energy propellant combinations for comparison with LOX-ammonia and examined physical and chemical compatibility requirements in relation to existing *X-15* components. In addition, the propellants were compared with LOX-ammonia on the basis of specific impulse, density impulse, thrust and thrust-weight ratio.

The four substitutions were LOX-hydrazine, LOX-hydrogen, nitrogen tetroxide-hydrazine and hydrazine-pentaborane. Their findings were:

- **LOX-hydrazine**—Substitution can be accomplished with only minor physical changes. Fuel impeller must be trimmed slightly because of higher density. To make hydrazine compatible chemically, magnesium fuel pump casting must be switched to aluminum and substitutions must be made for some elastomer materials in fuel system. Adequate cleanliness is a greater concern in fuel system than with ammonia.

Specific impulse is increased by about 6% and density impulse rises by 27%. Since substitution can be made without changing chamber pressure, thrust and thrust-weight ratio will not change materially.

However, if propellant flow rate is increased to the full capacity of existing pumps and the thrust chamber throat is enlarged slightly without changing chamber pressure, the engine produces a thrust of almost 100,000 lbs. and thrust-weight ratio rises 46% —without sacrificing safety factors necessary for a manned vehicle.

- **LOX-hydrogen**—Low density of liquid hydrogen requires threefold increase in pump volumetric flow capacity but the low viscosity enables this to be accomplished with pressure drops actually lower than in ammonia system. All metallic materials are chemically compatible with liquid hydrogen, but most of the elastomers would shrink and harden. Material substitutions will solve this problem.

Specific impulse is increased 38% over LOX-ammonia. Density impulse, however, falls to about half of LOX-ammonia. Thrust and thrust-weight ratio again are unchanged if chamber pressure remains the same. But if flow rates are increased and the chamber throat is enlarged slightly, the thrust level and the thrust-weight ratio can be increased 28%.

- **Nitrogen tetroxide-hydrazine**—No difficulty is encountered in adjusting the pumps for this change. Chemical compatibility requires the same changes

THE *X-15:* **an artist's conception by Mel Hunter for Purolator Co.**

in the fuel system outlined for LOX-hydrazine. Similar changes must be made in the oxidizer system.

Specific impulse is about the same. Density impulse increases about 30%. Thrust remains the same unless the thrust chamber throat size is increased and pumps uprated. In the latter case thrust rises to over 100,000 lbs., thrust-weight ratio climbs more than 60%.

• **Hydrazine-pentaborane**—Here the hydrazine, formerly a fuel, becomes an oxidizer—nitrogen and boron combining to form boron nitride. The same changes as outlined above are needed for hydrazine compatibility. Certain elastomers must be replaced for compatibility with the pentaborane.

Specific impulse is 19% higher than LOX-ammonia. Density impulse is 4% greater. At constant chamber pressure, thrust rises slightly, because of the lower molecular weight of exhaust products. If the pumps are uprated to full flow, thrust rises 25% and thrust-weight ratio climbs 31%.

Not all of the increased specific impulse shows up as increased thrust. The remainder in each case would result in increased burning time.

Cramer and Barton did not discuss what booster would be used to lift the system. They indicated merely that the booster would be in the thrust class of a million pounds or more.

However, they gave comparative figures for payload in orbit and terminal velocity based on a fixed gross weight and a fixed booster. Setting 100 as the figure for LOX-ammonia, they said velocity would be 119 for hydrazine-pentaborane and 139 for LOX-hydrogen. Payload would be 151 for hydrazine-pentaborane and 193 for LOX-hydrogen.

More than two years ago, North American proposed an orbital *X-15* based on the G38 *Navaho* booster (3 chambers, about 400,000 lbs. thrust, LOX-RP) and the S4 *Atlas* sustainer. Those were the engines available at the time that seemed most suited. It can be assumed that the new proposal depends on later engines for boost.

How to Propose a Research Program

by Charles N. Bernstein*

The continually increasing demands of the missile developer and user for higher and higher performance provide a tremendous incentive to the propellant and propulsion scientists. They have within their hands the capability of effecting major changes in the missile and space pictures.

In solid propellants, however, the point is rapidly being reached where current systems are attaining the performance limits set by thermodynamics. It is evident, therefore, that a new and daring scientific bag of tricks must be created in order to provide a broad spectrum of varied knowledge which will enable the propellant developer to make major jumps in performance.

The primary objective of this article is to outline a *modus operandi*, from the research management viewpoint, which will best utilize the reservoir of talent that must be exploited for solid propellant investigations. Some of the general conclusions will apply equally to the liquid area.

Despite the urgency of the current situation, the scheduling of research, in the narrow sense of the word, is unrealistic. Granting hunting licenses for areas likely to contain the more attractive "varmints" is certainly one way to do the job; but how can we be sure that some unpredicted creature is not lurking in a place nobody had the foresight to explore?

The only safe procedure is to make the ability to perform imaginative research your prime criterion in selecting a group to do the job.

The person in a position to make the necessary decisions is literally being bombarded with proposals and ideas. It is obviously impossible—and in fact undesirable—to sponsor more than a small fraction of them. How, then, does one select the most fruitful avenues to pursue and the best organizations to support?

• **Criteria**—First, the reputation, background and record of accomplishment of the organization must, of course, be taken into consideration. It is not necessary that all of this background be in the relatively limited area of solid propellants. A great deal of the technology and know-how developed primarily for liquid propellant systems is now directly translatable to solution of associated problems in the solid area.

The second criterion relates to research goals. Can the proposer define the objective he is trying to reach? Even in the purest of research programs, the investigator should be able to describe, in at least general terms, what he is trying to do even if it has no relationship to any practical application. Looking at the other side of the coin, be suspicious of the research proposal that provides in the minutest detail all of the steps leading to the stated goal and almost guarantees results.

The third criterion can best be answered by asking the question, "What are the consequences of success?" Recognizing that most research proposals offer a potential promise of providing something different from what now exists, this does not necessarily mean that any improvement will be accomplished. However, research enthusiasm is a God-given attribute that we must catch at its crest and direct into useful channels.

In evaluating a research proposal, the reviewer's intuition and experience are very useful but not enough.

• **Uncertainties**—Unfortunately, it is not always possible to perform calculations which unequivocally demonstrate the value of the particular approach. This deficiency stems in part from important gaps that still exist in available thermodynamic data. A somewhat different area of uncertainty derives from the fact that performance of a new ingredient is usually calculated on the basis of a composition in which the other ingredients are known or postulated. The new ingredient, however, may be optimum in a composition which has not yet been dreamed up. In spite of these problems, it is still possible to recognize the interesting areas to pursue.

Although advanced research and high performance have been emphasized in this discussion, there are many other propellant problems that require solution. A number of these are in development, design and engineering. For such problems, competence and background of an organization are a dominating factor in contract award. The rocket groups obviously occupy a strong position because of their great experience.

The main intent of this presentation has been to show that talent should be used wherever it exists and that great care should be taken in selecting projects for support that meet the criteria of organization reputation, defined research goals and the consequences of success. It must be recognized, however, that research always involves capital risk and that it is impossible to guarantee results.

**Charles N. Bernstein is a group scientist, propellants and polymers research, with Rocketdyne Division, North American Aviation. He was formerly head of the Supporting Research Section, Surface Weapons Propulsion Branch, Navy Bureau of Ordnance.*

Market Opening for Beryllium Sheet

by **Rebecca H. Sparling***

Beryllium sheet has a big future in missile structures, Convair/Pomona materials researchers feel on the basis of test results.

Beryllium has a weight only 25% that of steel but 140% of steel's stiffness. Since stiffness is just as important as strength in many designs, particularly those involving sheet metal, the lighter metal is a natural candidate for missile use.

One calculation has showed that if a short-range ballistic missile made of steel, with a weight at launching of 4000 lbs., were re-designed for beryllium, the weight would drop to 3500 lbs.—a 12½% reduction—and the range would increase 60%.

But there are several problems facing designers who want to use beryllium. First, not much metal has been available for test and evaluation. Until very recently, beryllium has been used primarily by the Atomic Energy Commission for purposes other than structural, and chiefly in the form of blocks. Second, missile engineers want sheet for maximum efficiency and minimum weight—and beryllium sheet was not even considered possible until 1959. Third, more mechanical property data on the effect of temperature, strain rate, direction of rolling, and other variables, must be available before parts can be designed with any degree of confidence.

Another disadvantage to beryllium is the $100 per pound cost for sheet. But there are still some applications where usage is practical, even at this price.

To learn more about beryllium, Convair/Pomona materials research sponsored a test program on beryllium sheet supplied by the Air Materiel Command. Answers were sought to the following questions:

- Does beryllium have a good strength/weight ratio above room temperature, when heated and loaded rapidly?
- Is the high modulus of elasticity quoted for beryllium affected by the direction of rolling?
- How bad is beryllium's poor ductility?

Low ductility is a major worry in missile design. Interceptor-type missiles encounter very rapid loads in service, which encourage brittle failures even in metals which are usually ductile. Also, missiles are liable to be bumped during shipping, or in normal shop handling. A really brittle material will have limited usefulness for missile structures, no matter how good it looks on paper. We investigated this low ductility very carefully.

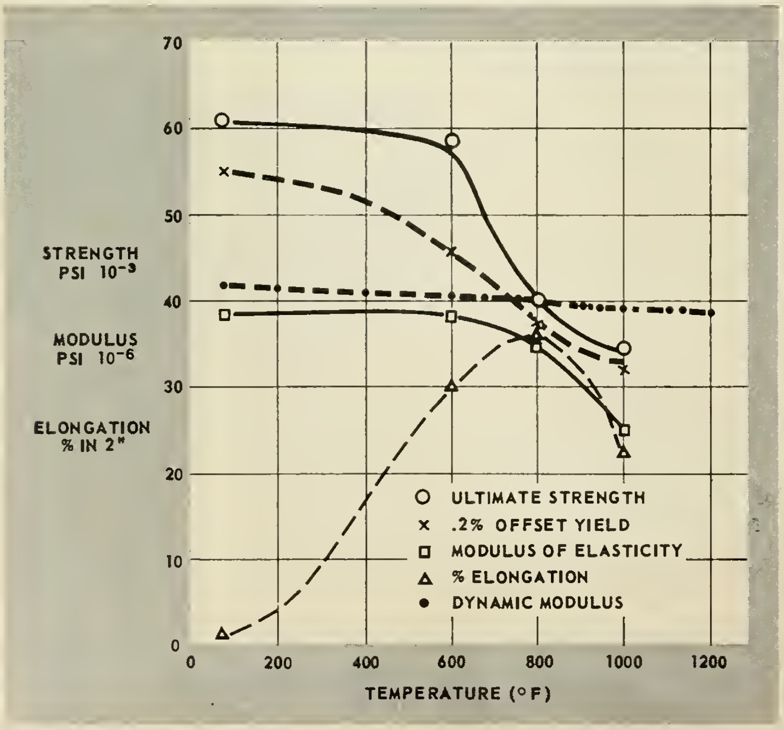
The test program included some fifty-odd coupons from beryllium sheet 0.040 in. thick, tested at strain rates from

Table I Tensile Properties of Beryllium Sheet*

Temperature, °F		Yield 1,000 psi	Ultimate 1,000 psi	Elong. % in 2"	Modulus 10^6 psi
R.T.	MAXIMUM	60.6	73.5	2.5	41.0
	MINIMUM	50.8	50.8	0.2	34.9
	**AVG. OF 9 COUPONS	55.0	60.0	1.0	38.0
600	MAXIMUM	49.6	64.8	34.0	41.0
	MINIMUM	42.9	53.0	25.0	35.3
	AVG. OF 8 COUPONS	46.0	58.3	29.9	39.2
800	MAXIMUM	43.3	48.0	51.0	37.4
	MINIMUM	35.1	36.8	27.5	28.8
	AVG. OF 15 COUPONS	38.1	40.1	36.3	34.1
1,000	MAXIMUM	37.3	38.1	32.0	33.8
	MINIMUM	29.2	29.4	17.5	17.7
	AVG. OF 12 COUPONS	33.1	33.6	22.4	24.1

* Only etched coupons included.
** 7 unetched coupons gave comparable average but wide range.

Beryllium Sheet Strength Characteristics



*Mrs. Rebecca H. Sparling is staff consultant for materials at the Convair Division of General Dynamics Corp. Pomona, Calif.

0.004 in./in./min. to 0.20 in./in./min. Test temperatures were 80°, 600°, 800° and 1000°F. with coupons heated at a rate of about 200° a second, to simulate aerodynamic heating during flight. Dynamic modulus tests were also made from room temperature through 1200° F. The results (shown in Figure 1 and Table 1) answered our questions in the affirmative.

The good strength/weight ratio of beryllium is maintained up to 1000°. The modulus is high in both the longitudinal and transverse directions. The low ductility at room temperature will probably be a problem in design, but it is not severe enough to cause breakage from normal handling. It is no worse under rapid loading. At 600° and above, there is enough elongation to permit forming parts.

Here are details of the test results:

• **Strength/Weight Ratio**—Beryllium's strength/weight ratio is excellent. It is as good as, and sometimes better than, semi-austenitic precipitation hardening steels up to 1000°F. Furthermore, we think that the agreement between coupons was exceptionally good for such a new material, and for one of the first attempts to roll beryllium into sheet. As other work on extra-pure beryllium, and new alloys of beryllium, gets under way, no doubt the strength will be increased appreciably.

Table I lists the maximum, minimum and average values for 0.2% offset yield strength, tensile ultimate, % elongation at fracture, and the modulus of elasticity. Four coupons which broke in the grips before loading, or had obvious defects in the material as one did, were not reported.

• **Modulus of Elasticity**—No effect of directionality was observed. The longitudinal coupons tested at room temperature were slightly stronger than the transverse ones, but the difference was so small that no conclusions can be drawn. At other temperatures, the direction had no significance at all. The modulus was not affected by direction at any temperature.

The results of the dynamic modulus tests are listed in Table II. The dynamic modulus does not decrease nearly so fast with rising temperature as the static modulus, no doubt due to

Table II Effect of Temperature on Dynamic Modulus of Beryllium

Temperature °F	Dynamic Modulus 10^6 psi
75	42.1
200	42.0
400	41.8
600	41.3
800	40.5
1,000	39.6
1,200	38.5

Table III Strain Rate Effect on Beryllium

Temperature °F	Strain Rate in/in/min.	Yield Relative Standing	Yield 10^3 psi	Ultimate 10^3 psi	Elong. % in 2"	Modulus 10^6 psi
R.T.	Max. .204	1 of 9	60.6	73.5	2.5	39.1
	Min. .004	3 of 9	55.2	65.8	2.0	37.0
600	Max. .186	2 of 8	48.7	64.4	25.0	38.3
	Max. .186	8 of 8	42.9	56.5	34.0	39.0
	Min. .004	1 of 8	49.6	64.8	27.0	41.0
800	Max. .075	10 of 15	36.9	38.9	38.5	28.8
	Min. .004	6 of 15	38.1	38.9	BOM	35.3
1,000	Max. .096	4 of 12	34.4	34.8	19.0	17.7
	*Min. .020	8 of 12	32.6	33.4	28.0	18.5
	Next to slowest .050	5 of 12	33.7	34.1	8OM	31.8

* The slow rate could not be maintained because the coupon crept so much.

the creep which is present in high-temperature tensile tests. The coupons in the dynamic modulus tests were not loaded, but vibrated at their resonant frequencies without any load.

• **Strain-Rate Sensitivity**—From our tests, it does not appear that beryllium is sensitive to changes in strain rate. At room temperature, the two strongest coupons were those pulled at the fastest strain rate, but there was no correlation between strain rate and strength among the other seven coupons pulled at room temperature, nor among those tested at elevated temperatures. Table III points this out.

Although the slow strain rate of 0.004 in./in./min. could be maintained without trouble at 600 and 800°, the beryllium started to creep so fast under load at 1000° that we had to increase the strain rate. The coupon listed as pulled at 0.020 in./in./min. at 1000° actually strained at a much higher rate after yield. For that reason, the second slowest coupon tested at 1000° is also included, with the thought that the 0.020 in. strain rate might not be representative.

In an effort to evaluate the effect of strain rate, we chose the relative standing in yield strength as the criterion. The highest yield strength at each temperature would be 1, the next highest 2, and so on. We also checked the relationship, if any, between strain rate and modulus, and strain rate and elongation. The conclusion is that beryllium is not affected by changes in strain rate within the limits of our tests.

• **Ductility**—The ductility of beryllium, as measured by elongation after fracture, was poor at room temperature, good at 600° and 800°, and dropped off again at 1000°. But elongation is not an adequate measure of the ductility of sheet. We also checked the reduction of width of the coupons at the point of fracture; however, these values correlated very closely with the elongation. Another way to estimate ductility is by the difference between the 0.2% offset yield strength and the tensile ultimate strength. These figures, listed in Table IV, again emphasize the superiority of 600° so far as ductility goes. We think this may be the optimum temperature for hot forming beryllium parts.

Table IV Difference Between Yield and Ultimate

Temperature °F.	Difference 10^3 Psi Max.	Min.	Av.
75	13.8	0	5.7
600	15.7	9.4	11.1
800	4.7	0	2.2
1,000	0.8	0.2	0.5

• **Future use**—In spite of low ductility, high cost, and necessary health precautions, beryllium has a bright future for missiles and aerospace vehicles. No other structural metal offers such high stiffness with such low weight. In the short time that work has proceeded on rolling beryllium sheet, enormous strides have been made. The improvements resulting from present programs on high-purity, alloys, zone-melting, etc. will no doubt improve the mechanical properties of this attractive metal. And with increased usage will come lower cost.

So much has been said about the very high temperatures encountered by missiles, that we sometimes neglect all the parts which are not hot! For such applications, beryllium will help missile designers reduce weight and improve performance.

Raincoat Process Applied To Mixing of Solid Fuels

A process developed in World War II for production of vinyl raincoats now is used for mixing solid propellant.

Atlantic Research Corp. uses the technique in obtaining the desired rubbery consistency in its polyvinyl chloride-based propellant. Union Carbide Corp. developed the process which uses a plastisol.

A plastisol is a dispersion of vinyl resin particles in a plasticiser. The mixture fuses into a tough, rubbery material when heated to about 350°F. In the solid-propellant formulation, the resin and plasticiser is mixed with aluminum powder and ammonium perchlorate. The perchlorate is the oxidizer and aluminum increases the temperature of the flame, thus increasing the specific impulse.

In the Atlantic Research process, the four ingredients are mixed into a mud-like slurry. The plastics used are

POURING polyvinyl chloride-based propellant at Atlantic Research Corp.

based on Bakelite vinyl chloride resins produced by Union Carbide. The raw mix is poured into a mold that is steam-heated through the outer jacket and usually the inner mandrel.

After heating, water cools the grain and it is trimmed before loading into the rocket case.

Atlantic Research propellant powers such rockets as the *Arcon* and *Arcas,* high-altitude sounding rockets, and the *PET* (propellant, experimental test), which performs spin and retro functions on larger rockets. Since all of these are relatively small, Atlantic Research spokesmen said, there has been no requirement for case-bonding. However, they say it is possible to case-bond polyvinyl chloride-based propellant.

Improved Oxidizers

Thiokol Chemical Corp. reports discovery of improved methods of producing three new nitrogen-fluorine compounds used as propellant oxidizers—dinitrogen fluoride, dinitrogen difluoride and difluoramine.

Step-Up in Materials Testing Urged

Researchers score lack of background materials design data; say early space testing is critical requirement

by William J. Coughlin

SANTA BARBARA, CALIF.—Establishment of a large-scale national program for testing space age materials in space has been called for by three members of the Lockheed Missile and Space Division.

"We have to considerably increase our knowledge of the performance of basic materials in space," they told a three-day session of the American Rocket Society here. "At the present time our knowledge of the effects of the space environment on the behavior of materials is not complete, especially when we are required to design satellite systems for reliable operation for prolonged periods of time."

The proposal for a stepped-up test program was made in a paper delivered by Morris Steinberg, J. J. Fox and Bruno Augenstein to the ARS conference on Structural Design of Space Vehicles held April 6-8. The meeting, sponsored by the Structures and Materials committee of ARS, drew more than 300 industry and government specialists from throughout the nation.

"First of all," the Lockheed personnel said, "we have to learn more about the actual environmental conditions, especially the many simultaneous environments existing in space. Secondly, we have to determine the effects of these special environments on our materials, and thirdly, we have to determine ways of improving our materials and establishing criteria by which we can select materials for appropriate jobs with confidence that these materials will operate successfully and usefully."

• **No design info**—They said the large background of information required to design high-confidence but not over-conservative systems does not yet exist. A list of some of the problem areas where further knowledge is needed included:

• Erosion of surfaces and finishes by meteoritic matter.

• Long term radiation effects on organic material such as Teflon or lubricants, or on dielectrics and solid state materials.

• Sublimation and evaporation of materials in a vacuum.

• Friction and lubrication in bearing surfaces, switching contacts and gear trains.

• Degradation of organic materials by the short-wave end of the solar spectrum.

• Permeability of thin shells such as those used in space structures rigidized by internal pressure.

• Behavior of thin films of material.

• Possible problems of sputtering of materials by incident atomic and molecular surface bombardment.

• Damage to materials by corpuscular radiation from the sun.

• Problems arising from leakage radiation produced by a nuclear source.

"It will be noted that these typical problems involve damaging effects to either electrical, mechanical or optical properties of the vehicle and its components, all of which are of significance to the vehicle operation," they said. Some, it was acknowledged, may turn out to be phantom problems.

"In any event, until we can be confident that these are phantom problems or that we can correctly design against these problems, uncertainties will exist in our ability to fully exploit the great potentialities of space systems," they declared.

To remedy the situation, an "immediate, vigorous and carefully-planned" program of ground and space research and testing was proposed. The program places heavy emphasis on testing in space.

"Although this program seems to differ, at least initially, in some ways from the ballistic missile test program, which is keyed towards ground testing . . . we expect that the majority of the test work will ultimately be done in ground tests, once the requisite knowledge, facilities and techniques are available and well established, and have been shown to be adequate," the three men said.

• **Five-point program**—The proposed five-point program calls for:

• An increased effort to obtain complete information on geophysical environments. "Much of the current scientific measurement program is perforce of a cream-skimming nature, and does not permit us to state in an unambiguous fashion that possible difficulties are phantom problems, nor does the current program in most cases give very useful design information," the Lockheed researchers charged.

• Immediate initiation of complementary ground and space testing programs for materials, with early and urgent emphasis on space testing. "Initially, because of geophysical uncertainties and because of difficulties of ground simulation, there will be an urgent requirement for space testing," it was stated. "Furthermore, many of the ground facilities are still in the planning stage and will not be available for some time . . . Consequently, there will be considerable motivation for a number of early tests to be done in space. Once we have learned more about the space environments, have developed the capability to simulate them as well as we need to, and have determined that we can test effectively in our ground laboratories without having to duplicate simultaneously all the space environments, more of the testing burden should fall to the ground laboratories."

• Consolidation of accumulated data into one source, with periodic revisions and up-dating. "Our knowledge of the geophysical environments and the response of materials to these or analogous environments, as determined in ground testing and in space testing, is scattered through a great many literature sources," it was stated. "In this form the information is not very accessible and cannot easily be brought up to date. Furthermore, the information is not often cast into a form most useful for design purposes."

• Initiation and extension of theoretical studies relating to the interaction of environments and the response of materials. "Some of these studies can tell us how to extrapolate our meager theoretical knowledge and experimental data to other situations, other studies can clarify the physical mechanisms involved in degradation of materials, and still others can help us in designing unambiguous experiments in our ground and space testing program."

• Initiation of a test program at high or extreme values of the environmetal parameters wherever such tests are possible. "Such studies can have a number of consequences," the researchers stated. "In some cases problems of measuring instrumentation could be simplified; in other cases the material response to hyper-environments would provide critical tests of a theory and would allow more confidence in the extrapolation of that theory to a variety of different situations. A most important consequence would be the possible compression of testing time in our ground laboratories, if correlations could be shown between long duration tests in a conventional environment and accelerated tests in hyper-environments."

• **Cite Lockheed's work**—To back up their proposal for a national program, the three men cited the extensive materials testing program underway at Lockheed Missile and Space Division.

Plans for construction of a large LMSD environmental facility to simulate some of the space environments are in the advanced design stage, it was disclosed.

A major LMSD program also is underway to study the stability of various temperature control coatings under combined vacuum, temperature, and ultraviolet radiation and under rapid ascent heating.

Among in-flight experiments under consideration at Lockheed are:

• A flyable package that will investigate a number of mirror materials by utilizing a point light source and a photocell or thermopile and intermittently comparing the values of the incident and reflected energy. This will be used to study rate of deterioration of mirror reflectiveness, of major interest where mirrors are used in satellite solar power packages.

• An "oriented cube" in a noon polar circular orbit to measure the sputtering process which results in the ejection of an atom, molecule or ion of a surface material when it is bombarded by an external atom, ion or molecule. It also would measure micrometeorite erosion. An oriented cubical satellite will be used since it can measure effects on sides facing only the earth and only the sun as well as the varying combinations.

• An experiment in which bearings will be operated in a special tester carried aboard a satellite, with the operating characteristics and failure times of the bearings to be telemetered to earth. Running torque of the test bearings will be indicated by strain gage transducers and the variation of the transducer output will be directly related to torque. Failure points as well as temperature readings via thermocouple signals will also be available.

Motor power consumption also will be measured. As bearing torques increase, motor power consumption can be expected to increase. When a failure point is reached, the bearing will be pulled out of the system. A sharp drop in motor power consumption should be detectable, giving a second check on the failure point of that bearing.

• Space experiments in the "not-too-far-distant" future to study a number of methods of rigidization of inflatable structures.

• **Stress composites**—Several papers stressed the use of composite materials to overcome some of the space difficulties cited by the Lockheed team. Hans Schuerch of Astro Research Corp. told the group that many undesirable side effects of certain materials may be overcome by selecting combinations of sceletal and matrix materials that exhibit different types of materials response to the particular environment for which the composite material is designed.

Emphasis placed on inflatable space vehicle structures . . .

SANTA BARBARA, CALIF.—Heavy emphasis was placed on the use of weight-saving inflatable structures for space vehicles and manned space stations at the American Rocket Society conference here.

Some of the designs for expandable structures included:

• A "link sausage" space station proposed by Emanuel Schnitzer, aeronautical research engineer at the National Aeronautics and Space Administration, Langley Research Center. The erectable interrupted torus would be carried aloft unmanned in the nose cone of a space vehicle and inflated on station. Its two-man crew would rendezvous with the space laboratory in a taxi of the Dyna-Soar type. Powerplant would be an inflatable solar energy collector, although this might be replaced by a nuclear powerplant similar to *Snap II*. The 40-ft. diameter station would spin at about six rpm to provide gravity of a quarter G force. Gross weight of the station, which would carry food and water for 60 days although designed to a minimum station life of one year, would be 15,000 lbs.

• Rocket-powered land vehicles, helicopters and aircraft for surface exploration of Mars, suggested by Rand Corp. engineer Francis T. Cartaino. Powerplants would be rocket turbines consisting of a fuel and oxidizer source, a combustion chamber similar to a rocket motor, a multistage turbine and a reduction gear. Cab of the Martian truck would be of lightweight pneumatic construction consisting basically of rubber impregnated fabric similar to that used in the Goodyear Inflatoplane. Body and rotor blades of the helicopter would be of inflatable construction with the landing gear, powerplant and fuel tanks the only major metal components. This also would be true of the proposed airplane, a twin-engine high-wing monoplane similar to present-day aircraft. It would be equipped with rough field fixed landing gear and cruise at 180 knots. The rocket engines would drive unusually large propellers due to the low atmospheric density, equivalent at Mars' surface level to about 55,000 ft. earth altitude, but otherwise the aircraft would appear almost conventional.

• A space station converted from the empty fuel tanks of the final stage booster. This was proposed by NASA's Kurt Stehling, who said space available in the tankage could be supplemented by inflatable structures, probably of a fiberglas reinforced plastic or neoprene sealed fabric.

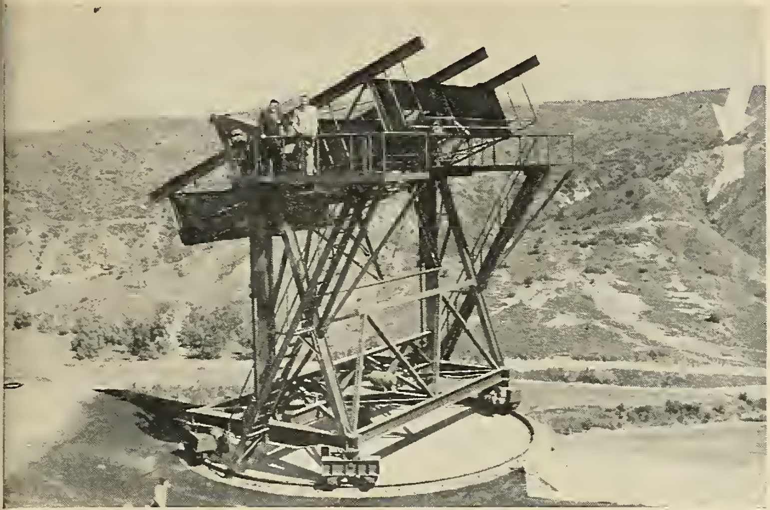
• A two-man inflatable space station with a usable volume of 5000 cu. ft. for a structural weight of 2600 lb., proposed by Goodyear Aircraft Corp.'s Frank B. Sandgren and James T. Harris. Total station weight would be 6000 lb., including life support, laboratory and communications equipment; solar power converters; and food and medical supplies for six days. Boost package would be a filament wound rigid fiberglass cylinders 10 ft. in diameter and 28 ft. long, weighing an estimated 1000 lb. This would become a zero gravity laboratory forming the hub of the inflated torus. The fabric torus would provide living quarters 30 ft. in outside diameter with a seven ft. diameter cross section. Sandgren said such an inflated structure would provide ample safety at far less weight than a rigid structure. The structure could be "rigidized" by blowing quick-setting plastic foam between the walls or by use of castable neutron shielding materials. The Goodyear engineers also suggested that a 14-man expandable station could be packed into a compartment 10 ft. in diameter and 40 ft. in length, the space available in the final stage of the *Saturn*.

Among the non-inflatable designs discussed at the meeting were:

• A non-recoverable three-man 14-day orbiting scientific laboratory of aluminum sandwich construction proposed by J. W. Bilodeau and D. M. While of the Astronautics Division of Chance Vought Aircraft, Inc. The system includes an entry vehicle design to transport occupants to and from the orbiting station. Combined weight of the laboratory and entry vehicle is approximately 15,000 lb., limiting boosters to the *Saturn* class. The Chance Vought engineers said, however, that use of the modular concept in contrast with one integrating the laboratory with the entry vehicle showed a 20-30% weight saving.

• A winged and recoverable rocket booster on which Convair Astronautics has carried out preliminary design studies under an Air Research and Development Command contract. These studies indicate a first stage winged booster will be about 60% greater in size and weight than conventional boosters.

mergers and expansions



This huge rotatable antenna mount is part of Hughes Aircraft Co.'s new $225,000 advanced radar test center just put into operation near Yorba Linda, Calif. The mount can handle an antenna weighing up to 25 tons, turn a full 360 degrees, and tilt up to 90 degrees. It will be used in testing advanced military antennas in conjunction with a transmitter site (arrow) 4000 feet away on the other side of the canyon.

MISSILE R&D FIRM FOUNDED: Unified Science Associates has established facilities for basic research and development in Pasadena. The independent firm will conduct basic R&D in propulsion, cryogenics, data storage, heat transfer, optics and infrared.

Dr. S. Naiditch, formerly with Electro-Optical Systems, Inc., is president of the new company. Members of the scientific staff include Dr. Stuart Fisher, previously with Space Technology Laboratories, and Dr. Phil Taylor, formerly with Aerojet-General.

CLARY SELLS DIVISION: The Clary Corporation, designer and manufacturer of electronic computers, data handling equipment, and mechanisms for guidance and propulsion systems used in missile programs, has sold its adding machine and cash register division to Remington Rand Division of Sperry Rand Corp.

WALTHAM ACQUIRES ELECTRO-MEC: Waltham Precision Instrument Co.'s sales are expected to be increased 50% by the acquisition of Electro-Mec Laboratory, Inc., of Long Island City, N.Y.

GOODRICH PLANT TO TRIPLE: B. F. Goodrich Co.'s rocket motor plant in Rialto, Calif., will be expanded to three times its present size. Facilities under construction include an office building, R&D area, and production equipment.

LITTON EXPANDS IN CANADA: Litton Industries has acquired the Canadian subsidiary of Servomechanisms, Inc. (Servomechanisms, Ltd.) in a recent cash transaction. Already specializing in development and production of equipment for airborne electronic and electromechanical instrumentation, the Canadian operation will be expanded with emphasis on advanced electronic products including inertial guidance systems for the RCAF Lockheed CF-104.

SIEGLER MERGES: Siegler Corp. stock is being exchanged for three and one-half shares of Magnetic Amplifiers stock.

SYSTEMS OPERATION FOR GT&E: A Systems Engineering and Management Operation has been established within Sylvania Electronic Systems, a division of Sylvania Electric Products, Inc. The new operation will represent GT&E in all activities relating to large military systems contracts, with headquarters in Needham, Mass.

PEARCE-SIMPSON EXPANDS: The Miami electronics manufacturer has established a Molded Plastics Division. The plant was formerly known as the Varney Plastics Co.

ESCO BUYS ELECTRO: The Electro Switch Corporation of Weymouth, Mass., has purchased the assets of Electro Contacts, Inc., Osterville, Mass.

PSI MOVES: Reliability functions of Pacific Semiconductors, Inc. have moved to large new quarters in Hawthorne, Calif. PSI produces microminiature diodes, transistors and other semiconductor devices.

ALLIED RESEARCH DIVIDED: Allied Research Associates has formed two divisions, Research and Engineering. Daniel J. Fink will lead the former and Roger S. Warner the latter.

financial news

Teleflex, Ltd.—Net sales climbed 52% to a record $6.2 million from $4 million in 1958. Earnings jumped 73% over the '58 figure, from $151,362 to $262,273. The company succeeded somewhat in decreasing its dependence on sales of control systems for military aircraft, which accounted for 48% of total sales in 1959, as opposed to 62% in 1958 and 76% in 1957.

• **Motorola Corp.**—Motorola broke two company records with an increase of sales of 33% and earnings 92% over 1958. Fourth quarter sales of $83.5 million were also high for the period, and earnings of $4.69 million the highest since 1950. Total 1959 earnings were $289.5 million.

• **Borg-Warner**—Sales for 1959 hit an all-time high of $469.9 million—an increase of 21.9% over 1958.

• **IT&T**—International Telephone and Telegraph Corp. showed a record year for sales and revenue. Total sum was $765.6 million or 11% over 1958.

• **Hazeltine Corp.**—Gross income including royalties declined from the 1958 peacetime peak of $62 million to $55 million, due in part to 1959 being a heavy development year. Net income rose almost 21%.

• **American Electronics**—American Electronics, Inc., reported net earnings of $609,599 for 1959 as compared to a net loss of $2.3 million in 1958. Net sales totaled $25 million, a 44% increase over the $17 million registered in 1958.

• **Republic Aviation Corp.**—Republic reports sales of $198 million with profits after taxes of $3.4 million, a drop from 1958 net sales of $218 million and net income of $5.1 million. Backlog at beginning of 1960 was $511 million.

Soviets Optimistic on Space Flight

Unlike most U.S. scientists, Russians minimize hazards other than re-entry, which they expect to solve soon

by Dr. Victor P. Petrov*

Recent Russian publications indicate a difference of opinion between U.S. and Russian scientists as to how soon man will be able to undertake meaningful space flights.

Most U.S. scientists prominent in the study of space flight have predicted that extended flights into space will be extremely hazardous because of cosmic radiation and related solar activity. A sudden flare-up in this activity, according to many of them, could quickly disintegrate the space ship.

The published writings of Soviet scientists in this area do not agree with these gloomy predictions. The Russian scientist B. S. Danilin, in a recent article, stated that according to data received from the Soviet *Luniks,* extended space flights are possible, that at present it is feasible to map out the existing problems quite accurately.

The main problem, Danilin said, is to return the astronaut safely to earth. Most of the other problems connected with space flight have been studied thoroughly and apparently can be dealt with even with our present knowledge, he said, except for the problem of re-entry.

• **Dogs & rabbits**—Danilin stated that Soviet experiments have shown that animals can withstand extreme acceleration and radiation, apparently without any harmful effect. These tests were conducted with several dogs and rabbits some of whose names are now history.

The first visible indication of Soviet space flight research in August, 1958, when Russian scientists sent a rocket to an altitude of 280 miles with two dogs.

In addition to the dogs was a bank of scientific instruments weighing 3726 pounds. Soviet scientists claimed at the time that this was the first time that a one-stage rocket, carrying a load of over 1½ tons, rose to such a height and returned to earth intact, bringing back alive and unharmed the animals it carried into space. They also claimed that the shot marked the first use of a new guidance system which caused the rocket to land at a pre-determined location. This guidance system has, undoubtedly, been further improved; perhaps we were recently witnessing its performance when the Soviets sent their long-range missiles into the Pacific Ocean areas, attracting world-wide attention.

Information on the results of Soviet biological experiments is gradually becoming available. As we already know, dogs were launched in rockets in two ways: in hermetically sealed compartments, and in special flight suits with oxygen helmets. Fourteen dogs were used for experimental flights to various altitudes in hermetically sealed compartments; these dogs weighed from 5 to 7 kilograms. Experiments with dogs in special flight suits and helmets were conducted with 12 smaller animals, weighing on the average 4 to 5 kilograms. Some dogs made two and even three trips into space.

• **Weightlessness harmless**—Another problem to cope with was weightlessness in space. Again, several flights of dogs and one rabbit, by name Marfushka—and especially the protracted flight of Laika in *Sputnik II*—proved that animals easily endure the state of weightlessness. The main lesson learned from the Laika experiment was "that the animal was not harmed by acceleration nor by gravity-free conditions."

This was the first data ever obtained on the effect of weightlessness upon an organism over an extended period. It provided reason to believe that man also can function under gravity-free conditions.

We know that the Soviets are energetically preparing for man's travel into space. Photographs published in Soviet magazines show an airman, attired in a pressure suit, undergoing tests of his physical reactions to simulated high-altitude conditions, extreme cold, and rarified air. These test probably will lead to advanced training for actual flights. Alexander Bukulev, President of the USSR Academy of Medical Sciences, said as recently as January, 1960, that "Soviet physiologists have already obtained experimental data proving that the living organism is not seriously affected in space flight . . ."

• **Meteors likewise**—One of the problems which has occupied the minds of scientists is meteors—how real a hazard they will be for future space ships. B. S. Danilin, in his article mentioned above, says this danger was obviously exaggerated.

Up to now, not a single Soviet *Sputnik* has had a collision with a meteor of any appreciable size. Even the solar (silicon) batteries placed on the surface of *Sputnik III* were not damaged. This tremendous satellite, orbiting around earth for almost two years, still sends its radio signals by means of electric power obtained from solar batteries on its surface. The author expresses the opinion that this successful experiment means that similar solar (silicon) batteries will be used in future interplanetary flights.

• **Radioactivity minimized**—At the same time Danilin said, contrary to the opinion of American specialists, Soviet *Sputniks* and *Luniks* have definitely lessened fears of the effects of cosmic radioactivity on living organisms. Proper protective clothing and correct selection of launching sites for space ships would, he declared, preclude the possibility of astronauts being affected by radioactivity.

More information is necessary before man embarks on his first space flight, Danilin admitted—more accurate information and data on the density of air at high altitudes, the degree of ionization of the earth's atmosphere, the intensity and power of cosmic rays, meteoric danger, were the major areas he listed. All these data are needed, according to the Russian scientist, for calculating the lines of radio communication for plotting rocket or satellite flights, and finally for determining the take-off and landing sites of space ships.

• **Matter of fact**—The latest exploits of *Luniks,* he said, clarified to some extent the question of whether or not the space between planets is

**Dr. Petrov is a Professor of the U.S. Naval Post-Graduate System, Washington, D.C., and a contributor to U.S., British and German magazines.*

void of any matter. It is not an absolute vacuum, as it was previously thought. Even *Lunik I,* which went into orbit around the Sun disclosed according to the Russians, that at a distance of 1500 kilometers from the earth's surface there are about 1000 protons per cubic centimeter of space, and even at an altitude of 110,000 or 150,000 kilometers there are from 300 to 400 positively charged particles per cubic centimeter.

Another thing, proved by *Lunik I,* the Soviets say, is that the meteoric matter in space consists of very small particles. They are not solid rock or metal but rather friable matter, something resembling snowflakes or flakes of soot. The contact of the rocket's surface with meteoric particles the size of about one billionth part of a gram occurs once in several hours, while contact with larger bodies is practically nonexistent.

• **Re-entry remains**—Therefore, according to Soviet scientists, the only real problem is the question of re-entry. With the present level of knowledge, a rocket travelling with enormous speed will enter the atmosphere and will melt or disintegrate, as a result of friction. It will be necessary to find means of effectively cooling the body of a spaceship and retarding its speed, possibly by means of a specially designed medium combining aerodynamic and ballistic principles.

Until this problem is solved, it will be premature to talk about timetables of man's flight into space. However, the scientist concluded that he has no doubts that "Soviet people will eventually solve this problem and shall witness our country's new brilliant achievements in conquering cosmic space."

Soviet scientist E. K. Fedorov's theory on return landings states that spaceships will be braked either with the aid of jet engines, which will require enormous amounts of fuel, or by gliding. The latter would be done by diving into the dense atmosphere and then ascending again so as to lose heat resulting from friction in the denser atmosphere. An article in the Soviet Department of Defense newspaper proposed a similar gliding process,—i.e. diving and ascending, and then repeating the process.

• **Lots of confidence**—There are no qualms in the writings of Soviet scientists on the subject of flights to the moon and planets. Academician J. Bardin said that "the time is not far off when the first manned rocket will start off into the space." Academician V. Fesenkov said that, "undoubtedly the flights around the moon, Mars and other planets, and even landing on them, will be possible in the nearest future."

In the same vein, Academician A. Lebedev stated that "the time will come, when similar, more perfect laboratories will fly to the moon and the nearest planets." Academician L. Sedov (the one probably most frequently quoted) also said that soon "manned space ships will be sent on interplanetary trips. . . . Undoubtedly, these flights will be preceded by interplanetary flights of 'automatic research laboratories'."

• **Moon stressed**—Since the moon is the nearest target for such flights, V. E. Yegorov said that the "next stage, apparently, will be the realization of flights to the moon. With the present know-how in rocket construction, obtaining speeds for such flights is a definite possibility." The moon, in the opinion of Soviet scientists, will be the first target for man's flight into outer space. It can be used not only for the study of this outer space body, but can also be utilized as an interplanetary station—a launching site for further explorations of the Universe.

Study of the moon, according to Yegorov, is most important to scientists who want to know the physico-geographic conditions on that natural satellite of the earth.

"We know Yegorov states that there is no water and very little if any atmosphere on the moon. We also know the range of daily temperatures, but there are still many unknown things which we would like to learn about the moon. Even before future astronauts land on the moon, we will be able to learn many things by flights of rockets similar to *Lunik III* around it; this data by means of photographs will be televised to earth."

An enormous push in the flight of imagination was provided by the first *Lunik* sent into solar orbit, passing at a comparatively short distance from the moon. Prof. B. Kukarkin, on this occasion, said that from now on the planning of interplanetary travel within our solar system becomes a goal of practical realization. Trips to Venus and Mars will be made within a few years. Prof. Yu. Pobedonostzev said that, the time is not far off, when interplanetary ships will fly to the farthermost corner of our Solar system. Mankind has entered into the era of actual penetration into the Universe. . . ."

• **Farther out**—A fantastic preview of what to expect in the future is given by B. Mirtov, who said that the next cosmic rockets will allow us to penetrate the Universe even further. We may meet there some forms of matter, whose existence we do not even suspect. He is sure that we shall be able to peek into the unknown worlds of the moon, Mars and Venus in the very near future with the aid of the television eye first.

This initial investigation will tell us if landings will be possible on these planets. Next, a manned cosmic rocket will be on the way to reveal secrets of enigmatic worlds. "And who knows . . .", he said, "perhaps these ships of the star world will find the first Soviet messenger into the Cosmos (now orbiting around the sun), and will tow it back to earth."

Inevitably the question is asked:

French Push for A-tipped Missile

by Jean-Marie Riche

PARIS—With two successful atomic explosions to their experience, France is accelerating studies for an IRBM/-ICBM with a nuclear warhead.

French atomic experts state that they now are able to produce any type of A-bomb or A-warhead the French Defense Department may order. With the appropriate financial effort, they say they are ready to undertake the development of H-weapons. Their confidence is based on the two recent successful experiments in the Sahara.

Research and development of the French ICBM/IRBM is managed by the Air Department of Defense, in cooperation with the Army, Navy and Scientific Dept. of Defense. It will be designated *SSBS* (Sol-Sol-Balistique-Strategique) and almost certainly will have a solid motor.

France's space efforts, led by the *Veronique* rocket, essentially use liquid rocket engines. An advanced model, the *Super Veronique,* is under development for spatial experiments.

The biggest problem facing French missile experts is that of re-entry. More confidence is evidenced in the fields of propulsion and guidance.

Preparations for testing of the *SSBS* have already begun on the Saharian test-range at Colomb Béchar (Hammaguir) in the direction of Reggane.

Half-mobile shelters will be used in the calibration tests of the trajectories of the missile in the Sahara. These same shelters were used in the latest atomic test, instead of hard-built, more expensive structures.

Indications show that the second French atomic weapon is a much lighter instrument than the one first tested, since it was flown from France to Reggane entirely assembled. Neither is operational.

how soon will space travel take place? A. Dorodnytzin, member of the USSR Academy of Sciences, is certain that it is not far off. In fact, he said that "there is no doubt that within the life span of our generation man will set foot on the planets of our Solar system and, of course, first of all on the moon."

It is interesting to note that in May, 1959, N. P. Barabashov, a member of the Ukrainian Academy of Sciences and also director of the Kharkov State University Observatory, stated that, "one of the first problems in the development of astronautics is the launching of an interplanetary ship to orbit the moon at very close range to give us detailed information about the moon's surface and the physical conditions on it. This ship will have TV cameras and other complicated equipment . . ."

Dr. Barabashov probably knew what he was talking about, as soon afterwards *Lunik III* did exactly what he predicted. Prof. Barabashov, by the way, is in charge of the Soviet investigation of the physical structure of the moon. The next step will be to land a rocket on the moon to measure temperatures and analyse soil properties at various depths, said Dr. Barabashov. All this will be an important step toward man's eventual ascent into space.

• **Detailed timetable**—Soviet Academician L. I. Sedov, who recently was elected President of the International Astronautical Federation, has presented quite a detailed statement relating to a timetable of further explorations of the Universe.

Sedov stated that, from all indications, the work in the field of astronautics will follow the following three paths: first, experiments will be continued with launching the earth's satellites to solve many of the yet unsolved problems, particularly the practical application of acquired knowledge.

The second step will be flights to the moon. Successful launching of the Soviet rocket to the moon on Sept. 12, 1959, blazed the way, he said, for further work in this field. It certainly leads the way for manned rockets to fly to the moon and land there. This stage of space exploration, definitely not in the field of scientific fantasy, still presents enormous difficulties, especially a return of the rocket to earth. Still more difficult will be the creation of special scientific stations on the moon. However, he said, "many things that seem to be Utopian at present will become a reality in the near future."

Finally, according to Sedov, flights within our Solar system, namely to Mars and Venus will be undertaken. "Interplanetary flights are becoming a reality in our era," he added.

• **Food for flight**—A problem of food supply for future astronauts was discussed by G. A. Arutyunov in the January issue of the USSR Illustrated magazine. He said that "scientists of other countries are inclined toward synthetic mixtures of amino acids and carbohydrates . . . Soviet scientists prefer natural products enriched with amino acids." The main problem will be in flights of several months' duration.

According to Arutyunov, two solutions are suggested. "The first is to create new foods by chemical means—proteins, fats, carbohydrates and vitamins can be obtained from the products of nitrous metabolism. The second is the use of microorganisms and water plants. Scientists have already found about 15 varieties of water plants that can serve as adequate human foods. A plant called chlorella has particular merit since it also converts carbon dioxide into oxygen . . . Another problem is the water supply. On a long flight it can be obtained either from the air in the cabin which settles in drops on the cooled surfaces or by chemical means."

Future flights into Cosmos will solve any questions of the existence of life similar to that of Earth. Soviet academicians Oparin and Fesenkov estimate that life similar to ours is possible on only one in a million of the planets of our Galaxy. Even at this conservative estimate, it means that life is possible on at least 150 thousand planets!

Germans Build Rocket Test Site at WWII Installation

Berlin—A testing site for rockets and ramjet propulsion units is under construction by the German Research Establishment for Aviation at the site where much of Germany's early rocket work was done.

The installation is located at Trauen, near Soltau, the same place Dr. Eugen Saenger conducted his rocket research and development during World War II, and where the studies on the "Long Range Rocket Bomber" were conducted. This was the famous "skip" re-entry concept, forerunner of the US Air Force *Dyna-Soar*.

Scheduled for operation in the spring of 1960, the project includes a one-kilometer-long rail track for steel rocket sleds with Mach speeds. The operation is subsidized by the German Federal Ministry of Defense.

West German Scientists To Study Space Problems

Berlin—West Germany has formed a group of top-level scientists representing several disciplines to research problems of space flight.

Created by the German Rocket Society, the group includes Prof. Ehmert, Max Planck Institute of Aeronomy; Prof. von Diringshofen, an expert in aviation medicine; Prof. Dr. Schuette, astronomer at University of Munich; and Dipl.-Ing. Staats, President of the German Rocket Society. The group will conduct its work in Hanover.

The German Rocket Society maintains development and production workshops in Bremen. Membership totals more than 400, representing 14 countries. Among honorary members in the U.S. are Profs. Dornberger, Oberth, Wernher von Braun, and Saenger.

Space Telescope Slated For Launch from Woomera

A space telescope—mounted in the nose cone of a *Skylark* rocket—will soon make its first flight at the Woomera range in Australia. The rocket will reach a height of 100 miles above the earth's surface before taking pictures.

The telescope will build up a television type picture of hitherto unknown aspects of the sky and, at the same time, measure the intensity of ultraviolet light beyond the earth's atmosphere. This picture will be transmitted to earth via a radio-telemeter. Scanning will be accomplished by the yawing motion of the vehicle.

Six photo-amplifiers in the telescope—each fitted with a pure quartz window and transparent gold cathode—are set at various angles to the vertical so as to look at different areas of the sky.

Combined readings will build up a composite picture of space and will distinguish between point sources of ultraviolet light from stars and other sources of light such as gaseous nebulae.

A moon-detector in the unit is used to accurately establish the direction in which each photo-amplifier is looking at any instant.

The bearing of the earth's magnetic field is also taken by a magnetometer, and bearings on the earth's horizon are obtained from the photo-amplifiers themselves.

The telescope is expected to be in use only five minutes—but it is hoped that during that time results will give positioning precise to one degree.

Tiny 'Dice-Sized' Module Produced

Development of a tiny, dice-sized sub-module said to be the most compact circuit unit ever designed for off-the-shelf electronics components has been announced jointly by the United States Army Signal Corps and Republic Aviation Corp. The half-inch cube modules, each holding anywhere from 12 to 18 components and weighing only two grams, will be used in the guidance system of the AN/USD-4 *"Swallow"* reconnaissance drone the company is building for the U.S. Army's Signal Corps.

Engineers of Republic's Missile Systems Division, Mineola, N.Y., say the module is suitable for use in any all-purpose digital computer whether for military or commercial use. It has a packing density of a quarter of a million parts per cubic foot, or five times the density attainable through standard circuit techniques.

In other words, the large printed circuit boards required to mount several hundred resistors, diodes, transistors, capacitors and other components take up five times the space needed by the same components in this modular form. This miniaturization of "packaging," say the engineers, allows the building up of an extensive logic capability for a computer without materially adding to its overall size—or, conversely, to provide for normal logic capability at considerably reduced size.

Discussing use of the modules in the navigational computer which is the "heart" of the *Swallow's* central "nervous system," Republic's missile engineers say the units are arranged on modular "cards" at a rate of 44-50 per card. Use of the module technique in computers is not new, say the engineers, but the smallest general purpose computer on the commercial market today holds the equivalent of only 8-10 modules per card. Furthermore, say the engineers, the new units are uniform in size, which means the cards can be stacked on top of one another with no wasted space.

One of the main design features of the new module is its encapsulation. Electronic components when densely packed often cause one another to heat up to an excessive degree. The encapsulating material used here eliminates so-called "hot spots" by evenly distributing the heat. It also seals the circuit against moisture.

Another feature stressed by the designers is the use of standard components. Because of the high stress requirements of an airborne computer it is necessary to use elements of proven reliability, rather than newly developed units that might not hold up under environmental pressures, they point out. Furthermore, since silicon semiconductor components are used in Republic's new module circuits, the components are expected to perform with complete reliability in a temperature range of from –70 to +240°F. They can withstand a thermal "shock" of 100 degrees per minute.

Circle No. 225 on Subscriber Service Card.

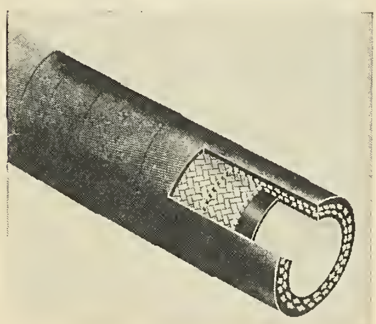
Teflon-Lined Hose

A special R/M hose, Flexlon, withstands all known chemicals except fluorine gas, chlorine trifluoride, and molten alkali metals.

This hose, manufactured by the Manhattan Rubber Division, Raybestos-Manhattan, Inc., has very low permeability, and zero water absorption. Since nothing will stick to the waxy Dupont Teflon tube, cleaning and sterilization are easily accomplished. Another advantage claimed for Flexlon is its flexibility and easy handling.

Flexlon Hose construction features a unique bonding of the glossy Teflon tube to the hose body, which is said to eliminate separation, cracking or splitting—even with small bending radii. Plies of high tensile cotton cords or special braided steel wire, (depending on pressure or temperature) form the strength members, securely bonded to the tube and heavy-duty cover.

Flexlon hose is especially suited for hot paint and lacquer spraying processes, for flexible connections in process equipment handling corrosives, caking slurries or solvents, and for conveying pharmaceuticals, milk, foodstuffs, and other fluids requiring sterilization and easy cleaning. Temperatures to 325°



F and working pressures to 1500 psi are acceptable, depending on size and type of hose.

Flexlon Hose is available regularly in diameters to 1¼ in. in 15 to 50 ft. lengths, (depending on size) with brass or stainless steel fittings. Larger sizes can be supplied on special order.

Circle No. 226 on Subscriber Service Card.

Severe Temperature Gloves

A new glove which industry, science and the armed forces will find useful wherever extremes of temperature are encountered during the Space Age is now being manufactured and marketed by J. M. Rubin & Sons.

Severe laboratory tests of the new glove, known as Fotiaire, have provided complete protection to the wearer at temperatures of absolute zero (460° below) and at 1200° above.

Fotiaire is manufactured in three

parts. The basic glove (left in photo) uses a combination of air and quality rubber to provide outstanding protection for the hand. A specially tanned leather glove is worn over the basic glove for protection from cold and a covering aluminized asbestos glove replaces the leather shell for protection from heat.

Contrary to appearances, the glove is not bulky. The forefinger construction enables wearer to manipulate instruments and dials with ease.

Tests made on the glove include the holding of liquid nitrogen in the cupped palm of the glove while being worn. The hand remained completely warm while the liquid nitrogen evaporated and there was no ill effect whatever on the leather. Metal parts overheated to 1200° have been held in hands protected by Fotiairc with no discomfort. Also, Fotiaire-protected hands have been immersed in boiling water with no ill effects to the wearer or to the gloves.

Circle No. 227 on Subscriber Service Card.

Moisture Getters

Development of tiny moisture getters for semiconductors has been announced by Corning Glass Works.

The company said the getters comprise the initial volume application of its porous, or "thirsty" glass. Production of the getters in the millions already has begun in several configurations.

The material of which the getters are made is Corning's 7930 glass—the porous form of its 96% silica glasses that go into Vycor brand products. An advantage of thc material, besides its ability to absorb moisture, is its mechanical strength. This allows easy handling and mounting of the getters in transistor and diode enclosures.

Corning said getters are available immediately in the form of discs, with or without holes, in thicknesses of .030-inch or more. Largc quantities can be produced in three weeks to meet requirements of other designs, the company said.

Prices are dependent on the design and the quantity ordered.

Circle No. 228 on Subscriber Service Card.

5 Watt Power Supply

Magnetic Research Corp. announces a series of new airborne instrumentation power supplies capable of supplying a stable source of DC power for instrumentation, telemetering and recording systems. Three models are available, offering a nominal output of either 5 volts, 10 volts, or 15 volts DC. All models operate from standard airborne 115 volts 400 cycle power and afford excellent regulation and ripple characteristics.

The design of these power supplies features dual magnetic power regulation consisting of a flux oscillator and a magnetic amplifier regulator. These circuits suppress line voltage transients and are essentially unaffected by changes in load or by line frequency variations. Construction features high-temperature magnetic and solid-state components, which enables these units to successfully withstand applicable portions of MIL-E-5272A.

Small quantities of all units are available from stock. Prices are available on quotation.

Circle No. 229 on Subscriber Service Card.

new literature

FLAME SPRAY PROCESSES—An engineering data bulletin on basic flame spray processes has just been published by Metallizing Engineering Company, Inc. The 16-page bulletin covers the metallizing process which sprays powdered metals, including tungsten carbide and self-fluxing alloys of the boron-silicone, nickel, chromium type and refractory ceramics, such as aluminum and zirconia; and the new METCO Plasma Flame Spray process which develops temperatures up to 30,000°F. and can spray any material that can be melted without decomposition. In addition to covering the basic engineering considerations for each process, the bulletin includes tables and charts on specific characteristics of these coatings, such as hardness, tensile strength, bond strength, etc. Illustrated and described and typical applications of these coatings in the production of original equipment. One section of the bulletin illustrates a typical automatic production set-up as well as the requirements for a typical research department installation.

Circle No. 200 on Subscriber Service Card.

MISSILE LAUNCHER FLUID—Data on Ucon Hydraulic Fluid M-1, specifically developed for the *Titan* missile's hard-site installations, has just been published by Union Carbide Chemicals Co. American Machine and Foundry Company, contractor for a series of *Titan* hard-sites, was faced with finding a hydraulic fluid able to meet severe operating conditions safely. Ucon Hydraulic Fluid M-1, developed specifically for the *Titan* by Carbide, was the only such fluid with operational capability from minus 35 to plus 160°F; satisfactory liquid and vapor-phase corrosion inhibition over this range; resistance to spray flammability in 100% oxygen atmosphere with an electric arc ignition source; resistance to detonation under 320 foot-pound per square inch impact force in the presence of liquid oxygen; and adequate lubricity for rotary gear, vane, and axial piston pumps. The new 8-page data booklet describes the properties and handling of Ucon Hydraulic Fluid M-1, with information on viscosity-temperature relationships, effect on rubber and metals, results of pump tests, and other data.

Circle No. 201 on Subscriber Service Card.

VACUUM LABORATORY—An illustrated technical data sheet has been issued describing research facilities available in the new Space Vacuum Laboratory of National Research Corporation.

Circle No. 202 on Subscriber Service Card.

DOD Tries To 'Disown' Gale Letter

Just as quickly as it leaked out the Defense Department last week tried to disown a letter purporting to detail the "combined thinking" of Defense Secretary Gates and his top military advisors on the "missile gap."

The letter—which states flatly that "reliance on manned bombers at the present time makes a good deal more sense for the U.S. than does reliance on the ICBM"—was written by onetime advertising man Oliver M. Gale, now a special assistant to Gates.

Flustered DOD spokesman hastily assured newsmen that Gale's 4000-word rendition of the nation's military posture was "unofficial," something "he did all by himself without showing the Secretary." However, in the letter to American Machine & Foundry President Carter L. Burgess, a former assistant secretary of defense, Gale said the paper had been "cleared by Security Review."

It also was revealed that more than 600 copies of the letter had been distributed by Gale to "opinion leaders" in business and government, as one observer put it, apparently because "he was so proud of it."

In essence, the Gale statement hews to the long-established Eisenhower Administration concept that bombers are more reliable and accurate than ICBM's and are therefore the "most efficient" defense; and that in overall military strength the U.S. is considerably ahead of Russia and will remain so.

Obviously intended to offset Democratic criticism of Eisenhower Administration defense policies, the letter was said to be inspired by Vice President Nixon and other leading Republicans.

• **Amateurish and political**—Military men who looked at the letter passed it off as "amateurish," containing "superficial reasoning," and "obviously politically motivated." They said Gale had disregarded a wealth of military advice he could have obtained right in his own building—the Pentagon.

Some items from the letter:

• "If our security demanded it, we would of course have produced the *Atlas* in greater numbers. This country could have turned out almost any number it wished."

• "Because of the promise of second generation ICBM's and the diversity of offensive weapons, both air and seaborne, the U.S. has settled on a minimum number of first generation ICBMs. We already have the deterrent potential that permits us to hold back and wait for superior weapons."

• The B-70 was cut back because it "could not be operational before 1965 at the earliest and probably not until 1967 or 1968. By 1965 four systems of ICBMs will be operational—*Atlas, Titan, Minuteman and Polaris* . . ."

In answer to whether 300 Soviet missiles could wipe out U.S. retaliatory capability, as claimed by SAC Commander Thomas Power, Gale said:

If the Soviets had launchers for a stock of 300 missiles, if countdowns for all of them were perfect, if our intelligence did not detect such a massive effort in advance, if all our strategic bombers and carriers were located or if the bombers were all on the ground—in short, if the Soviets are willing to gamble on every detail working perfectly—such a sneak attack might be effective. "Obviously the chance that all these conditions would occur simultaneously are remote."

Range Responsibility Now York's

Responsibility for central control of all U.S. test ranges, tracking stations and other support facilities has been given to the Director of Defense Research and Engineering (DDR&E), Dr. Herbert F. York.

The decision to provide a single office for range coordination and supervision was made by Defense Secretary Thomas Gates after a six-month management study of all the missile/space test ranges.

The action is based on the recommendations presented by Walker Cisler, consultant to the Secretary. No formal report was prepared, according to Dr. York, but Cisler's oral and written recommendations have been presented to Gates over the past few months.

The new centralization, said York, has two objectives: single effective control for more efficient ground environment coordination and better liaison between the Department of Defense and the National Aeronautics and Space Administration.

To carry out this control, Air Force Major General Donald N. Yates will be reassigned as deputy director of DDR&E. Yates will be relieved shortly as Commander of the Atlantic Missile Range.

Also Alvin G. Waggoner, who assisted Cisler in the range study, will be named assistant director under York. Waggoner will establish the necessary staff and facility to carry out the new control program.

In the past, effective control and supervision of the ranges had not been formalized because all the problems were not fully understood, said York.

York's office now will set up and maintain an information center including an inventory of all test plans requiring range and ground equipment use. Long-range schedules will be maintained.

All future proposals for range use and for development, procurement, installation and operation of ground environment equipment (items not considered an integral part of a weapon system) to be used in the R&D, test, and evaluation of missiles and space programs must now be approved by DDR&E.

• **Responsibilities**—Under the new authority, Yates will act for DDR&E in all matters which involve missile and test ranges and all other associated ground stations. Because of his long background in command of missile facilities and launchings (six years at Cape Canaveral), it is expected that the General will be a strong force in guiding future range programs.

After organizing his staff, Waggoner will

• Establish and maintain inventory records of all ground environment support of all space programs and at all missile ranges, training and test facilities.

• Establish and maintain an inventory of plans for the development, procurement and installation of new equipment for the facilities above.

• Establish and maintain an inventory of test plans requiring the use of existing or projected ground environment support equipment or facilities. This will involve the continuous maintenance of a complete schedule of all future launch dates—(thus, this will be the first central information pool for such data).

Waggoner's group also will recommend to DDR&E range assignments for future missile and space programs. It will approve, modify or turn down all DOD proposals for new or additional facilities and proposals for installing NASA equipment or military sites.

Finally, the group will monitor all proposals to avoid unnecessary duplication between DOD and NASA and arbitrate when conflicts arise on use of ranges and launch facilities.

contracts

AIR FORCE

$33,058,690—Western Electric Co., Inc., New York City, for tracking system for Project *Mercury*.

$900,000—General Electric's Light Military Electronics Department for study and development contract which encompasses Electrostatic Latent Image Photography.

$639,500—Douglas Aircraft Co., Inc., Santa Monica, Calif., for development and test of rocket motor applicable to the *MB-1* air-to-air rocket.

$350,000—CompuDyne Corp., Hatboro, Pa., for instrumentation and control components for propellant-loading systems at six *Atlas* ICBM operational bases.

$250,000—Martin, Denver, for venting connectors on the *Titan* launching complexes.

$224,343—Aerojet-General Corp., Azusa, Calif., for solid propellant combustion research.

$199,284—Olin Mathieson Chemical Corp., Baltimore, for propellant.

$187,890—Washington University, St. Louis, for "investigations of strong (cyclotron induced) interactions and of the weak interactions of beta decay."

$139,184—University of Pittsburgh, for continuation of research on "magnetic and structure properties of solids and solutions.

$78,000—General Electric Co., Schenectady, N.Y., for research on interactions of gases with nonmetallic surfaces.

$72,020—Vitro Laboratories, West Orange, N.J., for research on physical properties of high-intensity arc.

$65,904—Polytechnic Institute of Brooklyn, for research on investigation of the effects of phase, transformations of the properties of solids.

$65,000—University of Colorado, for research directed toward development of miniature radiometers for high-altitude vehicles and a program for the reduction of data obtained with these radiometers.

$64,494—General Electric Co., Cincinnati, for continuation of research on high temperature heat transfer.

$60,064—Universal Match Corp., St. Louis, for servometer.

$57,906—Vitro Laboratories, West Orange, for design and development of laboratory device for simulating solar energy and spectral distribution of solar radiation.

$57,105—Lockheed Aircraft Corp., Sunnyvale, Calif., for research on theory of composite propellant burning.

$55,132—Atlantic Research Corp., Alexandria, Va., for research on solid propellant combustion.

$49,729—University of California, Berkeley, for research on tolerance and adaptability of the brain to environment imposed by space flight.

$48,756—Stanford Research Institute, Menlo Park, Calif., for investigation of solid-state electrolyte behavior in semiconductors.

$40,360—Washington University, St. Louis, for research on primary cosmic ray composition and ray variations.

$37,812—Kaiser Fleetwings, Inc., Bristol, Pa., for services and materials 6-100 foot inflatable satellite container assemblies.

$37,737—Washington University, St. Louis, for continuation of research on problems in mathematical analysis.

$33,332—Stanford Research Institute, Menlo Park, for the study of the origin and propagation of disturbances in the burning of solid propellants.

$29,490—University of California, Berkeley, for studies of complete biological systems for manned space vehicle, space station or extraterrestrial base.

$27,073—Pennsylvania State University, University Park, gasdynamics of plasmas.

$25,570—Allied Research Associates, Inc., Boston, for research in analysis of heat conduction and convection in aerostructures.

$21,820—University of California, Berkeley, high-precision geocentric orbits.

ARMY

$2,184,000—Temco Aircraft Corp., for manufacture of components of the *Hawk* air-defense missile.

$1,687,000—The Martin Co., Orlando, for engineering services for *Lacrosse* weapon system—supplement.

$1,331,725—Douglas Aircraft Co., Santa Monica, for repair parts for the *Nike* system (three contracts).

$1,011,414—Raytheon Co., Waltham, for concurrent repair parts, *Hawk* missile system (two contracts).

$369,624—Western Electric Co., New York City, for *Nike* spare parts and components (four contracts).

$154,900—Domestic Film Prod. Corp., Millersburg, Ohio, for tent, *Nike-Hercules*, air-supported, complete, without fan.

$95,000—General Electric Co., Pittsfield, for development of cryogenic gyro.

$86,781—Biltmore Construction Co., Clearwater, Fla., for NASA Minitrack facility.

$86,573—Barnes Engineering Co., Stamford, Conn., for design, development and fabrication of prototype horizon sensor system.

$48,490—Western Electric Co., New York City, for *Nike* spare parts and compounds.

$29,447—CBS Laboratories, Div. of CBS, Inc., Stamford, for study of development in ball bearings for space application.

$28,008—Douglas Aircraft Co., Santa Monica, for *Nike* replenishment spare parts.

NAVY

$38,500,000—Westinghouse Electric Corp., for developing and producing a prototype model of the long-range radar for a new ship-based antiaircraft and missile weapons system.

$10,868,269—Sperry Gyroscope Co., Syosset, L.I., N.Y., for field service and liaison engineering on Type II periscope drive system.

$8,817,022—Sperry Gyroscope Co., Syosset, for design of navigation subsystem.

$4,895,000—General Electric's Light Military Electronics Department, for continued production of the *Sidewinder* air-to-air guided missile.

$2,561,000—The Martin Co., Orlando, for development of a modified version of the *Bullpup*.

$700,000—Hermes Electronics Co., for design and manufacture of space guardians, for use in the Navy's artificial Earth Satellite Observation Program (AESOP).

$325,000—The Diehl Manufacturing Co., Finderne, N.J., for cover resolvers to be used chiefly as government-supplied equipment to prime and sub-contractors.

$200,000—Radar Relay, Inc., Santa Monica, for readout and electronic control display units for *Polaris* missile checkout system to be installed aboard *Polaris*-firing submarines.

$174,563—Industro Transistor Corp., L.I., N.Y., for germanium alloy junction transistors for the *Polaris* missile program.

$152,529—Wallace & Tiernan, Inc., Belleville, for bathythermographs.

$58,268—Battelle Memorial Institute, Columbus, Ohio, for studies and investigation of the mechanism of cracking of weldments of submarine hull structures made from HY-80 steel.

MISCELLANEOUS

$1 million+—Lear, Inc., for manufacture of universal component test stands for ICBM rocket engine.

$100,000—Lear, Inc., for production of test stand couplings for the Rocketdyne 150-million-h.p. engine.

reviews

CONTAMINATION CONTROL OF LIQUID PROPELLANT ROCKET ENGINES. Order from Aerospace Industries Assn., 610 Shoreham Bldg., Washington 5, D.C.

The handbook has been prepared by a team of specialists from government and industry and is being sponsored by the Guided Missile Council and Propulsion Technical Committee of the Aerospace Industries Assn. Copies are available to any organization concerned with design, development, manufacture, procurement, inspection, storage or handling of components or complete engine systems.

UPPER ATMOSPHERE RESEARCH REPORT NO. 35: GROUND STATIONS FOR NRL ROCKET STUDIES OF THE IONOSPHERE. J. E. Jackson and G. H. Spaid, NRL. Order PB 151763 from OTS, U.S. Dept. of Commerce, Washington 25, D.C. $1.

The Navy's use of high altitude sounding rockets transmitting signals to Earth has made measurements of the ionosphere possible and exploded the theory of separation of its E, F_1 and F_2 layers.

The report explains techniques for operating narrow band receiving equipment on the ground. Innovations described include a new type crystal filter, an adaptation of the "magic T" at 7.75 megacycles and more stable rf sweep generators, used to calibrate ground station gear.

—when and where—

APRIL

International Symposium on Active Networks and Feedback Systems, sponsored by Polytechnic Institute of Brooklyn, Dept. of Defense Research Agencies, Institute of Radio Engineers, Engineering Societies Bldg., New York, April 19-21.

Society of Plastics Engineers, North Texas Section, Annual Regional Technical Conference, Hotel Texas, Fort Worth, April 20.

National Symposium on Manned Space Stations, Institute of the Aeronautical Sciences, co-sponsored by National Aeronautics and Space Administration, and The Rand Corp., Ambassador Hotel, Los Angeles, April 20-22.

Symposium on Electrical Conductivity in Organic Solids, Air Force Office of Scientific Research and Office of Naval Research, Duke University, Durham, N.C., April 20-22.

Royal Aeronautical Society, On Reducing Costs of Space Research, London, April 21.

Southwest Metals and Minerals Conference "Metals and Materials for the Space Age," American Institute of Mining, Metallurgical and Petroleum Engineers, Ambassador Hotel, Los Angeles, April 21-22.

Seventh Annual Heat Transfer Conference, "Survey of Radiation Phenomena and Heat Transfer Equipment for Space Flight Application," Oklahoma State University, Stillwater, April 21-22.

American Ceramic Society, 62nd Annual Meeting, Bellevue Stratford Hotel, Philadelphia, April 24-28.

The Combustion Institute, Western States Section, Spring Meeting, sponsored by Lockheed Aircraft Corp., Palo Alto, Calif., April 25-26.

ASME Maintenance and Plant Engineering Conference, Chase-Park Plaza Hotel, St. Louis, April 25-26.

American Welding Society, 41st Annual Meeting and Welding Exposition, Los Angeles, April 25-29.

2nd Southwestern Metal Exposition and Congress, State Fair Park, Automobile Bldg., Dallas, April 25-29.

National Meeting on Space Age Materials, Cincinnati Chapter of the American Society for Metals, Sheraton-Gibson Hotel, Cincinnati, April 27-28.

British Interplanetary Society, High Altitude Chambers and Pressure Suits, Church House, London, April 28.

MAY

National Association of Relay Manufacturers, Eighth Annual Conference on Electromagnetic Relays, Oklahoma State University, Stillwater, May 3-5.

Materials Handling Exhibition and Convention, Mechanical Handling, sponsored by Associated Iliffe Press, Dorset House, Stamford St., London, May 3-13.

Radiation Research Society, Annual Meeting, San Francisco, May 8-12.

Russell C. Galbraith: Named to the new post of vice president - administration at Lockheed Electronics Co., responsible for financial and legal matters, industrial relations, public relations and organizational planning. Was general manager of the Lockheed Electronics and Avionics Division before the consolidation of that division and the former Stavid Engineering, Inc. into Lockheed Electronics Co.


GALBRAITH

Darwin W. Mark: Formerly with Marquardt Aircraft's engineering department and vice president of Rowin Plastics, appointed technical director of Nash-Hammond, Inc.'s Fiberglas and Plastics Division.

Edward L. Maguire: Former assistant general manager of The Alloy Fabricating Div. of Standard Steel Corp., appointed manager of Cryogenics for Uni-Flex Manufacturing and Engineering, Inc.

John A. Farris: Named manager of engineering liaison by Aircraft Porous Media, Inc., a subsidiary of Pall Corp.

John B. Suomala: Formerly with the Instrumentation Laboratory at Massachusetts Institute of Technology, named vice president-engineering at Gabriel Electronics Division, The Gabriel Co. At M.I.T. he had staff and line responsibilities for inertial guidance systems of ICBM programs; automatic ground environmental systems and antenna systems including the Air Force early warning radar antennas systems.


SUOMALA

Thomas J. Lynch: Elected vice president of Vector Manufacturing Co., Inc., and **Charles Weidknech,** vice president and general manager of Vector Communications, Inc., a wholly owned subsidiary. Lynch was formerly with the test engineering and computer section of Philco Corp. and with Tele-Dynamics. Weidknech was previously associated with Tele-Dynamics and General Electric Co.'s Missile Division.

Aero-Flex Corp., appoints **George Lewis** as vice president-operations and **Phil Hobbes** as vice president-product engineering.

Edward C. Grimshaw: Named manager of United Aircraft Corp.'s Norden division's Data Systems department.

Robert E. Dryden: Elected vice president-engineering at Pearce-Simpson, Inc., heading the new Research and Development Division. Formerly directed the instrumentation division of Radiation, Inc.

John W. Ryberg: Formerly with Goodyear Tire and Rubber Co., appointed application engineer for the Aero Hydraulics Division of Vickers Inc.

Robert E. Steinman: Former product manager, Charles Bruning Co., Inc., elected vice president of Gaertner Scientific Corp.

Dr. Harald T. Friis: Retained as a consultant by Wheeler Laboratories, Inc., a subsidiary of Hazeltine Corp. Dr. Friis retired two years ago as director of Research in High Frequency and Electronics at Bell Telephone Laboratories, Inc. He served on the panel for basic research, Research and Development Board, and on the Air Force's Scientific Advisory Board. Has received various awards for his scientific contributions, including the Morris Liebmann Memorial Prize, Medal of Honor of the IRE and the Stuart Ballantine Medal.


FRIIS

William A. Linton, Jr.: Formerly president of LaRoe Instruments, Inc., joins the staff of Rixon Electronics, Inc., as staff engineer-physicist.

Donald L. Erickson: Former chief production engineer promoted to production manager at Brooks & Perkins, Inc. Previous posts: Tool designer and process engineer with Ford Motor Co., and production engineer with Goodyear Aircraft Co. and Bell Telephone Laboratories.

Herman O. Mueller: Appointed head of the newly-formed Special Products Development Dept. of The Liquidometer Corporation.

Marshall C. Harrington: Succeeds **John P. Craven** as Contract Research Administrator at the Navy's David Taylor Model Basin. Dr. Harrington was formerly head of the Fluid Dynamics Branch. Dr. Craven is now chief scientist, Special Projects Office, Dept. of the Navy.

Arthur C. Metzger: Former coordinator and manager of the test equipment program at Frankfort Arsenal, joins General Precision, Inc.'s Kearfott Division as senior project engineer in the firm's Provisioned Military Equipment Laboratory.

Dr. John T. Ludwig: Recently a senior research and development engineer with Minneapolis-Honeywell Regulator Co., appointed to Electronic Communications, Inc.'s Scientific Advisory Group as a principal engineering scientist. **Dr. Richard A. Ibison** also joins the firm as a Principal Engineering Scientist concerned with human factors engineering, maintainability and training.

R. A. Irwin: Appointed director of space activities, a new position at the Westinghouse Electric Corp.

Litton Industries Electron Tube Division promotes: **George S. Stuart** to production manager-Magetron Product Line; **John V. Lyddane,** production manager-Traveling Wave Devices Product Line; **Allen C. Ashley,** project engineer, Magnetron Product Line.

Cecil Young: Formerly with Peerless Electric, joins Hydro-Aire Co. as engineering manager of electro-mechanical equipment.

Charles M. Saffer, Jr.: Former technical coordinator of the AFN High Energy Fuels Program at American Potash & Chemical Corp. joins Thiokol Chemical Corp. as assistant director, Research Planning.

Bertram Magenheim: Former senior project engineer of the technical staff at R.C.A., joins Control Electronics Co., Inc., as Microwave Division head, responsible for overall design, development and manufacture of microwave components and instruments. Previous posts: Microwave signal generator group leader at Polarad Electronics Corp., microwave section head at FXR and electrical engineer at Raytheon Co.


MAGENHEIM

Gerald G. Loehr: Named manager-contracts and negotiation for Aerojet-General Corp., Washington office.

Solomon Charp: Manager of navigation and control electronic equipment for General Electric's Missile and Space Vehicle Dept., directing investigation of complete navigation and control electronic systems, design and development of control components and design of electronic circuitry.

Dean C. Reemsnyder and **George E. Shimp:** Promoted to project engineers in the engineering department of New Devices Laboratories, Thompson Ramo Wooldridge, Inc.

W. P. Horton: Formerly manager of Computer Control Co.'s Engineering Dept., Eastern Division, appointed vice president.

Advertisers' Index

BUSINESS OFFICES

Washington 5, D.C.—1001 Vermont Avenue, NW; STerling 3-5400
Walton E. Brown, Advertising Sales Manager

New York 17, N.Y.—20 East 46 Street; YUkon 6-3900
Paul B. Kinney, Eastern Advertising Manager
Paul N. Anderson
Raymond G. Quirk

Los Angeles, California—8929 Wilshire Blvd.; OLeander 5-9161
James W. Claar
Charles R. Martz, Jr.

Detroit 2, Michigan—201 Stephenson Building; TRinity 5-2555
Kenneth J. Wells

Chicago 2, Illinois—139 N. Clark St.; CEntral 6-5804
George E. Yonan

Miami, Florida—208 Almeria Ave., Coral Gables
Richard C. Hager

London, W.I, England—28 Bruton Street; Grosvenor 8356
Norall and Hart

Geneva, Switzerland—10 Rue Grenus; Geneva 321044

Paris, France—11 Rue Condorcet; TRU 15-39

BMEWS Signal Opens New RCA West Coast Facility

VAN NUYS, CALIF.—Telephone and tropospheric scatter communications brought a signal from a Ballistic Missile Early Warning System site near Thule AFB, Greenland, to Van Nuys last week. Occasion was the official dedication of Radio Corp. of America's new multimillion-dollar, 240,000-sq.-ft. electronics facility for the company's West Coast Missile and Surface Radar Div. (M/R, April 11, p. 18).

RCA's latest plant, described as one of the nation's most advanced facilities for engineering and production of ballistic missile checkout, guidance and control systems, is already in production of automatic checkout and launch control systems (APCHE) for the *Atlas* and autopilots for the *Thor*. New site is also producing Loran navigation equipment, weather radar for the USAF and Navy, countermeasures and BMEWS system elements.

Human Factors Research Begun by ACF, Catholic U.

A cooperative program in human factors research applied to space age electronics has just been announced by the Electronics Division of ACF Industries and Catholic University. Called a "model agreement," the program is believed to be the first between industry and an educational institution in the human factors field.

Under the agreement, the University will supply personnel and facilities of its experimental and physiological psychology laboratories. ACF Electronics will contribute engineering and production support as well as the services of its human factors department. In addition, the University's Department of Psychology and Psychiatry will be able to train students in the research program.

ACF Electronics has been active in human factors and human engineering in the design of aircraft simulation and other training devices since 1949. Dr. John Townsend, Professor of Psychology at CU has been retained as a consultant to ACF for the past three years.

The first broad research project under the agreement will be basic work on the dynamics of decision-making. According to the participants, study of human decision-making processes will contribute significantly to the understanding of man-machine relationships in the design of future defense and space systems.

Under today's concepts, many contemplated space systems must contain a man since his observation and decision-making capabilities cannot be duplicated by computers. Dr. Townsend contends that the most critical problem lies in teaching man to make better decisions. The human factors project is therefore aimed at finding ways to equip man to assimilate large quantities of data and arrive at the most intelligent decision based on the data.

First findings of the program are scheduled to be published next fall.

The Things We Stand For

The magazine MISSILES & ROCKETS was born in October, 1956, conceived and dedicated to serving the missile and space market.

This was one full year before the Russian *Sputnik* awakened the world to the electric possibilities of space exploration. It was before the International Geophysical Year. In October, 1956, neither *Thor* nor *Jupiter* nor *Atlas* had been fired from a launching pad. The *Titan* was still in the fabrication stage. The government was officially laughing at the idea of exploring the moon, front or backside.

MISSILES & ROCKETS was the first publication in the missile and space field. Since then a dozen or a score have rushed to emulate and follow. It is sincere flattery.

Ours is an exciting field, a changing, pulsating field where yesterday's wondrous discoveries are today's commonplaces; a field of new and strange materials, products and techniques—a field which questions basic scientific theories.

We at MISSILES & ROCKETS have changed some since 1956. We changed from a monthly to a weekly because news of the market demanded it. We have broadened our outlook as the missile/space horizon broadened. We are constantly changing the emphasis of our coverage as the market changes with new discoveries and new achievements. From our changes and our growth have come the beliefs and ideals for which the magazine stands. Simply stated, they are:

• That for the foreseeable future the missile is the preponderant weapon in military deterrence or offense and the United States must maintain a superiority in this field, whether these missiles be land, sea or air-based.

• That we must lead in the exploration of space, not only as a matter of pride and prestige but also because any nation or group of nations which can deny the use of space to others will find a way to utilize that advantage to control the world and perhaps the cosmos. Such control might be with weapons, commerce or technology—even some technology as yet undreamed of.

• That the government and industry must cooperate to achieve this superiority and leadership and that only through cooperation and mutual assistance will they be achieved.

• That this country's strength lies in its free enterprise system and that inherently our greatest achievements will always come from research, design, development and production by private industry rather than from use of the government arsenal system.

• That space is a place and not a project. NASA has a mission there for scientific exploration. The military—any or all of the Services—have a right and duty there to prevent illegal dominance by any other power. Other government agencies will utilize space in performance of their missions. Private industry will be there.

• That both government and industry must encourage advancements in science, recognizing that industry's strength rests on its technology. That both must support a strong program for increased scientific education.

We believe that both government and industry have great responsibilities in this new missile/space field.

For government:

• To never forget that private industry is the basic strength of the country.

• To maintain a productive and economically healthy defense industry.

• To assume greater costs in both basic and applied research.

• To make administrative adjustments which will permit recognition of the necessity of the negotiated contract, protection of industry's proprietary and patent rights, and a redefinition of rules covering the renegotiation of defense contracts.

For industry:

• To realize that the nation's requirements supercede the financial welfare of any single company.

• To realize that the costs of modern air, missile and space systems are so great that not all promising projects can be exploited.

• To rigidly apply realism and common sense to industrial proposals. Don't gain a sale and lose the country.

• To engineer realistically for function and reliability.

• To price realistically: don't gold-plate the product.

• To accept, together with the scientific community, the responsibility to maintain and increase our scientific and industrial leadership; to fight against stifling over-controls and even ineptness in government administration.

Clarke Newlon

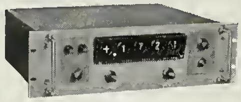
16 NEW! Low cost all-electronic totally-transistorized DIGITAL MULTIMETERS

Now in a single 5¼″ or 8¾″ x 19″ panel
Digital Multimeters for measuring any combination of AC/DC volts, AC/DC ratios, and resistance, with new pre-amps for higher sensitivities, optional electrical output and print command capabilities!

FLIP-TOP BOX CONSTRUCTION FOR EASY MAINTENANCE.

- 50 readings per second, average
- Inline "SUPER-NIXIE." readouts
- 0.01% accuracy
- 1000 megohm input impedance
- Automatic, manual and remote ranging
- Automatic polarity
- Twin Zener diode internal reference
- Front panel sensitivity control
- Etched circuits, plug-in card construction
- Will operate directly in multi-point scanning and print-out data logging systems without any additional circuitry or auxiliary equipment.

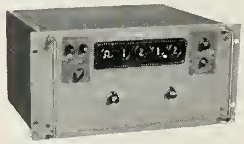
NOW, pick only the parameters you need, order by model number!



MODEL 840
DC Volts/DC Ratios

MODEL 841
DC Volts/DC Ratios/Resistance

MODEL 842
DC Volts/DC Ratios/AC Volts

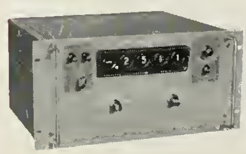


MODEL 843
DC Volts/DC Ratio/AC Volts/Resistance

MODEL 844
DC Volts/Ratio/DC Pre-Amplifier

MODEL 845
DC Volts/Ratio/Resistance/DC Pre-Amplifier

MODEL 846
DC Volts/Ratio/AC Volts/DC Pre-Amplifier



MODEL 847
DC Volts/Ratio/AC Volts/Resistance/Pre-Amplifier

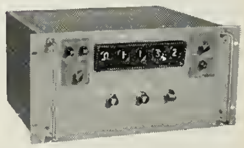
MODEL 848
DC Volts/Ratio With Electrical Outputs

MODEL 849
DC Volts/DC Ratios/Resistance
With Electrical Outputs

MODEL 850
DC Volts/DC Ratios/AC Volts
With Electrical Outputs

MODEL 851
DC Volts/DC Ratio/AC Volts/Resistance
With Electrical Outputs

MODEL 852
DC Volts/Ratio/DC Pre-Amplifier
With Electrical Outputs



MODEL 853
DC Volts/Ratio/Resistance/DC Pre-Amplifier
With Electrical Output

MODEL 854
DC Volts/Ratio/AC Volts/DC Pre-Amplifier
With Electrical Outputs

MODEL 855
DC Volts/Ratio/AC Volts/Resistance
Pre-Amplifier With Electrical Outputs

Many variations of these basic models including AC ratiometers, milli-ohmmeters, microvoltmeters and specialized measuring instruments tailored to individual systems requirements are available in the same physical configurations. *Ask your EI sales office or representative for complete specifications today!*

Electro Instruments, Inc.

3540 AERO COURT
SAN DIEGO 11, CALIF.

Circle No. 12 on Subscriber Service Card.