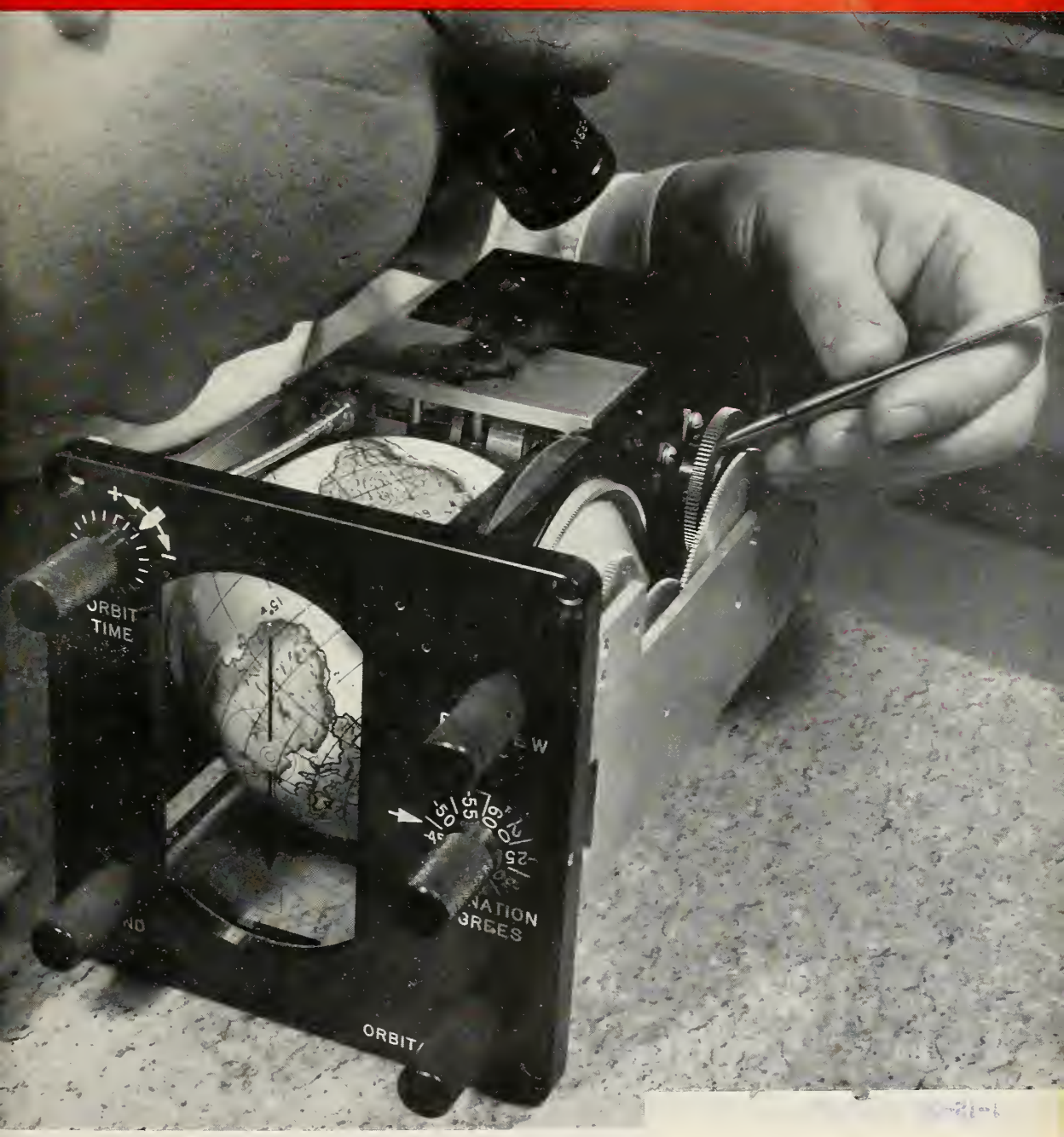
MARCH 28, 1960

missiles and rockets

THE MISSILE/SPACE WEEKLY



Honeywell's Compass for Astronauts

AN AMERICAN AVIATION PUBLICATION

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Specifications for tomorrow's high-speed aircraft and missiles call for engineering and materials of unsurpassed *quality* . . . and quality is built into every product of Avco's Nashville Division.

Making structures of aluminum, titanium and stainless steel—including *Arcomb* stainless steel honeycomb structures—is a Nashville Division specialty. The *Convair 880* and *600* jet transports have major structural components built of Nashville aluminum honeycomb. The B-70 *Valkyrie* intercontinental bomber, designed for the Air Force by North American Aviation, will have large panels of stainless steel honeycomb in its fuselage.

Avco/Nashville's work in structures also includes airborne and ground radar antennae and large, heavy pedestals for ground radars. Nashville offers design, engineering and production facilities for a wide range of lightweight structures, including aluminum and stainless steel honeycomb.

At Nashville, each structures program is assigned its own task force of specialists backed up by the latest equipment for chemical milling, metal bonding and heat treating, including a brazing furnace large enough to accommodate stainless steel honeycomb panels up to 7 feet wide and 25 feet long.

For more information on Nashville's facilities and capabilities, write: General Marketing Manager, Structures Nashville Division, Avco Corporation Nashville, Tennessee

Avco // Nashville

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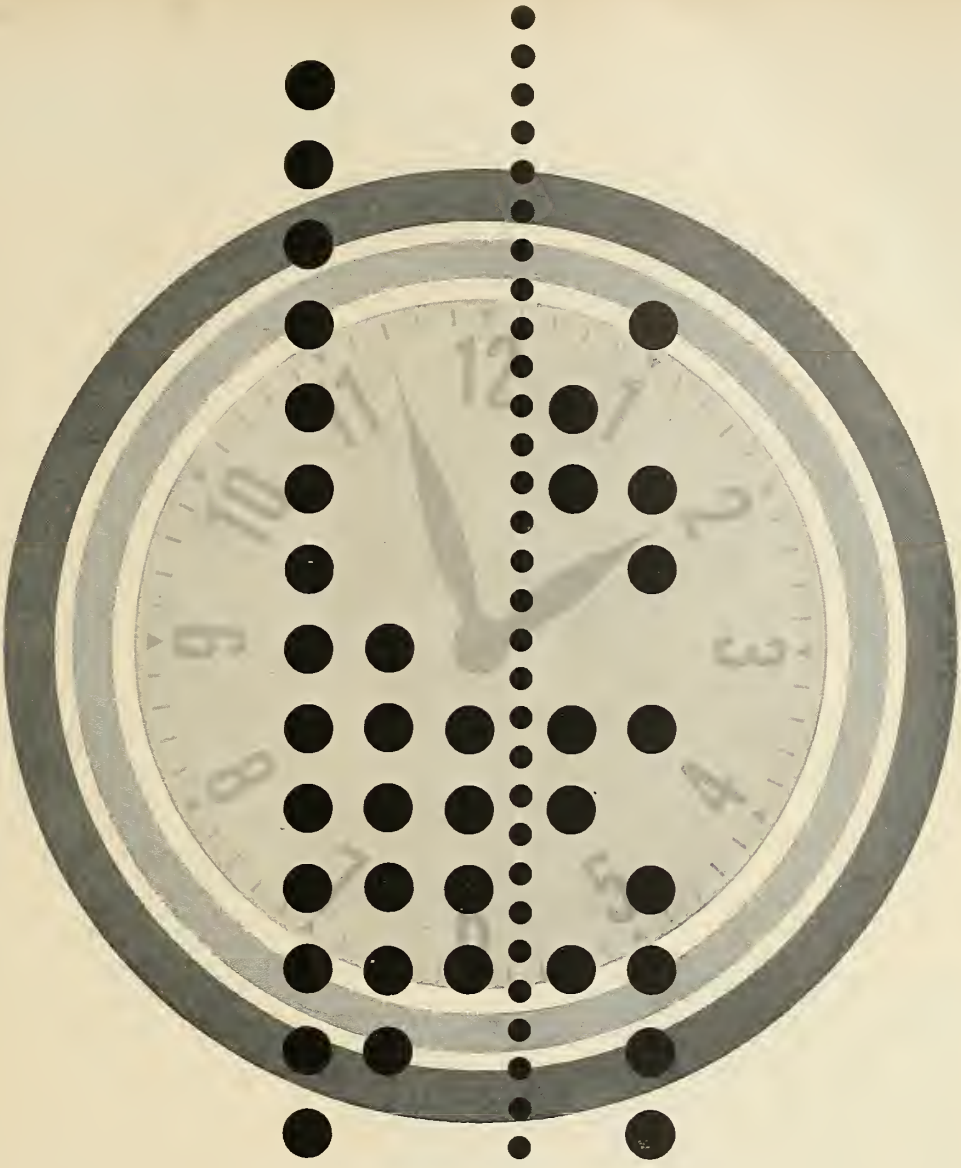

TAPE AND MICROSECONDS

are essential to missile development. Instruments must record every function against time... in fractions often finer than one ten-thousandth of a second. Reams of electronic and optical data must be collected, reduced and evaluated before any missile can become operational. Vitro designed, built and helped instrument the Air Force missile test center at Eglin Air Force Base, Florida. Today it operates the center's test ranges and tracking stations throughout the Southeast. At Eglin, Vitro and the Air Force, working as a team since 1952, are responsible for checkout of missiles, rockets, weapon systems, countermeasures, space probe vehicles and bombing techniques. Beyond this Florida site, other Vitro capabilities: underwater (torpedo) and electronic environmental ranges.

SCIENTISTS AND ENGINEERS: JOIN THIS TEAM.

Vitro LABORATORIES
A DIVISION OF VITRO CORPORATION OF AMERICA
SILVER SPRING, MD. • WEST ORANGE, N. J. • EGLIN AFB, FLA.

—when and where—

MARCH

22nd Annual American Power Conference, sponsored by Illinois Institute of Technology, American Society of Mechanical Engineers and others Sherman Hotel, Chicago, March 29-31

APRIL

University of Connecticut, Sixth Annual Advanced Statistical Quality Control Institute, Storrs, April 3-15.

Solar Energy Symposium, American Society of Mechanical Engineers, and Mechanical Engineering Dept., University of Florida, Gainesville, April 4-5.

1960 Nuclear Congress: "What will the future development of nuclear energy demand from engineers?" includes 6th Nuclear Engineering and Science Conference; 8th NICB Atomic Energy in Industry Conference; 6th International Atomic Exposition, New York Coliseum, April 4-7.

Society of Automotive Engineers, National Aeronautical Meeting and Missile and Aircraft Engineering Display, Commodore Hotel, New York, April 4-8.

American Chemical Society, 137th National Meeting, Cleveland, April 5-14.

American Rocket Society, Structural Design of Spaee Vehicles Conference, Biltmore Hotel, Santa Barbara, Calif., April 6-8.

1960 National Meeting "Hyper-environments—Space Frontier," Institute of Environmental Sciences, Biltmore Hotel, Los Angeles, April 6-8.

Royal Aeronautical Society, Coventry Branch, "The Optimum Size of Rocket Engines," Coventry, England, April 7.

Society of Instrument Technology, "The Electronic Computer as a Unit in an Automatic Data-Processing System for Missile Trials," Overheu, London, April 7.

ASME-SAM Management Engineering Conference, Statler-Hilton Hotel, New York City, April 7-8.

IRE and ARS, Southern Ohio, Fourteenth Annual Spring Technical Conference, Hotel Alms, Cincinnati, April 12-13.

British Institution of Radio Engineers, Computer Group, London, April 13.

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 City, April 19-21.

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

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.

THE MISSILE / SPACE WEEKLY

missiles and rockets

Volume 6 No. 13

THE COVER

"Space Compass" developed by Honeywell for Project Mercury *capsule will enable astronaut to tell instantly his precise position relative to earth (see p. 28).*

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Wayne W. Parrish, President
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Fred S. Hunter
Vice Pres. and Editorial Director

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Pioneer V
Paddlewheel Planetoid
Is Vaulting
Through Unexplored Space
Toward The
Orbital Path of Venus

At this moment Pioneer V, one of the most advanced space probe vehicles ever launched, is on a course toward the path of Venus—26 million miles from earth. Blasted aloft March 11 by a Thor Able-4 rocket booster, this miniature space laboratory will reach its destination in about 130 days.

The project, carried out by Space Technology Laboratories for the National Aeronautics and Space Administration under the direction of the Air Force Ballistic Missile Division, may confirm or disprove long-standing theories of the fundamental nature of the solar system and space itself.

Energy from the sun—captured by almost 5,000 cells mounted in the four paddles—is used to supply all of the electrical power to operate the sophisticated array of instrumentation packed into the 94-pound spacecraft which measures only 26″ in diameter.

By combining a phenomenal digital electronic brain (telebit) with a powerful radio transmitter inside the satellite, STL scientists and engineers expect to receive communications from Pioneer V at their command over interplanetary distances up to 50 million miles.

STL's technical staff brings to this space research the same talents which have provided over-all systems engineering and technical direction since 1954 to the Air Force missile programs including Atlas, Thor, Titan, Minuteman, and related space programs.

Important positions in connection with these activities are now available for scientists and engineers with outstanding capabilities. Inquiries and resumes are invited.

SPACE TECHNOLOGY LABORATORIES, INC.

Los Angeles • Santa Maria • Edwards Rocket Base • Cheyenne
Cape Canaveral • Manchester, England • Singapore • Hawaii

P. O. Box 95004, Los Angeles 45, California

Washington Countdown

IN THE PENTAGON

The long shot . . .

of a Convair *Atlas* 9000 miles across the Atlantic to the Southern Indian Ocean is looked for about the end of April. The trajectory will carry the big ICBM over water all the way. However, it will pass near Brazil and South Africa.

• • •

Reduced payload . . .

will account for most of the extra range in the 9000-mile shot aimed at taking some of the propaganda value out of Russia's shot into the mid-Pacific. But the two shots are not comparable: The *Atlas* will have a thrust under 400,000 pounds; the Soviet missile is estimated to have had upwards of 1 million pounds of thrust.

• • •

Project *Advent* . . .

is ARPA's new name for three of its communication satellite projects—polar-orbiting satellites *Steer* and *Tackle* and 24-hour satellite *Decree*. ARPA's *Courier* communications satellite remains as a separate project. The agency says no change in funding or schedules is involved.

• • •

Dummy Lockheed *Polarises* . . .

for use in system checkouts and training aboard *Polaris* submarines are undergoing preliminary underwater launching off San Clemente Island, Calif. The operational-scale dummies—nicknamed *Dolphins*—clear the surface by only a few feet and fall back into the water where they are recovered.

ON CAPITOL HILL

Concern is mounting . . .

among members of the House and Senate Space Committees as to whether the Administration's proposed changes in the National Space Act go far enough. Some committee members are saying that the changes only recognize legally the status quo.

• • •

A hot floor fight . . .

is expected in the House over the new bill aimed at curbing the employment of recently retired military officers by defense contractors. A group of congressmen including Rep. Alfred Santangelo (D-N.Y.) will move for a much tougher bill.

Big money boosts . . .

are now expected by many insiders to be enacted by the House for the *Atlas, Polaris, Titan* and *Minuteman* programs—and possibly the B-70. The Senate probably will go along with most of it.

AT NASA

Astronaut escape training . . .

has convinced the *Mercury* team that the first man into space will leave his capsule only in case of extreme emergency. Lying flat on his back, the Astronaut must remove the instrument panel, push the empty parachute can out the escape hatch, and wriggle through a 16-by-32-inch hole into his inflatable raft. The Astronauts have had great difficulty attempting this in Langley's hydrodynamic test tank.

• • •

NASA's payroll . . .

will reach 16,373 early in the next fiscal year—more than double the payroll of the old NACA around which NASA was formed. Major additions are 5500 at Huntsville's George C. Marshall facility and 2000 at the new Goddard center.

INTERNATIONAL

***Tartars* for the Japanese Navy . . .**

are reported to have been purchased from Convair. Japan bought the new surface-to-air missiles for its latest 2600-ton destroyers.

• • •

A Malta missile depot . . .

is being planned by the British. The depot in the strategic Mediterranean will be used for surface-to-air *Firestreaks* and *Seaslugs*.

• • •

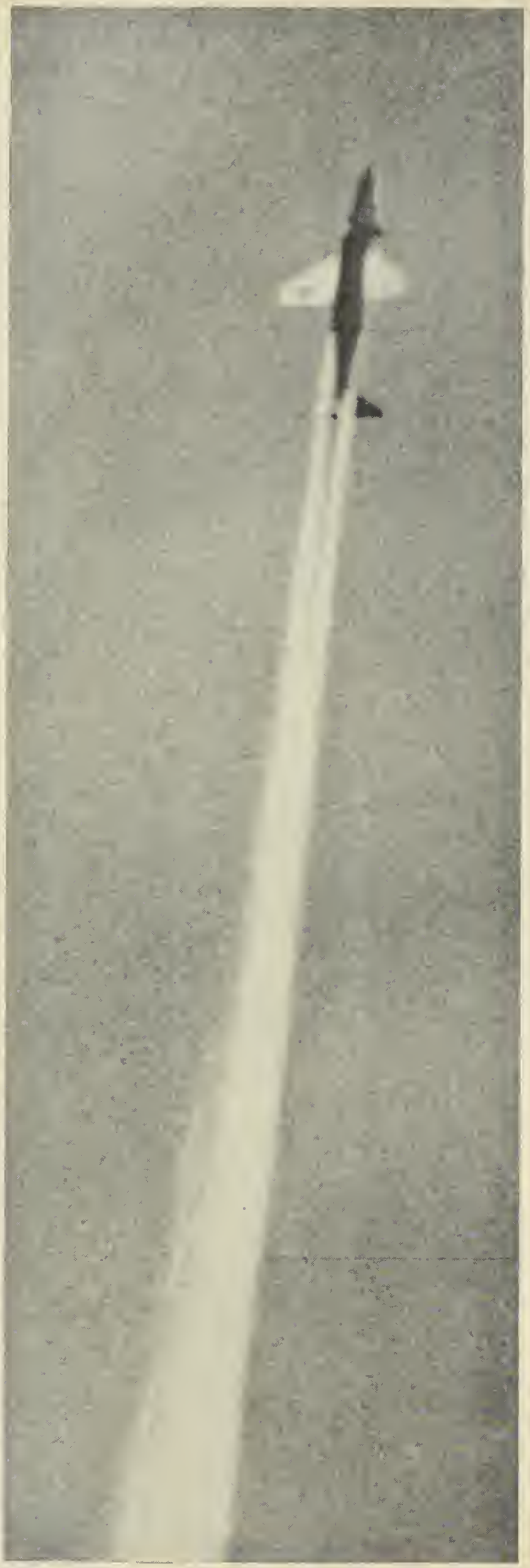
An Anglo-German deal . . .

on the surface-to-air *Seacat* is understood to be under consideration. Under the proposal, Focke-Wulf would handle testing, maintenance and guidance work for the British missile.

• • •

Russia's next move . . .

in space is expected to precede the Summit meeting May 16. Some are guessing that the Russians will put the first man into orbit.



NEWS IS HAPPENING AT NORTHROP

TARGET MISSILES FOR TRAINING
DRONES FOR WEAPON SYSTEM EVALUATION
DRONES FOR AERIAL SURVEILLANCE

TRAINING FOR AIR DEFENSE– THE BEST THING TO FIRE UPON IS A RADIOPLANE TARGET

Radioplane's business for twenty years has been to know military target applications and to produce target aircraft that fill specific training requirements.

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A Division of ***NORTHROP CORPORATION***
Van Nuys, California, and El Paso, Texas

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Industry Countdown

MANUFACTURING

Shift of Louis Michelson . . .

from manager of General Electric's Rocket Engine Section, Evendale, Ohio, to a special assignment has taken place as part of a shake-up of the company's Flight Propulsion Division. W. B. Boyd has been moved over from division manager of manufacturing to replace Michelson on a temporary basis. The section was hit by the recent cancellation of NASA's *Vega* project and its only major contract at present is development of a second-stage rocket case for *Minuteman*.

• • •

A top-secret missile . . .

project is reported under negotiation between Convair and de Havilland.

• • •

Some 6500 Convair . . .

employes covered by Engineers and Architects Association contracts are expected to okay demands for a 10% package increase in wages and benefits before EAA opens negotiations with the company about May 28. EAA's present agreement expires June 2.

• • •

Main bargaining point . . .

in the upcoming industry-wide labor negotiations this spring may be employment. Management is expected to stress that overall defense industry employment is down, in an effort to hold the line on rising fringe benefits.

PROPULSION

Insiders say NASA is trying . . .

to grab full control of the Joint AEC-NASA Project *Rover* nuclear rocket. NASA Administrator T. Keith Glennan is said to be seeking the transfer of all key *Rover* administrative people from AEC headquarters at Germantown, Md., to NASA. AEC is fighting the move strenuously at a series of high-level meetings in Washington.

• • •

Boost-glide passenger . . .

space transport is predicted in the 1980-90 decade by Leston Faneuf, Bell Aircraft Chairman. He foresees vehicles similar to *Dyna-Soar* carrying 30 persons and a crew of five to any point on earth within an hour. Fares would be comparable to those on today's jets.

DuPont's interest in . . .

metals processing is on the upswing. It has just taken on an Air Force contract to look into the extrusion of niobium.

ASTRIONICS

Belock Instrument . . .

is proceeding with plans to open a new facility at Huntsville—despite some uncertainties that have cropped up. Biggest question mark is Dr. Frederick K. Mueller and the other German scientists Belock says will staff the new operation. Mueller and the others have not yet resigned from Dr. Wernher von Braun's ABMA-NASA team, or said they will. Von Braun has expressed doubt whether the new Belock subsidiary will receive any business from NASA.

• • •

Look for a significant . . .

breakthrough in radar technology to be announced by DOD shortly. The development, called "synthetic aperture," achieves equivalent antenna lengths up to one mile in small light-aircraft antennas.

• • •

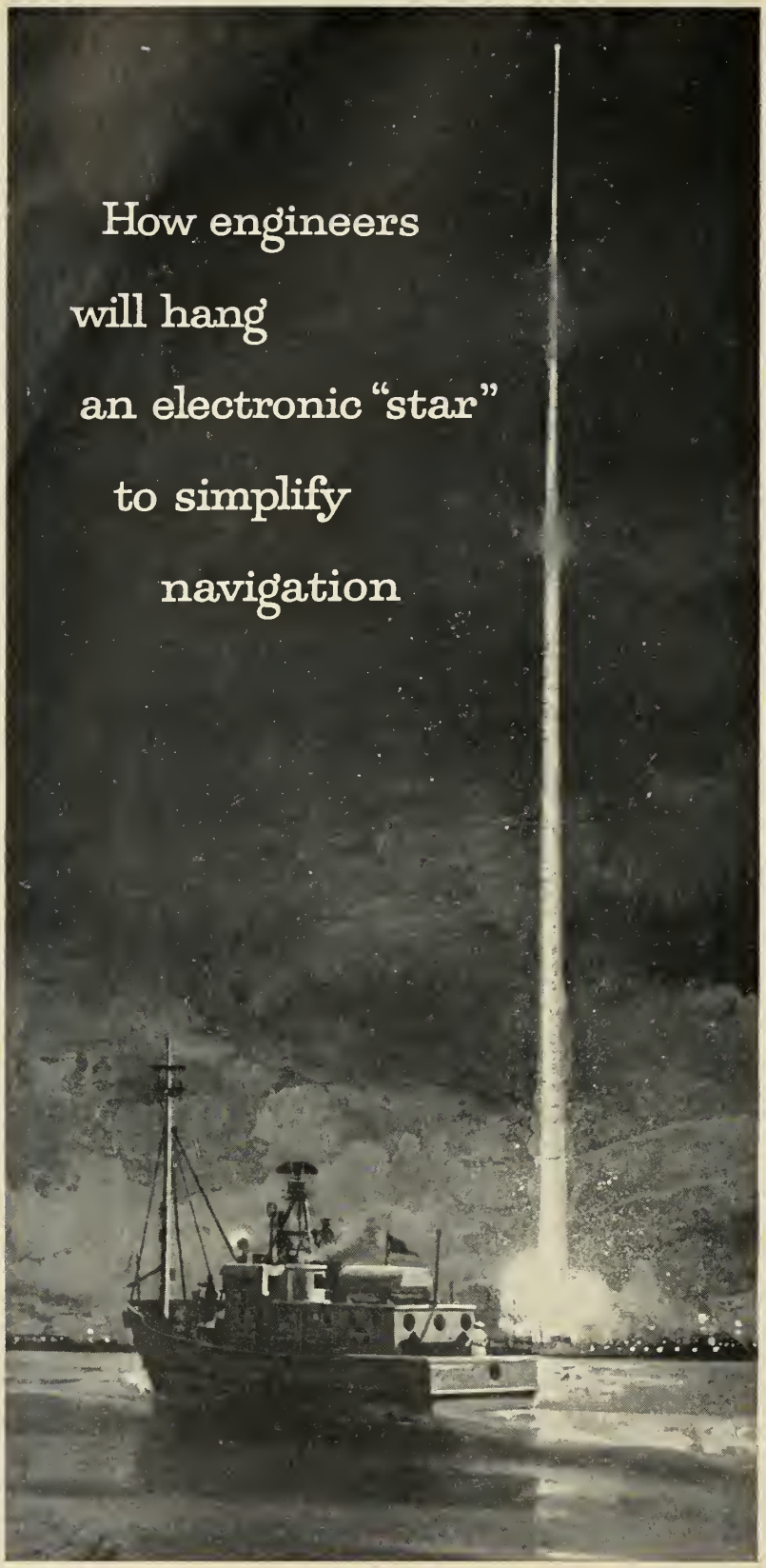
Successful tests of plastics . . .

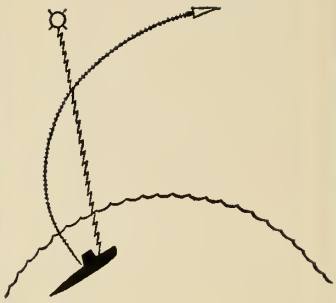
at temperatures up to 2000°F in long-period hypersonic wind tunnel experiments are being reported by Temco aircraft.

WE HEAR THAT

Merger of The Martin . . .

Co. and General Precision Equipment is expected to be fully negotiated this spring. Martin already owns 20% of GPE stock . . . Strong feeling is developing in Britain's defense ministry against cancellation of the *Blue Streak* IRBM . . . Ryan's *Firebee* target drone is being eyed by foreign nations, including Britain . . . Assembly and supply depot for the *Polaris* Atlantic fleet will begin operations April 1 at Charleston, S.C. . . . Fabrication is starting on the 310-ft. mobile service tower for *Saturn* following completion of designs by Kaiser Steel.





Anyone who has ever groped his way in the dark or navigated a ship in a fog will appreciate the promises this Space Age project holds forth . . .

A satellite program is now in development to improve the ancient art of celestial navigation.

A network of solar-battery satellites will encircle the earth, continually transmitting data that can let ships and aircraft figure their positions simply by tuning to the satellites. Submarines and long-range missiles may also use the system.

While the satellite network is still in development, Douglas *Thor* —the booster that can lift it into space—is already operational. It has proved highly reliable as the prime booster in the Air Force "Discoverer" firings and launched the first nose cone recovered at ICBM range.

Thor is another product of the imagination, experience and skill Douglas has gained in nearly 20 years of missile development.

The dependable Douglas *Thor*, prime booster in new multi-stage missiles, can launch satellites—or shoot for the moon.

DOUGLAS

MISSILE AND SPACE SYSTEMS • MILITARY AIRCRAFT • DC-8 JETLINERS • TRANSPORT AIRCRAFT • AIRCOMB® • GROUND SUPPORT EQUIPMENT

M/R Gets New Space Age Cover

For the past nine months we've been studying designs for a new M/R cover . . . designs submitted by several of the country's leading magazine layout specialists.

One problem became the location of the M/R signature; should it stay at the bottom of the cover page, or should we move it to the top? Opinions varied; one group of M/R staffers felt that a basic change in cover design might destroy the magazine's image. Others, the writer among them, had seen M/R's name obscured so often (due to its former location at the bottom of the page) in engineering departments, libraries, magazine racks, and on desks and coffee tables, that we crusaded for a change.

A noted business publication layout expert, Bill Watson, solved our problem by submitting, among two dozen others, the design which made its debut this week. We think he did a great job, and that we made a wise choice. But the cover, like the rest of M/R, belongs to you, the reader. Let's hear what *you* think.

Keeping pace with a market moving as fast and changing as rapidly as does the missile/space market requires neat footwork and a sharp eye on industry developments. Since M/R was first published four years ago, the market has expanded . . . up into space and down beneath the surface of the ocean.

Therefore, to better reflect the real meaning of the magazine, M/R has a new sub-title this week, "The Missile/Space Weekly," appearing on the cover and on the Table of Contents page.

And as part of M/R's continuing effort to keep you abreast of industry developments, we move beneath the waves with the establishment of a new section on Antisubmarine Warfare Engineering, to bow in the near future.

In this latter connection, we're proud to announce two additions to the M/R staff of missile/space market editorial experts: Vice Admiral Harry Sanders (USN, Ret), Director of Chance Vought's ASW Engineering Department, who will become M/R's ASW Engineering consultant and the newest member of our editorial advisory board; and William Beller, industry consultant, author and former Managing Editor of AERO DIGEST, who will serve as M/R's Engineering Editor, and who is already deep in research on the ASW Engineering problem. (For more on these appointments, see page 16.)

In his letter accepting the M/R editorial advisory board appointment, Admiral Sanders wrote, "The magnitude of the management and engineering problems in Underseas and Antisubmarine Warfare is very great. The difficulties are accentuated by scientific problems as complex and nebulous as any in the whole area of defense . . . problems such as detection and underwater communication (which) have emphasized the need for a scientific breakthrough. The subject is vast in scope and I'm sure that MISSILES AND ROCKETS can do much to help both industry and the Armed Forces within the confines of whatever editorial policy you decide upon."

We're grateful to Admiral Sanders and are confident that he, as one of the world's foremost authorities on ASW Engineering, will assist us with these missions.

He'll have a lot of help from the M/R staff. Managing Editor Don Perry, a Navy veteran, has an impressive background in submarine warfare. He qualified in submarines in 1942 and served six years with the underseas fleet, mostly on Pacific Theatre war patrol. Electronics editor Hal Gettings, a former Navy electronics officer with more than ten years' experience in engineering and writing, was responsible for the special Underseas Warfare report in M/R's Aug. 10, 1959 issue, regarded by many in the Pentagon as the outstanding interpretive job to date on this subject.

This week's issue incorporates other, less noticeable changes we believe will make easier your weekly reading of M/R. We've decided to concentrate technical editorial subject matter into departments, so look for electronics, propulsion engineering, ground support equipment, advanced materials, ASW Engineering and international sections each week from now on. Editorial space limitations may prohibit the appearance of every section every week, but over the course of each month you will find the latest news and technical development reports in each category.

The key word in the missile/space market has always been FLEXIBILITY . . . flexibility to meet the challenge of changing technology; flexibility of management and R&D teams to come forth with new concepts; flexibility of industry to establish systems and components requirements often before many in government realize the need for such requirements.

Flexibility within the missile/space market has resulted in continually improving missile and space systems. Flexibility on the part of MISSILES AND ROCKETS, The Missile/Space Weekly, will result, we hope, in a continually improving editorial product.

Edward D. Muhlfeld

letters

Storables Interest Grows

To the Editor:

I would like to obtain three reprints of Dr. C. M. Beighley's article, "Storables Stir Renewed Interest," which appeared in the Feb. 15 issue of MISSILES AND ROCKETS.

Stanley F. Sarner,
Rocket Thermodynamics Specialist,
General Electric Company,
Cincinnati

On their way—Ed.

Gracious Subscriber

To the Editor:

Thank you for your gracious words on my retirement. I still subscribe to MISSILES AND ROCKETS and hope to keep abreast of the fast-moving developments in this field through your publication.

H. N. Toftoy,
Maj. Gen., USA (Ret.)

The Way Things Are

To the Editor:

With reference to "What Industry Says" on page 19 of your March 14 issue:

1. Thomas J. Lanphier and Senator Symington are correct.
2. Mr. Eisenhower is a fool.
3. The Pentagon, in general is a collection of fools; always has been, and always will be.
4. It is now possible for people entirely outside the Defense Department or industry to build 20 to 50 kiloton boosters within two years using existing construction techniques and conventional fuels.
5. Terminal velocities of our larger boosters can be increased by 4000 to 8000 feet per second by a simple modification.
6. First-stage propulsion effort is limited only by strength (not weight) of subsequent rocket stages.

Herman L. Moor
261 State Street
Hackensack, N.J.

Tell us how, Mr. Moor.—Ed.

Credits Corrected

To the Editor:

I wish to call to your attention some inconsistencies and improper credits in the article entitled "Automatic Test Equipment Burgeons," in your Feb. 29 issue.

The graph on the bottom of p. 49 shows EPSCO as a supplier of test equipment to the *Terrier/Tartar* programs. They have supplied component parts such as memory units and analogue to digital converters of test equipment systems, but have never supplied complete systems.

On p. 52, the credit for the BOFTE system belongs to HYCON Manufacturing Co., which also furnished the AN/DSM-54 and-55 for *Terrier/Tartar*. The BOFTE is programed in a fixed sequence with stepping switches.

Convair-Pomona has automatic systems in use in our production line that are card-programed and do perform as indicated in your article. In addition, Convair-Pomona has supplied the AN/DSM-23 which is used for USMC checkout of *Terrier* missiles. This equipment is a tape programed system with a programable analogue voltage comparator and RF guidance simulator.

E. L. Watkins, Chief,
Support Systems Equipment Section
Convair Pomona

Barnes' DAMP Contribution

To the Editor:

As an avid reader of your excellent publication, I was particularly interested in the Feb. 29 issue which carried an article on page 22 entitled, *"Arcas* Launchers Put on Army's Range Ship." However, we were somewhat surprised to note that no mention was made of Barnes Engineering Company's continuing contribution to the DAMP Program.

Barnes Engineering, under prime contract to ARGMA, is responsible for the optical measurements portion of the DAMP project.

Edmund B. Palmquist
Barnes Engineering Company
Stamford, Conn.

Linde's LOX Policy

To the Editor:

I think you will be interested in the response accorded your recent article concerning liquid oxygen supplied to the missile industry. In general we felt that the treatment given the subject was entirely objective and factual. It certainly covered the subject to a more extensive depth than prior articles in "popular nontechnical publications."

Naturally, an article such as this one could not help but raise some issues with respect to the companies included. The only issue raised within Linde Company, however, was a feeling that your audience might possibly misunderstand our position concerning liquid oxygen supply to the government. Although all of our contracts thus far have specified liquid oxygen via the delivered route, Linde is not committed in any one direction and will use the most efficient method to supply government installations. Feasible methods, of course, include piping the product from "over the fence" plants, and even building a plant to be sold or leased to the government and operated by government personnel or by non-government personnel under contract.

A. Kiczales
Advertising Department
Linde Company, Div. of
Union Carbide Corp.
Room 2840
420 Lexington Avenue
New York 17, N.Y.

The sphere represents perfection in many ways to the designer of inertial instruments. It can be decoupled completely from torques due to external magnetic, electric, and gravitational fields. It has perfect symmetry, can be formed to extreme accuracy by simple machine processes. It is the primary element of Honeywell's electrically suspended gyro.

professional opportunities at Honeywell Aero

INERTIAL SYSTEM DEVELOPMENT

Systems Analyst—employs mathematical techniques such as operational calculus, matrix algebra, and difference equations to the solution of problems concerning performance characteristics of various system configurations including analysis for error introduced by sensors and computer, requirements for alignment, and optimization of the system configuration.

Digital System and Logic Designer—requires familiarity with capabilities of various digital computer configurations and ability to employ system and logic relations in specifying necessary configuration for solving inertial navigation problem.

Electronic and Mechanical Designers—engineers with background in transistor circuitry, inertial sensor development and evaluation, and precision mechanical equipment design are needed to perform component development and evaluation, and to design mounting and alignment equipment.

APPLIED RESEARCH

Programmer Analyst—mathematician with experience in the use of medium and large scale digital computers for analysis of scientific problems.

Human Factors Engineer—capable of analysis and direction of experiments in human motor skills, and application to man-machine systems involving automatic control techniques.

Systems Analyst—capable of conducting research studies involving new techniques of space navigation and guidance.

DESIGN AND DEVELOPMENT

Flight Control Systems—analytical, systems, and component engineers to work in areas such as advanced flight reference and guidance systems. Positions range from analyzing stability and control problems, systems engineering—through design, testing, and proof of electrical and mechanical equipment—including flight test and production test.

Advanced Gyro Design—Engineers with two and up to twenty years' experience in precision gyro and accelerometer development, servo techniques, digital techniques, solid state electronic development, advanced instrumentation and magnetic component design.

Electronic Circuit Designers—experienced in the areas of analog/digital computers, transistor circuits, servos, instrumentation, and/or gyro stabilization.

For the less experienced professional engineer, there are opportunities in the Evaluation Laboratory which lead to careers in any of the above fields.

To investigate any of the above professional opportunities, please write in confidence to Bruce Wood, Dept. 603, Honeywell Aeronautical Division, 1433 Stinson Blvd. N.E., Minneapolis 13, Minnesota.

To explore professional opportunities in other Honeywell operations coast to coast, send your application to H. K. Eckstrom, Honeywell, Minneapolis 8, Minnesota.

Honeywell

H Military Products Group

Project *SLAM* Awaits Go-ahead

Air Force evaluates design studies of low-altitude ICBM which might foil Soviet defenses; decision up to DOD

by William J. Coughlin

LOS ANGELES—Design studies for an intercontinental supersonic low-altitude missile powered by a nuclear ramjet engine—Project *SLAM*—have been completed and now are being evaluated by the Air Force.

Fate of Project *SLAM* will rest with a Department of Defense decision whether or not to proceed with research and development on another major missile program at this time.

Project *SLAM* envisions a missile with Mach 3 sea-level speed which will have unlimited intercontinental range and which will be capable of low-altitude approach to a target from any direction. Unlike the ballistic missile, it will be able to feint and dodge as it approaches target.

Launched from mobile bases in the U.S. or elsewhere by rocket boost, the *SLAM* missile would cruise to target in a corridor between 50,000 ft. and 100,000 ft. at speeds up to Mach 4 before diving to approach Soviet territory at Mach numbers between 2 and 3. Alternatively, the entire mission could be accomplished at low altitude if required.

SLAM will be capable of carrying multiple-warhead payloads and since, unlike a ballistic missile, its guidance system can monitor and correct its position throughout the flight, it will be able to achieve extremely high accuracy. No major breakthroughs in guidance are required.

• **Poser for Reds**—*SLAM's* long-range capability, supersonic speed, low-altitude and omni-directional approach would impose requirements on the Soviet defense system which it has not yet had to meet, military experts believe. Intelligence reports indicate the Russian missile warning network, like that of the U.S., is designed to cope primarily with ballistic missile trajectories.

One study for the *SLAM* project indicates that present Russian radar would be unable to pick up approach of the missile at 1000-ft. altitude until it was within 20 miles. Instantaneous response by an antimissile missile would be unable to destroy *SLAM* until it was within six miles of target—destructive range with a high-yield hydrogen warhead. Kill probability even then only would approximate 10%, the study indicates.

Initial *SLAM* design studies were made by North American Aviation, Convair and Chance Vought.

Experimental development of the nuclear ramjet engine, under way since early 1956 as Project *Pluto,* is being carried out by the Atomic Energy Commission's Lawrence Radiation Laboratory at Livermore, Calif., by Marquardt Corp. at Van Nuys, Calif., and by the Atomics International Division of North American Aviation.

LRL is responsible for the reactor and Marquardt, under Air Force contract, is developing non-nuclear components of the system.

Advanced materials research for *Pluto* is being done at Atomics International under an AEC contract. Major problem for the nuclear ramjet missile is development of materials capable of withstanding the high temperatures and radiation encountered.

• **Modest funding**—AEC expended some $27 million on the nuclear ramjet program through Fiscal 1959 and the Air Force $10 million. This compares with a total of some $880 million spent on the nuclear manned-aircraft program.

Air Force interest in the program is high. Gen. Thomas D. White, AF Chief of Staff, has this to say:

"Studies completed on nuclear ramjet proposals offer promise of low-altitude, high-speed, long-range missiles that can augment our strategic ballistic missile forces . . . the existing programs in development of nuclear missile propulsion are now in proof-of-principle status . . ."

The first *Tory-2* experimental reactor developed under the U.S. nuclear ramjet program is scheduled for testing shortly at AEC's Jackass Flats, Nevada, test site. This reactor built at Lawrence Radiation Laboratory is intended to prove out development of high-temperature gas-cooled reactor materials, neutronics and other design features.

Building of a full nuclear ramjet engine prototype still is some distance off. Funds for building of test facilities are included in the AEC budget for Fiscal 1961.

• **Direct cycle**—The engine for *SLAM* will be a direct-cycle unit in which the ram air is passed through a series of honeycomb holes in the cylindrical reactor. The reactor replaces the fuel injector and combustor of the conventional ramjet engine and is similarly situated. Supersonic inlet of the engine will be a simple conical spike with a pressure ratio of about 37/1 at Mach 3, more than 100/1 at Mach 4.

As the air passes through the "Swiss cheese" reactor structure, its temperature will be raised by nuclear heating and it then will be expelled through a conventional exit nozzle.

The reactor itself will be a homogeneous moderated reactor. (In a homogeneous reactor, the nuclear fuel is mixed with the moderating material.) A core reflector will be used to make possible a more uniform radial heat distribution. Controls will be largely pneumatic.

Reactor diameter will be large, as much as six feet, since increasing the dimensions beyond those of a conventional ramjet means a larger amount of air will flow through, increasing thrust with no penalty to speak of in increased consumption of nuclear fuel.

• **Vital statistics**—Dr. Theodore C. Merkle, Associate Director, Lawrence Radiation Laboratory, indicates in an article in the Fall-Winter issue of the Air University Quarterly Review that the open area of the multi-channeled cylindrical reactor will be about half the area of one end of the cylinder. Length of the reactor will be about equal to its diameter and the length-to-diameter ratio of the holes about 200.

In the same publication, Alan R. Gruber, Director of the Nuclear Systems Division of Marquardt, calculates that a nuclear ramjet engine with a six-ft. reactor diameter, delivering air at 1840°F, would provide 13,200 lbs. thrust for a missile with a speed of Mach 3 at 60,000 ft.

"Assuming that a lift/drag ratio of 4 could be achieved for a missile with this engine installed," Gruber says, "the missile's allowable gross weight would be 52,800 lbs. If we further assume that the missile structure weighs 35% of the gross weight, or 18,500 lb., and that the engine and its controls weigh 20,000 lb., then we find that a balance of 14,300 lbs. is available for useful load."

• **Strain on structures**—An increase in reactor temperature to 2240°F could bring the engine thrust to about 18,000 lbs., upping gross weight of the missile to approximately 72,000 lbs., and useful load to 26,800 lbs. It is apparent from this that the critical limitation in design of the nuclear ramjet for *SLAM* is the high temperature which the struc-

tural material of the reactor itself must withstand. On-the-deck aerodynamic heating also must be considered, as well as the fact that the reactor will have to stand a pressure across its face of 550 psi at Mach 3 at sea-level.

Present workable metal alloys are unable to meet the high-temperature structural requirements. Materials meeting temperature specifications present fabrication problems.

Friction losses of air moving through the many channels of the reactor also will be greater than the losses in the combustion chamber of a conventional ramjet engine.

Due principally to these two factors, specific thrust of the nuclear ramjet is inferior to the conventional ramjet. This can be offset to some extent by increasing dimensions of the engine.

• **Other problems**—Capt. John P. Wittry, an Air Force advanced propulsion technologist, reports in the Air University Quarterly that the biggest problem in development of the direct-cycle *Pluto* engine, where air passes directly over the hot elements in the reactor core, is oxidation. This causes materials to lose structural integrity.

Shielding for *SLAM* is a much smaller problem than for a nuclear-powered manned aircraft, although shielding of the missile still is a requirement. Radiation is sufficiently intense to prevent use of certain materials in the propulsion system and the missile.

Even at very low altitudes, however, passage of the *SLAM* missile overhead will pose no radiation problems on the ground since a typical mission will result in distribution of only a few grams of fission products over many thousands of miles.

U.S. Space Plans Slip Everywhere

by James Baar

The U.S. Space Lag is even worse than some critics have said it is.

Not only is the United States behind Russia in space, the United States also is slipping far behind the schedule of space exploration that some of its best minds believed possible nearly a year and a half ago.

At that time, the original Select House Space Committee polled dozens of the Free World's leading scientists, engineers and government officials in charge of space activities as to what they thought the U.S. could accomplish in space by the end of 1968.

The poll — subsequently compiled and issued Jan. 2, 1959, as a report called "The Next Ten Years in Space, 1959-69"—makes a handy yardstick for measuring current U.S. space plans.

Slippages show up everywhere. In some vital areas, the recent 10-year space program advanced by NASA (M/R, Feb. 8) is already five years behind some estimates.

On the prime goal of putting a man on the moon there is anywhere from a three to seven year lag compared to NASA's target date of about 1972.

Twenty of the experts polled in the survey said the U.S. could land a man on the moon by 1968 at the latest. Many of the 15 others commenting on lunar exploration felt a manned lunar landing would be near by then.

Dr. Herbert F. York, now Pentagon R&E Director and then Chief Scientist of ARPA, said a very high priority program could put Americans on the moon in 1965 and on Mars and Venus in 1968. Such a schedule would beat the announced Russian plan to land men on the moon by late 1967.

Others without specifying what years said the United States could put a man on the moon and bring him back before the end of 1968. Among these were: Lt. Gen. Bernard A. Schriever, commander of the Air Research and Development Command; Dr. Louis G. Dunn, president of STL; Dr. Walter Dornberger, technical assistant to the president of Bell Aircraft; Dr. James H. Doolittle, then chairman of the National Aeronautics and Space Council; George S. Trimble Jr., vice president of Martin; Brig. Gen. Homer Boushey, Air Force Advanced Technology director.

Event	NASA	House Poll
MAN IN ORBIT	1961	1959+
1.5-MILLION LB. THRUST BOOSTER	1963	1961
UNMANNED CIRCUMLUNAR FLIGHTS	1964	1961-3
MANNED CIRCUMLUNAR FLIGHTS	1969+	1965-68
MANNED SPACE STATIONS	1969+	1965-68
MAN ON MOON	1972	1965-68

COMPARISON of the current NASA timetable and opinions expressed in the year-and-half-old survey of experts made by the House Space Committee.

The NASA timetable—billed as a guideline subject to revision either forward or backward depending on funding and scientific progress—calls for firing a three-stage *Saturn* vehicle in FY 1963. The clustered booster would have 1.5-million pounds of thrust.

But Dr. Eric Durand, Aeronutronics' chief of space sciences, said a clustered 1-million pound thrust booster could be operational in calendar 1961 and a single chamber 1-million pound thrust booster could be operational by 1963. Boushey said a recoverable 4-million pound booster could be developed before 1964. George Stoner, Boeing manager of *Dyna-Soar* systems, said a 1.5-million pound thrust booster could be developed by the end of 1961.

The NASA timetable calls for putting the first manned satellite in orbit in the later half of 1961. Some of the experts polled said it could have been done by last year.

The NASA timetable calls for putting an unmanned satellite around the moon and bring it back in 1964.

But according to Schriever's proposed schedule the United States could be sending a man around the moon within about the same time period. George L. Haller, vice president of General Electric, said a soft lunar landing by an unmanned vehicle was possible by the end of 1961 at latest.

The NASA timetable calls for the first launchings between FY 1965 and 1967 leading to manned space stations and manned circumlunar flights.

But a number of the experts polled said the United States could have space stations in operation by the end of 1968 at the latest. Schriever said three-man space stations could be in orbit around the earth by around 1965.

They came up with approximately the same time period—1965 to 1968—for manned circumlunar flights. And they said such flights would be preceded by a controlled manned space flight.

The key to all of the forecasts in the committee report was money.

York based his most conservative schedule "on the assumption that expenditures will average very roughly $1 billion per year and that vigorous related programs of a military nature such as the missile and high speed aircraft programs will continue at more or less their present rate."

Durand based his forecasts on a total expenditure of about $30 billion over the 10-year period; Schriever on "relatively large amounts of resources;" others put the cost at about $20 billion; still others said bluntly:

The United States can have these things if it will pay the price.

M/R Expands Its Coverage of ASW, Technology Fields

Antisubmarine warfare expert joins board of advisors; veteran engineering writer-consultant added to staff

Two authorities in the missile/space field joined MISSILES AND ROCKETS last week to lend support to the magazine's expanding editorial coverage in the antisubmarine warfare and astronautical engineering areas.

Vice Admiral Harry Sanders, USN (Ret.) accepted appointment to the magazine's Editorial Advisory Board in the field of Antisubmarine Warfare Engineering. M/R in its April 11 issue begins a new department—ASW Engineering—with regularized coverage of this vast new field where the technological problems parallel those of missiles and space.

ADMIRAL SANDERS
CV's top ASW expert joins M/R's board.

WILLIAM BELLER
New M/R Engineering Editor.

William Beller, who has an impressive background as a scientific consultant and writer, joins the full-time editorial staff as an Engineering Editor. His first assignments will be extensively researched articles on the technological challenges of antisubmarine warfare.

Admiral Sanders is a long-time veteran of submarine warfare. After retiring from the Navy as a Vice Admiral in 1957, he joined the Chance Vought Aircraft engineering staff where he is now Director, Antisubmarine Warfare Engineering. He is a member of the Undersea Warfare Advisory Committee of the National Security Industrial Association. This committee was organized to advise the Navy on ways in which industry's specialized know-how could be applied to assist in antisub warfare.

Admiral Sanders began his career with the comparatively primitive submarines of the 1920's, when their depth limit was 200 feet and "even there they couldn't stay down very long." Later he went on Admiral E. J. King's staff as War Plans Officer, commanded a destroyer squadron in the European theatre during World War II, and took part in the invasion of Anzio, in the Normady Invasion and in the assaults on Omaha and Utah beaches. A graduate of the U.S. Naval Academy in 1923, he later received an M.S. degree in engineering from Columbia University.

Beller has been Consultant to the House Space Committee, to Booz-Allen Applied Research, to Applied Science and to other industrial concerns. He has been on the mathematics and engineering faculties of the University of Southern California and Polytechnic Institute of Brooklyn. Early in his career Beller was graduated from the Georgia Institute of Technology and from New York University with degrees in mechanical and aeronautical engineering. He has been Managing Editor of AERO DIGEST, and Engineering Editor of American Aviation, now AIRLIFT magazine. He is co-author of *Satellite,* one of the first books written about artificial satellites.

—news briefs—

TEST SHOT STEPUP—Testing schedule of the Martin *Titan* ICBM is expected to be accelerated following a seventh successful shot March 22. Second stage separation and ignition was accomplished along with a closed-loop test of the radio inertial guidance system. A capsule containing a recording of peak heating while telemetry was blacked out during re-entry was recovered.

***BOMARC* DECISION DUE**—The Air Force is winding up a review of the controversial *Bomarc B* air defense missile amid speculation it will fight a cutback of the program. A proposal is under consideration, the AF also disclosed, to add two *Atlas* ICBM squadrons (18 missiles) to the 13 presently programed. The move costing $326 million would provide for increasing the last six *Atlas* squadrons from nine to 12 missiles.

REDS THREE YEARS AHEAD—Former Assistant Air Force Secretary Trevor Gardner estimates the Russians are still three years ahead of the United States in the space race.

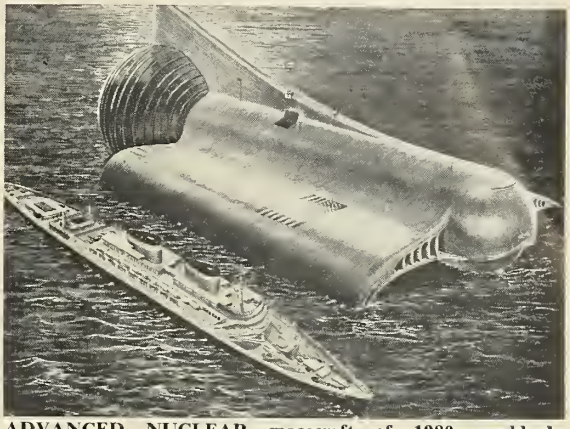
NORTHROP PROFITS SLIDE—Six-month income for the period ending Jan. 31 of $110.7 million and net profits of $3.1 million were reported by Northrop Corp. This compares with sales of $122.7 million and profits of $3.3 million for the same period last year.

MOBILE VS. HARD—Air Force and Navy witnesses will testify March 28 before the Holifield House Military Operations Subcommittee on the relative advantages and disadvantages of mobile and fixed missile base systems.

THIOKOL NET UP 84%—Thiokol Chemical Corp. net earnings for 1959 totaled $5,521,631, or $1.22 a share—an increase of 84% over the 1958 earnings, which were $0.72 a share . . . Temco Aircraft Corp. directors decided to defer payment of a dividend and invest earnings in a growth program although, directors said, "earnings for the year 1960 are currently projected to be greater than those realized in 1959." . . . Thompson Ramo Wooldridge Inc. earnings for 1959 totaled $9,743,918, or $3.02 a share, a rise from the 1958 income of $8,979,232, which was $2.86 a share . . . Admiral Corp. 1959 earnings tripled those of 1958. Net income rose to $4,108,450, or $1.71 a share, compared with 1958 totals of $1,375,017, or $0.57 a share.

Fantastic Vehicles Will Be Realities

NUCLEAR SHIP of the 1970-1975 period. Could be *Antares*-type vehicle, first major application of the *Rover* type fission reactor rocket.



ADVANCED NUCLEAR spacecraft of 1980, could be the *Aldebaran*. S.S. United States illustrates the scale of this 50,000 ton vehicle.

by John F. Judge

An increasing amount of vigorous interest in the developments of the next twenty years in space is being displayed by some of the nation's largest missile manufacturers.

Long-range studies are arriving at concepts which might seem to the layman to be at home in fantasy—but are nonetheless based on hard technical knowledge.

An effort just completed at The Martin Co. anticipates developments in the coming two decades such as—

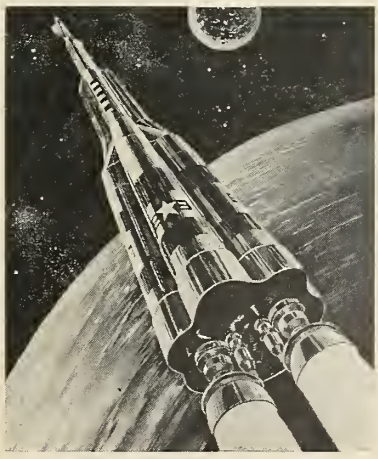
• *Antares*—a nuclear vehicle of the *Rover* propulsion type, weighing up to 20 million lbs. and capable of soft landing 4 million lbs. payload on the moon.

• *Aldebaran*—an advanced nuclear vehicle in the 50,000-ton class, rivaling the S.S. United States in size but with lunar capabilities.

This latest study is reported here as a result of MISSILES AND ROCKETS' continuing interest in the subject.

Postulating an intelligently planned and enthusiastically supported national space program—and assuming that the current effort will continue to be aggressively pushed on a broad front by industry and government, Dandridge M. Cole, Martin-Denver's senior advanced planning specialist, produced an analysis outlining the trend toward low-cost, high-performance, manned spacecraft.

In the beginning of the report, Cole examines the effect of structural improvements on the gross weight-to-payload ratio (G/L) of vehicles. The prevailing skepticism over the possibility of transporting several tons over extended reaches of space is understandable, says Cole, since all we have been able to accomplish is in the nature of the *Vanguard* and *Discoverer* shots—the average ratio involved here is about 400 to 1.



SUCCESSOR TO *Saturn* could be *Arcturus* employing two Rocketdyne F-1 engines. This is a logical replacement for *Nova* in terms of economy and development speed.

Considering lunar landings, the G/L ratio goes as high as 4000 to 1 with current propellant systems—again supporting conservatism.

But Cole points out that the expected G/L for *Vega* was only 700 and for *Saturn* is down to around 500. These reductions were due almost entirely to structural improvements.

Further, with current propellants, the G/L for a three-stage lunar landing vehicle can be lowered from 1000 to 1 down to 500 to 1 by raising the average propellant fraction (propellant weight divided by gross weight minus payload) from 0.86 to 0.89.

A 50% increase in propellant performance through high-energy chemicals would bring the G/L down to 200 for a propellant fraction of 0.76. Even greater reductions can be had through nuclear concepts such as *Rover*.

The upshot of all this is that large performance gains can be made from improvements in structural efficiency—particularly through increase in vehicle size.

• **Larger vehicles**—Cole says that the initial impetus for increasing the vehicle size and gross weight is founded in the need to place large manned payloads in orbit, and instruments on the

moon. *Saturn* will effectively meet these requirements.

Beyond *Saturn*—which is just about capable of one-way manned lunar missions—there is a need for manned round trip abilities which can be satisfied by increasing the gross weight to 2.4 million lbs. *(Arcturus)* or 4.8 million lbs. *(Nova)*. Some improvement in structural efficiency is to be expected.

The Martin scientist said that this is the area in which further increases in weight no longer result in propellant fraction improvements. This is the point at which the nuclear-propelled vehicle becomes superior to the chemical rocket. The reason is that the fixed weight items have become negligible when compared to the entire vehicle.

The large fixed weights of shielding in nuclear vehicles provide another incentive for an increase in size. The development and production costs in both systems do not increase as fast as the vehicle size, because the weight increase is in low-cost structural metals. Now the cost picture begins to change for the better in relation to the vehicle size.

In the gross weight vs. time chart, the broken line represents Cole's earlier advanced planning curve plotted during the 1955-58 period. Today this curve seems highly conservative, but Cole points out that as late as mid-1958 the idea of building vehicles of over 2 million lbs. by 1977 " . . . seemed to many to be too great a strain on the imagination."

It is interesting to note that the new curve shows the growth of U.S. vehicles may have started with the all-U.S. *Vikings* rather than with the modified and rebuilt German *V-2* rockets.

• **Specific impulse**—The relation of an increase in propulsion performance to the gross weight to payload ratio shows that three-stage vehicles with current propellant systems having vacuum specific impulse in the 300 second or lower range do not have the energy to provide efficient transportation to the moon. This changes as the I_{sp} increases to about 400 seconds.

When the I_{sp} is 600 the values of G/L reach 15 to 1, a very efficient level. The *Rover* nuclear rocket concept I_{sp} level reaches values of 800 and the staging requirement falls to just two, since little is gained with a third stage in terms of efficiency. At an I_{sp} of 1000, one stage almost equals three; in the advanced nuclear area of around 1700, the G/L drops to about 3 to 1—better than present commercial jets on a 5000-mile flight.

Current chemical propellants already have vacuum specific impulses above 300 seconds, and Cole expects that 320 seconds should be reached in the near future. Vacuum values cannot be attained in the atmosphere so an I_{sp} of 260 seconds more reasonably represents present sea level values. In anticipating the increase in specific impulse, Cole deducts the energy losses in overcoming drag and gravity and plots the average against time. Numbers taken from the curve can be inserted directly in the equation

$$\Delta V = IgLn\ \gamma$$

to give the velocity change for each stage. The value I is the adjusted specific impulse and γ is the ratio of gross weight to empty weight.

The Martin expert estimates that by 1965, large high-energy chemical upper-stage engines powered by LOX and liquid hydrogen will be in general use. Vacuum I_{sp} will then range above 400 seconds. He further anticipates the use of the atmosphere in stepping up performance. Initially this will take the former of afterburners and other methods of adding air to the rocket exhaust.

Even these early methods of incorporating the atmosphere into the propulsion system would have effective specific impulse values well over 500 and as high as 600 seconds. This means the average I_{sp} for all stages should exceed 450 seconds.

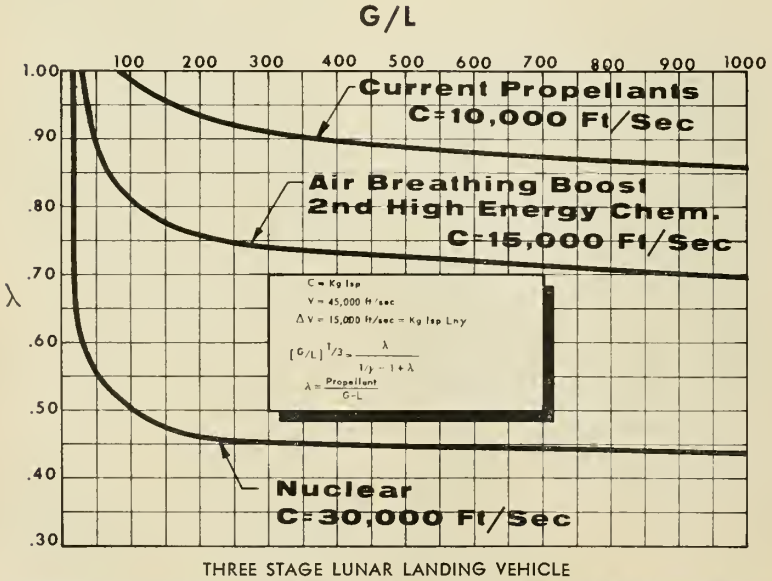
Cole finds substantial agreement among propulsion experts that the early nuclear rockets should be in use by 1970. These engines will have I_{sp} ranges from 700 to 900 seconds and will probably find extensive use in upper stages. By this time air-breathing first-stage systems should be in the neighborhood of 900 seconds, providing an overall vehicle average of about 800 seconds.

When the flight performance gains outlined in the first section of the study are combined into advanced vehicles, the capabilities are startling. Cole chose the amount of payload soft-landed on the moon as the performance parameter in considering the total effects of the improvements.

• **Underestimation?**—In this respect the Martin scientist notes a lack of appreciation of the lunar payload capabilities which can reasonably be expected of the 1970-1980 period.

Two tendencies contribute heavily to this indifference. The first is the habit of considering each improvement individually instead of combining them and the second is the general, unrealistic conservatism and excessive caution hindering extrapolation beyond current accomplishments.

In his analysis, Cole begins by considering the *Vega, Centaur* and *Saturn* vehicles. Although the *Vega* was cancelled, it represents the payload capability attainable with an *Atlas* or *Titan* with essentially no modification except the addition of an upper stage. The original *Vega,* an *Atlas* plus a *Vanguard* first stage, could softly land 500 lbs. on the moon. If the upper stages added to either *Atlas* or *Titan* used high-energy chemical propulsion systems, this payload could increase to 1000 lbs. The particular high-energy upper stage planned for the *Atlas* in the early 60's involves a LOX and liquid hydrogen system and is desig-



THREE STAGE LUNAR LANDING VEHICLE

EFFECT of improvements in structural efficiency of three-stage lunar landing vehicle.

MOLECULAR ELECTRONICS THE THIRD MAJOR BREAKTHROUGH in the history of electronics...

as significant today as the vacuum tube in 1907... as the transistor in 1948.

Molecular electronics use new insights into the structure of matter to create single crystals which perform one or more complete electronic functions in the control and transformation of energy.

Westinghouse can now report startling progress in this fantastic field—in this status report on a U. S. Air Force research program which began less than a year ago.

Fact one: molecular electronic systems are here today—in laboratory models which prove out the principle even as they pave the way for production models. On the next two pages are a number of different molecular electronic devices performing the functions of familiar systems, without conventional components.

Fact two: each one incorporates germanium or silicon crystals—etched, sprayed or alloyed.

Fact three: each one is a functional block which performs the missions usually requiring conventional components soldered together.

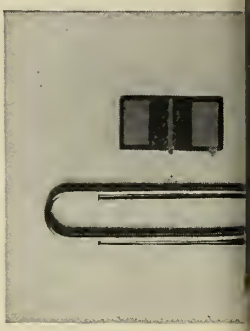
Prediction: soon, multi-zoned crystals will be "grown" and processed directly from the furnace melt—may emerge as ready-made electronic systems.

Prediction: only two to five years from now, the pattern of electronic systems will be changed to the core as a result of this historic Westinghouse breakthrough in research and development. Reliability, miniaturization and simplicity will show exponential progress.

Westinghouse presents working proof of the principle of molecular electronics

POWER AMPLIFIER: Button-sized molecular electronic device held by girl with a pair of tweezers performs the same amplifying function as a conventional 5-watt amplifier, has a frequency range from zero to 20,000 cycles. Working element is a block about as large as the head of a pin.

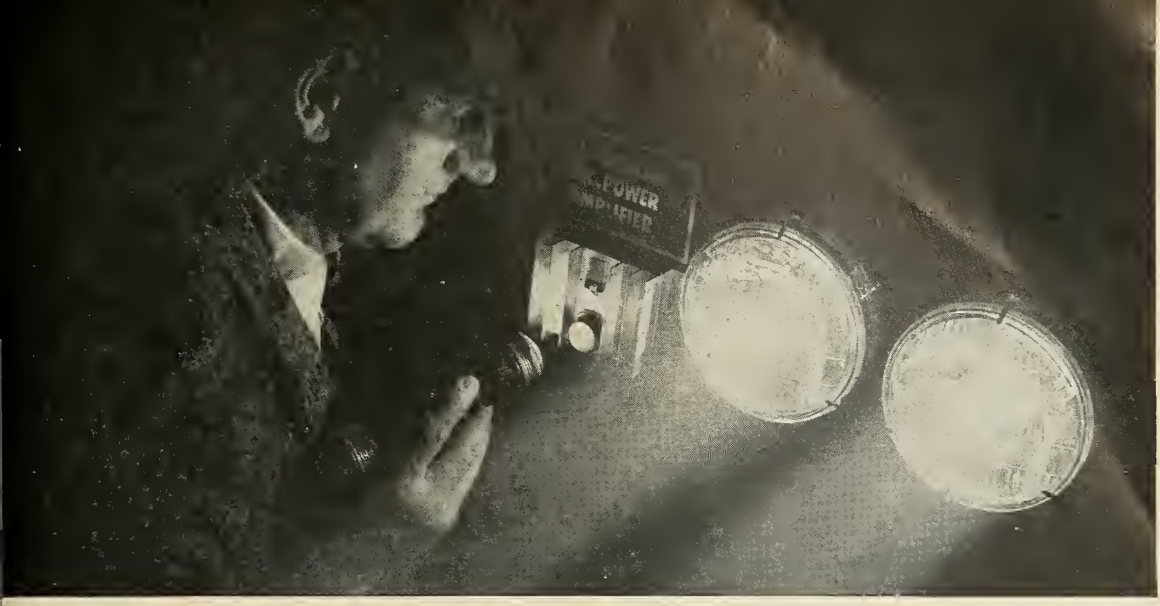
VIDEO AMPLIFIER: made with a tiny wafer from a ribbon of germanium crystal. This function block also works like a radar amplifier sub-system. Gain is essentially flat to frequencies of several megacycles.



MULTIVIBRATORS: stable, monostable, astable—covering quencies from 1 cyc less to 3 megacy Shown is a free run multivibrator alon paper clip.

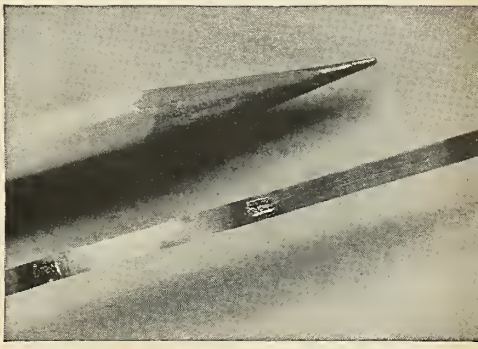
MULTI-POSITION SWITCHES: these molecular electronic devices evolved out of Westinghouse work on multivibrators—the "OR" logic switch illustrated has important potential applications in missile countdown functions.

LIGHT TELEMETRY SUB-SYSTEM: a single light-responsive monolithic element delivers output whose frequency is a measure of light intensity.



-C AMPLIFIER: connected to a solar cell, this tiny block takes an in-
ut of 4 milliamps . . . via flashlight beam, raises it to 40-watt output.

RYSTAL GROWING techniques developed by Westinghouse have already roduced germanium dendrites 300 feet long in the special furnace shown left, above. Crystal ribbons of almost any length are possible. The take-reel at right holds 300 feet of the brittle dendrite with each turn cushioned glass-cloth tape.



CRYSTAL RIBBON requires no grinding or lapping. Only a few steps are needed to turn these "educated" crystals into working electronic systems. Above, multiple-junction systems are shown on a crystal section.

The meaning of molecular electronics

RELIABILITY: molecular systems reduce drastically the number of components and internal connections required—and the fewer components and connections the fewer potential trouble spots.

MINIATURIZATION: molecular electronic systems are less than one-thousandth the volume and weight of conventional component systems. This is a conservative generalization—in many cases, much more startling size and weight reductions are possible.

POWER REQUIREMENTS: input power can drop almost as fantastically as size and weight. In a typical light telemetering sub-system, a 5-watt input is required; the transistorized version gets by with 0.75 watts. The same function is still performed by a molecular electronic block requiring but 0.06 watts.

ENVIRONMENT: inherently more resistant to g-loads because of their small mass and few components, Westinghouse-developed molecular systems show promise to be temperature and radiation resistant as well. New semiconductor materials and new large crystal surfaces point to very high temperature and power-handling capabilities.

FUTURE: progress in this new field is so rapid, and the advantages so great, that the molecular electronics concept will find wide applications in air/space electronic systems within 3-5 years . . . In particular, look for great advances in the state of the art in these areas: telemetering • fire control guidance • communications • counter weapons • flight control—as a direct result of the new molecular electronics era.

The Air Arm Division of Westinghouse Electric Corporation holds the U. S. Air Force management contract for this project. It is being supported by the Semiconductor Department, the Materials Engineering Department, and the Westinghouse Research Laboratories.

J-02311-1-3

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nated *Centaur*.

Cole refers to *Saturn* as the first big step in size and performance beyond the *Atlas-Titan* era. Weighing about 1 million lbs. this vehicle's first-stage engine will be static-tested in the next few months. The propulsion unit is a cluster of eight engines of a type already used in the *Atlas, Thor* and *Jupiter*. This is the vehicle which just reaches the area of manned lunar flight. *Saturn* may be able to place man on the moon, but some refueling concept is necessary if he is to return.

This is the point at which Cole says the importance of the moon in the exploration and exploitation of the solar system becomes more clearly established. Along with this will come recognition and general acceptance of the value of early large-scale manned lunar flights and basing.

The *Saturn* will see maximum use in this respect; Cole anticipates increased emphasis on the early application of the F-1 engine for this purpose. The 1.5-million-lb.-thrust F-1 is under development at Rocketdyne and an early experimental model has been successfully tested.

A great deal of preliminary study has been done on *Nova*, the vehicle to be powered by a cluster of four F-1 engines generating 6 million lbs. of thrust. *Nova* has been advertised as the first vehicle capable of roundtrip manned lunar flights without refueling. Its operational date has been estimated as approximately 1967.

Some thought has also been given to a vehicle powered by one F-1 engine.

Cole says that the use of two F-1 engines in a second or third generation *Saturn* "may turn out to be a more practical compromise than either one or four engines."

Three reasons are given to support this contention.

• A single F-1 engine vehicle would have only marginal performance advantages over *Saturn*. It is doubtful that significant benefit over an improved *Saturn* could be shown in an equivalent time period.

• The *Arcturus*, with two F-1 engines as the booster, could have sufficient performance to accomplish the advertised *Nova* lunar mission at an earlier time (1964 or 1965) and involve fewer development, transportation and handling problems—at lower cost.

• *Nova* would face serious competition in the 1966-1970 period from the theoretically superior air-breathing boosters. Cole questions whether *Nova* would ever reach operational status faced with the probable performance, operational and cost advantages in air breathers.

The *Arcturus*, as outlined by Cole, would have two F-1 engines and seven *Titan* first-stage tank assemblies as a booster. The second stage might have three *Titan* booster tanks with an engine of about 500,000 lb. thrust and a single *Titan* first-stage tank.

This vehicle would have more than twice the payload capability of *Saturn* and slightly less than that of *Nova*. This is sufficient to carry several men one way to the moon or one man on a round trip without refueling.

An air-breathing booster could be developed as an improvement over the high energy chemical *Arcturus II* and as an alternate to *Nova II*. It would be possible to build a turboramjet-powered booster weighing 1.2 million lbs. which would accelerate the *Arcturus II* to 4000 feet per second. This vehicle would weigh 3.6 million pounds as compared with the non-ramjet *Arcturus* at 2.4 million lbs. and *Nova* at 4.0 million lbs., and be capable of soft-landing 60,000 lbs. on the moon or 360,000 lbs. minimum earth orbit.

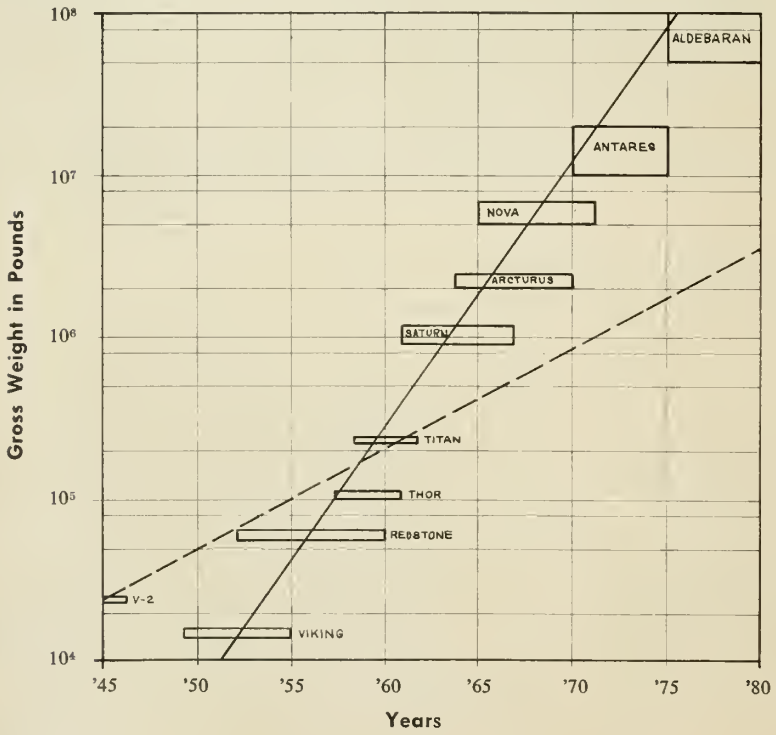
• **Projected vehicles**—In the nuclear era of the early 1970's, Cole envisions a conceptual vehicle christened *Antares*. This is the first major application of a *Rover* type fission reactor rocket system with an I_{sp} around 1000 seconds.

The initial boost of *Antares* is assumed to be provided by a captive acceleration system—turbojet-powered sled. The vehicle would reach a velocity of 2000 feet per second through a one g acceleration along an inclined 15-mile track. Then ramjet engines take over, bringing the speed up to about 10,000 feet per second, where the nuclear engines would kick in and take the vehicle to minimum earth orbit with an additional velocity change of 16,000 feet per second.

Cole expects these vehicle sizes to range from 10 to 20 million lbs. gross weight. Assuming this, the minimum earth orbit payload range would be from 2.5 to 5 million lbs. The *Antares* configuration (wings) would permit its safe return after an orbit trip.

Beyond orbiting missions some refueling may be desirable. In this event, 2 to 4 million lbs. could be achieved in a lunar landing payload. If there is no refueling, then upper

Increase in rocket vehicle gross weight



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costs should decline . . .

stages would be necessary—with some loss in payload capacity.

If the upper stage was nuclear-powered and winged, a lunar payload of about 800,000 to 1.6 million lbs. would be possible. With two high-energy chemical stages, a further reduction of the 600,000 to 1.2 million lbs. would result.

• **Aldebaran**—The conceptual vehicle of the 1975-1980 period is the *Aldebaran,* an advanced nuclear-propelled ship. The powerplant would represent a step beyond the *Rover*—controlled fusion, gaseous core fission or nuclear pulse. The vehicle will be in the 50,000 ton class, winged and have an I_{sp} of 1500 to 3000 seconds.

The anticipated size is a result of the design efficiency or operational limitations of the propulsion system—and the fact that operational economy increases with size. Cole's logarithmic growth curve extrapolations indicate ships of this magnitude for the 1980's.

With an I_{sp} of 3000 and a propellant fraction of 0.7, *Aldebaran* could haul 60 million lbs. to minimum earth orbit or 45 million lbs. to the moon. Because of its size, water takeoff and landing would be necessary.

For earlier versions of the *Aldebaran,* Cole assumes an I_{sp} of 1500 and a propellant fraction of 0.50. Orbital payloads of 20 million lbs. would be possible, but staging would be involved in deep space missions unless a refueling concept was employed. Utilizing a *Rover* type upper stage, larger than that of the *Antares,* 7 million lbs. could be deposited on the moon.

• **Pound-dollars**—The most fundamental question involved in all of this is cost. Right now our payload effort price tags run from $100,000 to $1-million per pound.

But Cole says there are signs of great cost reductions as payload capabilities increase.

An examination of Project *Mercury,* assuming the announced $350 million as the total four-year expenditure and considering the cost of ten orbital missions of 3500 lbs. each, the price per pound in orbit is $10,000. Further, if all of the twenty capsules now on order are to be used, the cost per pound drops by 50%.

In 1965 *Saturn* orbital pound figures would be about $200 and lunar payloads in the neighborhood of $2000 per pound. The advent of nuclear power in the early 1970's would bring lunar payload costs down to less than $100 per pound and, as 1980 approaches, a further reduction to less than $10.00 per pound.

Cole attributes cost reductions to increased performance, larger vehicle size, recovery and re-use of vehicles and the fact that the vehicle size increases faster than the expense per pound.

In making these extrapolations, Cole concludes that the evolution will occur at the predicted rates based on technical considerations alone. Greater emphasis on a space program now would result in even earlier achievements of the stated goals. Cole expects that the increases in space vehicle performance and reduction in transportation costs will be sufficient to permit the establishment of large bases of colonies throughout the inner solar system.

Industry Sets Its Own Parts Standards

Manufacturers are writing their own specifications to cover deficiencies in MIL requirements; synchro reliabilities upped 700%

by Charles D. LaFond

The battle for improved system reliability in electronics is slowly being won, but it's an uphill fight all the way just to obtain reliable parts and qualified vendors.

It has been said that the only real answer to the problem lies with the ultra "simplified" systems of the future which will employ solid-state or molecular-engineered functional units. A few subsystems based on such concepts already have been made, but for the next few years their use will be limited by our lack of know-how. Snowballing research efforts by many companies eventually will provide the answers.

But we must have the very best systems obtainable now and tomorrow with today's components, materials and processes. Extensive reliability programs being carried out by many in industry embrace all recognized approaches to the problem. Rigid quality control, reliability-proven circuit design, redundancy—these and other parallel approaches are yielding better system performance.

A major tool in all of these methods is the policy of rigid parts selection—a kind of "weakest-link" approach to critical components.

Wherever reliability is a major goal, leading manufacturers are using parts that exceed military specifications, often by several orders of magnitude. To do this, manufacturers are writing their own rigid specifications, carefully selecting and monitoring vendors, and continuously testing and retesting for further parts improvement.

The task is painstaking, tedious, expensive—but it is achieving results.

• **QPL & MIL spec. deficiencies**—Why have manufacturers written their own rigid parts specs? Here are the criticisms of one major producer—Motorola's Western Military Electronics Center:

• "We know that there are no two products from different vendors that are exactly alike. Yet the QPL (Qualified Products List) treats a large number of qualified vendors as equals. We need to be more selective. Tests to failure and multi-level stress tests help us be selective.

• "The MIL specification requirements are written for rather broad, general applications, whereas we usually are concerned with more specific applications. MIL requirements are not stringent enough and have merely succeeded in establishing a low level above which a great many vendors can keep their product.

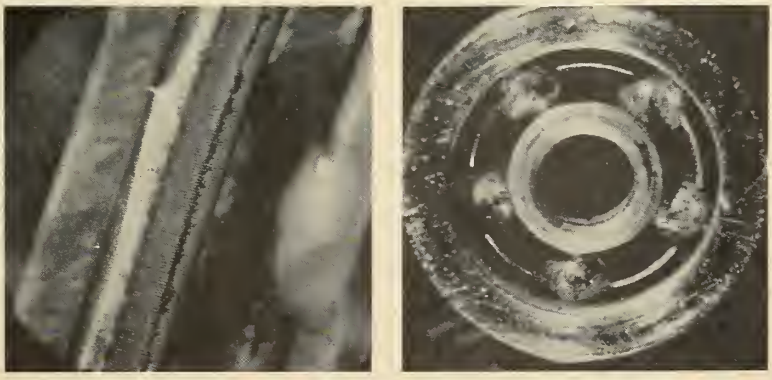
• "Most MIL specifications trust the qualification test to prove quality, whereas it may be representative only of the vendor's best, carefully planned effort. Most MIL specifications have inadequate provisions for follow-up tests to monitor the quality.

• "Quantities tested during qualification are too small.

• "Time delay in issuing MIL specifications is so great that they do not keep up with the newest developments in products or in requirements. (For example, dipped mica capacitors are still not standardized, and many specifications still call out only 55 cps vibration.)"

• **What's being done?**—Both Motorola and AC Spark Plug Division of General Motors Corp. (and of course many others) employ programs of extended performance testing under varied and severe environments to select reliable parts.

To obtain good parts (and vendors),



TYPICAL FAILURES which occurred on electrical or associated parts during rigid testing by AC Spark. Left: resistance wire of precision potentiometer exhibits varnish from resistance-wire mandrel cradle causing intermittent open circuit and high noise. Right: servo-motor miniature precision bearing shows deteriorated lubricant causing high-friction motor torque.

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MEET SOME OF THE AIRCRAFT/MISSILE/SPACE SPECIALISTS BACKING UP THE WESTINGHOUSE SALES ENGINEER:

A. M. Bruning, Engineer-In-Charge, Advanced Development Group
Age: 33
B.E., Johns Hopkins, 1949
M.S., Mathematics, University of Pittsburgh, 1956
Specialties: Arc Heated Aerodynamic and Thermodynamic Test Facilities, MHD Research Facilities
Years with Westinghouse: 8

W. J. Walker, Engineer-In-Charge, Aviation Facilities Group
Age: 42
B.S.M.E., University of Southern California, 1949
Specialties: Wind Tunnels, Sonic Fatigue Test Facilities, Hardened Base Equipment, Launchers
Years with Westinghouse: 11

R. A. Feranchak
Age: 29
B.S.E.E., Youngstown College, 1952
Specialties: Arc Heated Aerodynamic and Thermodynamic Test Facilities, Explosive Forming, Rotating Equipment Test Stands
Years with Westinghouse: 7

R. F. Leepa
Age: 29
B.S.E.E., Lafayette College, 1953
Specialties: Military Power Plants, Radar Antenna Drives
Years with Westinghouse: 6

P. J. Hawkshaw
Age: 36
B.S.E.E., Catholic University, 1950
Specialties: Continuous-Flow and Hot Shot Wind Tunnels, Explosive Forming
Years with Westinghouse: 9

J. McDonald
Age: 43
A.B., Chemistry, Engineering, Physics, University of California, 1938
Specialties: Arc Chamber and MHD Generator Development
Years with Westinghouse: 13

H. C. Lee
Age: 40
B.S.E.E., Chiao Tung University (Shanghai), 1942
M.S., Engineering, Cornell University, 1949
Ph.D., Cornell University, 1951
Specialties: Arc Chamber and MHD Generator Development
Years with Westinghouse: 2

H. A. Zollinger
Age: 30
B.S.E.E., Michigan College of Mining and Technology, 1951
M.S.E.E., University of Pittsburgh, 1958
Specialties: Drive Systems for Loaders, Elevators, Erectors and Launchers
Years with Westinghouse: 9

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tests made tougher . . .

AC Spark conducts selected tests on small samples of *each lot* of critical electrical and electronic parts. It feels its approach provides a rapid and economical method of testing.

It is a two-part program. Initially, extensive qualification tests are performed to determine parts capability and adequacy. Through performance and environmental tests, including the determination of destructive test limits and tests to evaluate life characteristics, a few qualified suppliers are found.

From then on, continuous surveillance is maintained to assure that the vendor's processes and manufacturing techniques do not deteriorate. This is accomplished by the extended performance testing on samples (10%) and by a 100% inspection of all parts to increase principal performance characteristics.

Whenever justified, requalification tests are initiated.

The criticalness of an item to the reliability of a particular system is judged largely by four factors:

- Environmental stresses.
- Total parts (of one kind) used.
- Expected or known part failure rate compared to the apportioned failure rate.
- Suppliers' ability to provide a stable product.

The results of such a test program have been very gratifying, according to AC Spark, in reducing the number of potential part failures in equipment.

Items shown in the accompanying table are a few of the critical parts in a ballistic missile guidance system. The last column indicates the increase in reliability achieved between early 1958 and December, 1959. Although other figures are not available, a 400% increase in reliability also was obtained for relays. Relays were tested from 34,000 to 136,000 operations.

- **Causes of failure**—While the program progresses, failure causes are determined and a solution is then worked out with the cooperation of the supplier. In general, the program results indicated a lack of control by parts manufacturers of their processes, manufacturing procedures, and quality control practices. Lack of adequate control was indicated in:
- Material inspection—improper or incomplete.
- Processing procedures—either not followed or lack of definition required to insure product consistency.
- Workmanship—poor and lack of inspection of critical workmanship items.
- Cleanliness—poor.
- Design changes—improperly researched or non-notification to user.
- Final inspection—inadequate.
- **Company specs**—When adequate—or required—strict MIL parts are procured to MIL documents; but the problem most firms face today is the urgent need for better-than-MIL parts.

Motorola engineers told M/R that they know many parts are better than the MIL reliability level from the results of its testing program. For these, the company has prepared its own specs, not making burdensome requirements but written around these quality items which are standard products of the vendor.

These specs follow the MIL format, but have more rugged tests and test sequences, require more specimens, allow fewer failures, tighten electrical requirements, and have provisions for periodic reassurance tests—including penalty clauses for failure.

Motorola has altered test sequences in the specs to represent the most rugged treatment sequence the parts could encounter. For example, for encapsulated parts it precedes humidity tests with lead-bend and thermal-shock tests so that moisture will enter if cracking occurs.

For environmental testing, MIL-STD-202A is used liberally; though it is not perfect, it at least represents a much used standard. However, the company feels increasingly perturbed by non-reproducibility of the "Moisture Resistance Test" (Method 106) when performed in different high-quality chambers. It uses steady-state, long-term humidity tests (over aqueous glycerin solutions of known refractive index; ASTM) for some of its screening tests. Also the vibration requirements of all of its specifications have been upgraded to include 2000 cps shake.

To provide an adequate number of specimens, the typical MIL quantity of 12 is upped to 20 or more and usually 30 to 50 for inexpensive parts.

Where screening tests show that a part can endure electrical stresses much in excess of ratings, Motorola attempts to persuade the vendor to agree to tests at these higher stresses. This is done not so much to accelerate the tests by a known amount, and thereby obtain a better approximation of the mean-time-to-failure, as to increase the general safety factor.

Allowable drifts and changes in value have been reduced and requirements for insulating properties have been increased. This results in a greater selectivity within the known better vendors.

The concensus is that in maintaining a rigid program for parts reliability the capabilities of the parts selected for use can be thoroughly understood. From this knowledge, adequate allowances for parts limitations can be made in the design of more reliable circuits.

PART TYPE	NO. LOTS TESTED	NO. LOTS REJECTED	% REJECTED	% INCREASE RELIABILITY
Resistor, Fixed Film	465	23	5	70
Resistors, Fixed Wirewound Power and Accurate	163	11	7	300
Capacitors, Paper	185	32	17	350
Motor-Tachometer-Generators	24	6	25	93
Synchros	22	7	32	730
Electron Tubes (miniature)	44	4	9	200
Diodes, all types;	36	16	44	120
Zener	—	—	—	300

SOME results of AC Spark Plug Div. critical parts test program over two-year period. (Numerical failure rates are not given since relation to environments, missile locations and firing information, and number of systems are not provided.

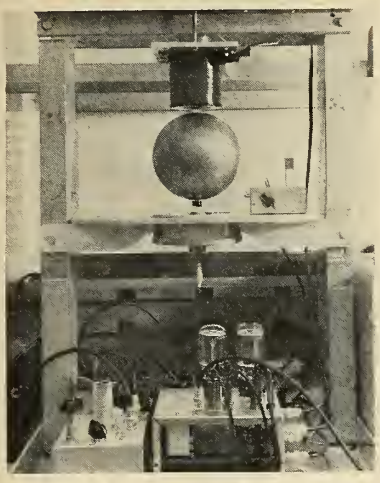
'Space Compass' Will Tell Astronaut Where He Is

(cover photo story)

A unique "space compass" will help Project *Mercury* astronauts return safely to earth in case of emergency. Called an Earth Path Indicator, the Honeywell-developed device will show the astronaut his position over the earth at all times. In case of failure of earth command control circuits, the EPI will indicate the precise point in the orbit for firing the retrorockets to land in the proper impact area.

The device contains a replica of the world revolving in a composite motion

Spacecraft Control—



ATTITUDE OF spacecraft can be controlled by electrically torquing a sphere-mass freely suspended in an electrical field, according to Systems Division of Bendix Corporation (M/R, p. 34, March 21). Shown is a working model of one such suspended sphere where the three mutually perpendicular torquing coils have not yet been mounted.

corresponding to the earth's rotation and the capsule's orbit track. A bulls-eye window pinpoints the capsule's instantaneous location over the earth. Other markings indicate capsule landing points.

In normal operation, the EPI will be started by the astronaut during the prelaunch countdown. After going into orbit, corrections will be manually cranked in to correspond to orbit determinations radioed from earth.

In case of communications failure, the device will operate on the basis of the planned orbit. The astronaut will be able to make corrections based on visual observation of the earth through the capsule's periscope.

Once set on the proper orbit track, the EPI will automatically continue its motion to follow this track. The astronaut will be able to visually follow his position and initiate orbit ejection at the proper point if this becomes necessary. Ordinarily, the ejection will be triggered by command from the ground. Only in case of circuit failure will it be necessary for the astronaut to initiate the action himself.

The device, though small, is quite complex. The requirement for the combination of two different motions—earth rotation and variable orbit track—made its design difficult. In addition, a high order of accuracy was vital. Impact on land might be disastrous; impact outside the designated Atlantic

area would complicate and delay recovery operations.

The EPI has four adjustments which the astronaut can control: position, inclination, period, and earth rotation. It is powered by a spring mechanism to make it independent of capsule electrical power.

Markings on the globe show longitude, latitude, continents, topography, and major cities. It is made of a hollow aluminum sphere covered with a map silkscreened on plastic.

Development of the Indicator grew out of human factor studies by Honeywell for McDonnell Aircraft, prime contractor to NASA for the capsule.

Telemetering Conference To Present 71 Papers

The 1960 National Telemetering Conference at Santa Monica, Calif., is shaping up as the biggest and most ambitious in NTC history, according to Hugh Pruss, conference chairman. The three-day meeting (May 23-25) will present 71 technical papers in 16 panel sessions. Two workshop sessions are also scheduled.

Theme of the conference is "Telemetry—Tool for Industry and Defense." Although most of the papers will deal with military problems and applications, the industry viewpoint will be represented in about half the sessions. This marks a definite departure from previous conferences which were devoted almost entirely to military aspects.

Sponsors this year include the Institute of Radio Engineers, which recently rejoined the NTC. (Other sponsors: American Rocket Society, Instrument Society of America, American Institute of Electrical Engineers, and Institute of Aeronautical Sciences.) Participation by the IRE in this conference will also have an effect on its heretofore competitive Telemetering Symposium—sponsored by IRE Professional Group on Space Electronics and Telemetry. This year's meeting (Washington, D.C., Sept. 19-21) will concentrate on space electronics and devote only one session to telemetry.

The preliminary program lists these session topics:

- Industrial data transmission systems
- Biomedical measurements
- Space data-acquisition systems
- General r-f components and techniques
- Missiles and aircraft telemetry workshop (R&D needed in the '60s)
- Data processing and presentation—(two sessions)
- PCM progress
- Transducers
- Ground stations—new components and techniques
- Industrial supervisory control
- Missiles and aircraft—flight data systems
- Telemetry techniques—(two sessions)
- Missiles and aircraft—environment measurement
- Transistorization progress
- Industrial telemetry workshop (What we really need is . . .)
- Reliability in telemetry

NBS 'Atomic Clock' Considered Most Accurate

A new cesium standard "atomic clock"—with an accuracy of better than one second in 1000 years—has been developed at the Boulder Laboratories of the National Bureau of Standards.

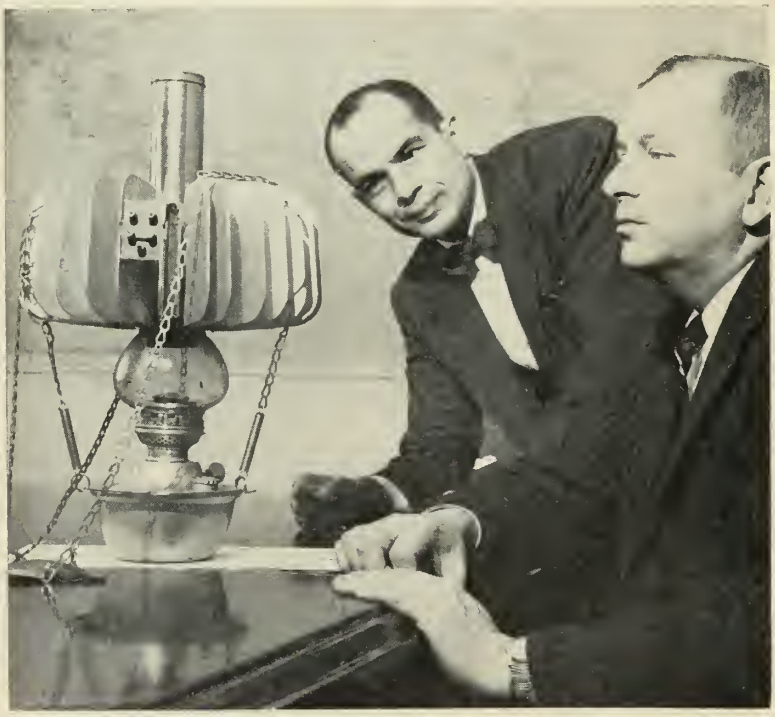
Believed to be the most accurate such instrument in the world, the new frequency standard is 10 times more accurate than any previous NBS atomic clock. It will be used to maintain the accuracy of radio time and frequency standards and calibrate other ultraprecise instruments.

The clock can also be used in experiments to verify concepts of Einstein's theories of relativity. Current NASA plans include placing an atomic clock in an orbiting satellite and comparing its time with a clock on earth. According to Einstein, the two will run at different rates depending on the satellite's speed and distance from the earth.

Such precise measurements of time and frequency have become increasingly important during the past few years. The missile/space program particularly has made demands for orders of accuracies not even considered a few years ago. As an example, to accurately plot the position of a long-range missile, time at tracking stations must be coordinated to within millionths of a second.

Until recently, the most precise frequency standards have been provided by the vibration of quartz discs in electronic oscillators. These are almost as accurate as atomic standards for short periods. Quartz tends to age, however, and over longer periods of time its vibration rate may change unpredictably.

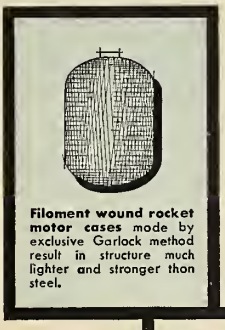
Studying Soviet Converter



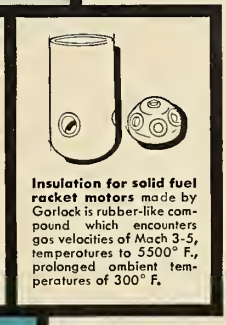
RUSSIAN-BUILT thermoelectric generator, used to convert heat from a kerosene lamp into electricity for radios is studied by energy conversion group scientists of Martin-Nuclear. The export model of the 20-pound Russian device was bought in England for $56. Group was set up recently to press research in thermoelectricity and other means of converting heat directly into electricity without the use of moving parts. Eventually, such methods will be used in connection with nuclear reactors.

Garlock's main objective

in missiles work . . .



Filament wound rocket motor cases made by exclusive Garlock method result in structure much lighter and stronger than steel.



Insulation for solid fuel racket motors made by Garlock is rubber-like compound which encounters gas velocities of Mach 3-5, temperatures to 5500° F., prolonged ambient temperatures of 300° F.

Missile parts from inert materials including newly developed asbestos-phenolic compound for nozzles . . . nose cones of fluorocarbon plastics.

Garlock metal fittings for rocket motor cases such as blast tube and thrust terminator support rings are machined to extremely close tolerances. Made from special materials affording minimum weight, maximum strength and rigidity.

is delivery of high quality rocket motor components in the shortest time. To reach this common goal, research and development, product design, tool design, pilot manufacturing, and production staffs work together as a fully integrated team. They solve problems of design and production jointly, thus eliminating weeks of possible re-designing and re-tooling.

Garlock is flexible: they'll swing into prototype production on short notice and follow this with full scale production as needed. *Garlock is diversified:* they'll design and manufacture rocket motor components from a variety of basic materials—rubber, metals, phenolics, fluorocarbon plastics.

Garlock engineers will work to your design or help you in developing designs. Call or write Military Products Department, The Garlock Packing Company, Palmyra, N. Y.

GARLOCK

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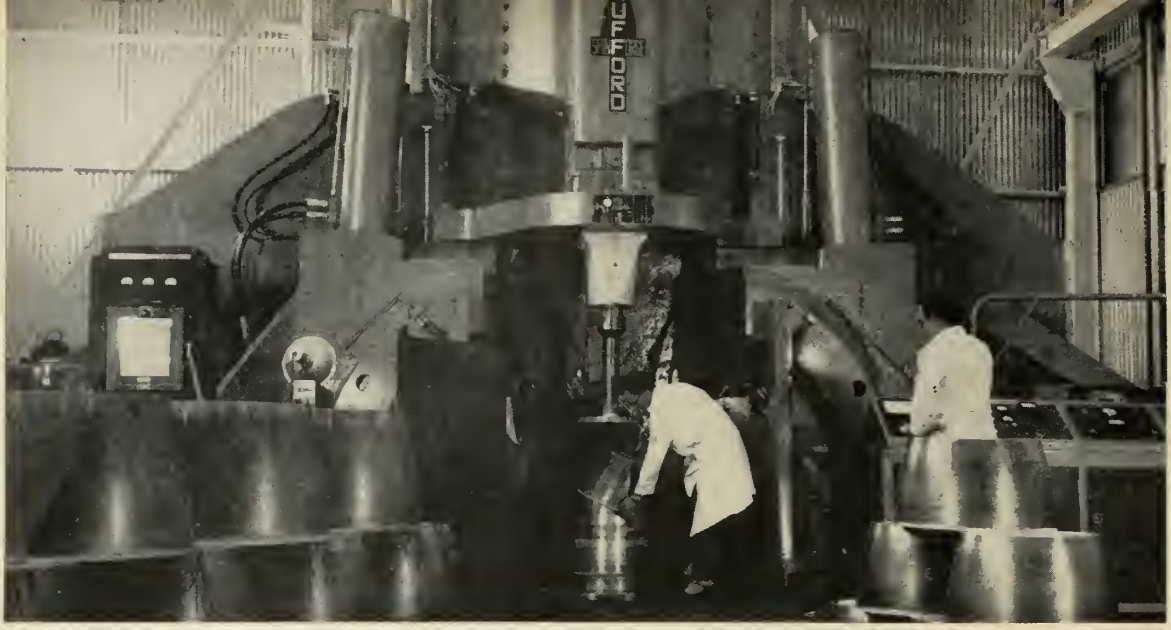
Garlock components are presently used in the development and production of:

• Vanguard • Super Vanguard • Polaris • Minuteman • Nike Hercules • Terrier • Super Tartar



SPIN-FORGE cold-flows preformed metal blanks into parabolic shape for *Bomarc* engine lip skin.

propulsion engineering

Marquardt's *Bomarc* Ramjet Production

EXPLOSIVE FORMING technique, used to form unusual configurations from preformed welded tubes, speeds production.

About 670 components go into the *Bomarc* kerosene ramjet sustainer engine, manufactured by the Marquardt Corp. at its Ogden, Utah, division.

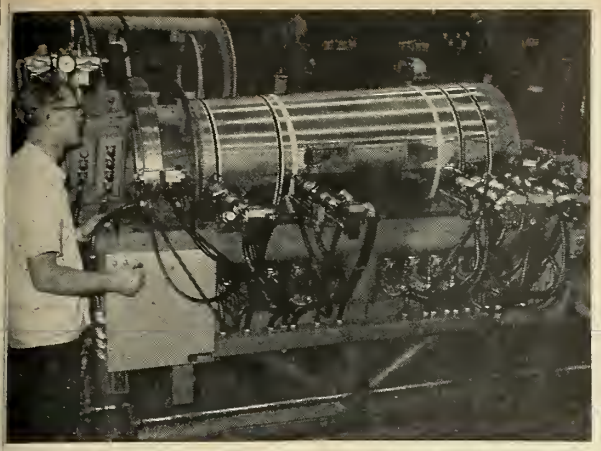
The engine, designated RJ43, breathes air and produces a compression ratio of 100:1 to maintain a velocity of 2600 mph. In comparison, a high-compression automobile engine operating on high-octane gasoline delivers a compression ratio of 10:1.

Manufacture of the 500-lb., 14-ft.-long engine is shown for the first time in the accompanying pictures.

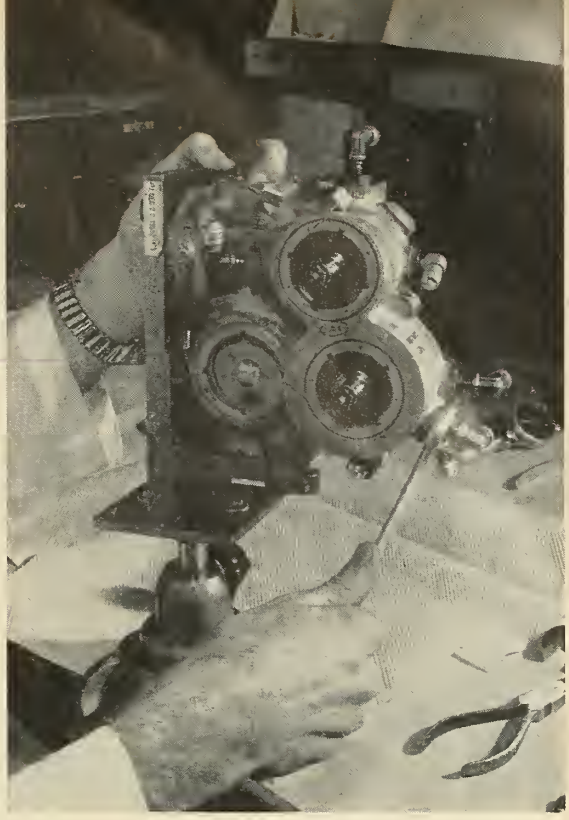
Bomarc, a 400-mile-range antiaircraft defense weapon, is designed to attack enemy bomber formations before they reach target areas. It is launched by a rocket booster. The currently operational *Bomarc A* uses an Aerojet-General liquid-propelled booster. The advanced *Bomarc-B,* in development, uses a Thiokol solid booster.

Twenty basic production techniques in metal fabrication and processing, heat-treating, machining, test and inspection are used in preparation of the components. The structural section develops through 17 assembly stations. Fuel control and other internal systems are put together in a hospital-clean precision assembly department.

Of the 670 components, 607 are manufactured at the Ogden plant. A new explosive forming technique is used in making high-strength tubular sections. After the completed engine leaves the assembly line, it undergoes flight test, post-burn systems check and is canned in a special inert-gas-filled container.

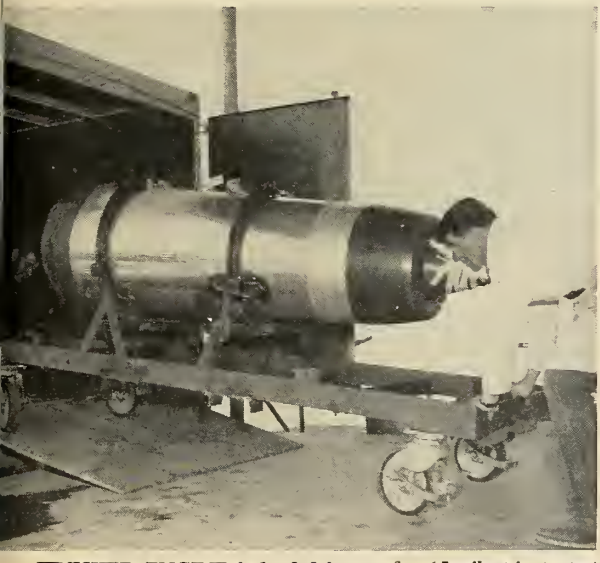


SPECIAL JIG holds outer skin over main structure as six automatic drills bore and counter sink riveting holes.

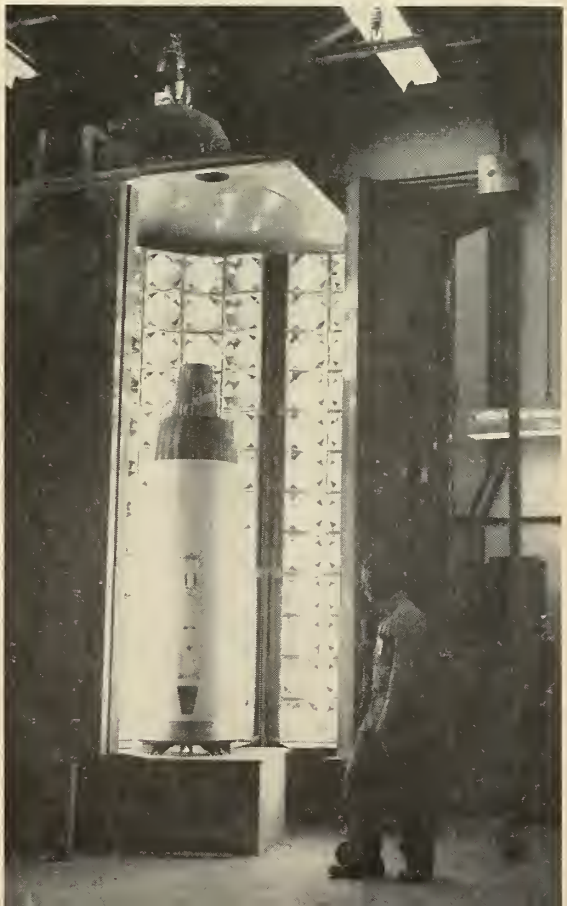


FUEL CONTROL is bolted to a jig in preparation for connecting fuel and air lines of the system.

Detailed



FINISHED ENGINE is loaded in van for 15-mile trip to test area with protective cover on end section.



HEAT-RESISTANT, high-finish paint is baked on the missile in this specially designed oven.

Aerojet Motor May Bring Big Booster

by Jay Holmes

Aerojet-General Corp. has successfully fired an experimental segmented solid-propellant motor that could be a forerunner for the Air Force's big Project 3059 booster.

The experimental motor generated almost 40,000 lbs. of thrust for 10 seconds, Aerojet said.

Meanwhile, it was learned in Washington that the Air Force and Aerojet were close to signing a contract last week on Project 3059—which calls for developing a new generation of solid-propelled rockets, several times larger than the *Minuteman* booster, the largest solid rocket now under development in this country.

Project 3059 calls for a rocket of about 100 million lbs. total impulse. Neither thrust nor burning time was specified. Thus the rocket could be 1 million lbs. thrust for 100 seconds, 2 million lbs. for 50 seconds or any combination with a 100-million product.

• **Second go-around**—This is the second time around for the big booster proposal. It was circulated in the spring of 1959 as a plan for a booster with a million lbs. thrust. However, Air Force officials at the highest level turned it down last summer on the grounds that it sounded more like a public relations gimmick than a serious proposal for rocket development.

Since last summer, the specifications were rewritten to give the contractor more leeway. The current idea is that instead of developing something to do a particular job the contractor will concentrate on advancing the state of solid-propellant technology.

Six companies bid on Project 3059. Besides Aerojet, they were Thiokol, Rocketdyne, Grand Central, United Technology Corp. and Hercules Powder Co. The bidders took two approaches toward solving the physical problems involved in building a large booster.

Aerojet, United and Grand Central based their proposals on segmented design, so that the parts could be transported by normal means from the manufacturing plant to the launch site. Thiokol and Rocketdyne proposed on-site manufacture and loading of propellant. It could not be learned which

approach Hercules favored.

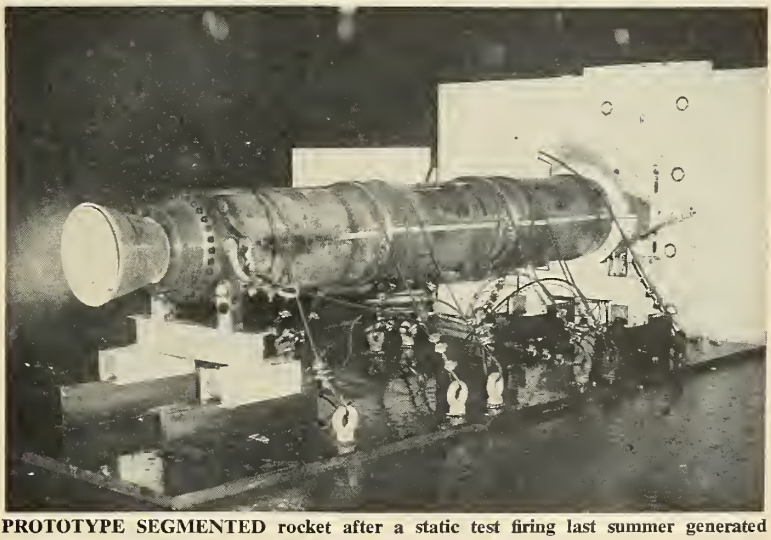
• **New flexibility**—Aerojet said its segmented rocket was static fired last July at its Sacramento test facilities. Dr. Ernest R. Roberts, Aerojet manager of solid rocket research and development, said the test was 100% successful.

Segmented rockets would give this nation its first truly flexible rocket program, Aerojet said. The blocks can be constructed with current technical know-how in present facilities, the company added. They would be shipped to the launch area over conventional roads, on conventional railroad cars and through conventional tunnels and underpasses, thus eliminating logistical problems.

The General Tire and Rubber Co. subsidiary said various-sized solid rockets, with thrusts from one to several million lbs., could then be assembled on the spot according to the demands of the mission scheduled for that day. Aerojet said huge savings are possible because of the elimination of need for new facilities, use of currently available transportation and absence of need for expensive new research and development programs.

The concept of the segmented rocket originated at Aerojet in 1957, the company said. Hardware was constructed in early 1959. More advanced design hardware was recently constructed and firings are imminent.

SEGMENTED ROCKET model that may be designed for big Air Force booster is shown by Dr. E. R. Roberts, research manager at Aerojet solid rocket plant.



PROTOTYPE SEGMENTED rocket after a static test firing last summer generated **40,000 lbs. of thrust for 10 seconds.**

Atlas, Thor Engine Costs Cut More Than One-third

A drop of 37% in production costs of *Thor* and *Atlas* missile engines from 1957 to 1959 is reported by Rocketdyne Division, North American Aviation.

The cost of the engines in 1959 was $45 million, Rocketdyne said. The actual number produced is classified. At 1957 production costs, the same number of engines would have cost $72 million, the company declared.

Factors influencing the cost reduction were normal manufacturing learning curves, design improvements, budgetary and production controls utilizing advanced electronic data processing equipment, organizational innovations and special suggestion award and conservation programs.

Five *Thor* engines are now being delivered for the 1957 price of two. Three *Atlas* propulsion systems are being delivered for the 1957 cost of two. Eight engines to be clustered for the *Saturn* booster are being delivered at the cost of five predecessor engines for *Jupiter*.

A contributing factor in the cost reduction was simplified engineering design adapted from a Rocketdyne experimental engine designated X-1. The experimental engine was designed in 1958 with only eight major working components, compared with a production engine then put into service with 88 major components.

Bristol Designs H_2 Engine With Upper Stage Potential

LONDON—A research team at Bristol Siddeley Engines Ltd. has completed a design study of a liquid hydrogen-LOX engine that could be used as second stage of a system capable of launching into orbit a 13-ton manned astronomical laboratory.

Bristol calls the engine Project X. It would have maximum thrust of 100,000 lbs. and would burn at full thrust for three minutes and then be throttled back to half thrust for another six minutes. Other specifications: dry weight 1420 lbs., specific impulse (vacuum) 420 sec., mixture ratio (O_2/H_2) 6:1, length 95 in., diameter 72 in.

The system would be lifted by a booster of similar design that generates 450,000 lbs. thrust. Burning time for the booster was not specified.

Thrust control would be achieved by adjusting the flow of hydrogen and

oxygen to the gas generator. This in turn would affect the turbine power, pump speeds, propellant pressures and flows, and hence the combustion pressure. The turbine is run by hydrogen at about 1475°F, the hydrogen being heated by burning it with a small amount of oxygen.

No hardware for the engine has been produced, nor has any estimate of cost been made.

Nitrasol Solid Fuel Plant Completed by Grand Central

Grand Central Rocket Co. has completed a nine-unit commercial pilot plant designed specially for production of Nitrasol solid propellants.

The company said it is believed the plant at Redlands, Calif., is the first such commercial production unit in the country. It was completed in eight weeks. (Start of production was reported in M/R Feb. 8.)

The facility—which consists of twin mixing stations, a remote control room, a screening and filtering building, a large vacuum still unit for handling some liquid ingredients, a large vacuum oven for drying, and three storage buildings—has mixed, cast, cured and successfully test-fired about 35 Nitrasol motors.

Two contractors were employed in the construction. R. A. Darling built the mix stations, the bridge, four storage buildings and all the static conductive floors. J. D. Diffinbaugh built the Nitrasol control station.

AF Missile Overhaul Center Opens on West Coast

A rocket engine overhaul center went into operation last month at Norton AFB, San Bernardino, Calif.

The first operational *Thor* engine was received for analytical overhaul in the beginning of a complex phasing plan. By midyear, more than 2000 parts of *Thor, Atlas* and *Titan* ballistic missiles will go to Norton for repair.

Engineering technicians will tear apart three main components of the $140,000 *Thor* engine—vernier engines, turbopump and gas generator.

The San Bernardino Air Material Area at Norton, an Air Materiel Command installation, also provides a storage-maintenance responsibility for *Thor*, currently deployed in Britain by the Royal Air Force.

Patent on Hybrid Motor Granted to British Firm

LONDON—A British patent has been granted to D. Napier & Son Ltd. for a hybrid liquid-gaseous propellant rocket motor.

W. Shirley and A. L. R. Fletcher invented the motor, which is intended for use with kerosene and decomposed hydrogen peroxide. The hydrogen peroxide is decomposed by passage through a catalytic bed and the resulting oxygen and steam mixture is introduced into the combustion chamber.

The burner is an annular duct through which the gases pass at high speed into the chamber. The liquid kerosene is introduced to the duct through an opening in the interior at a direction across the flow of gas. It sprays against the opposite wall of the duct and becomes thoroughly mixed with the gases. Thus combustion occurs while the propellants are still close to the burner.

ARC Machine Mixes Tiny Batches of Propellant

Atlantic Research Corp. has developed a laboratory mixer able to mix accurately batches of liquids and solids weighing from ½ to 2 ounces.

Atlantic said it developed the mixer after it surveyed the market and found no equipment suitable for such tiny batches. It now has been placed on the market. Specifications and price list are available on request.

The machine, which ARC calls the Micro-Mixer, is completely sealed. Operation can be observed through a transparent lid. Thick walls and top make possible the safe mixing of explosives and of toxic and flammable materials. It is a scaled-down model of a sigma-blade mixer developed by ARC six years ago, which has a capacity of 3 to 8 ounces.

ARC said it has proved of great value in mixing small experimental propellant formulations, particularly when rare or valuable ingredients are used.

Army Gets Navy, Air Force Aid to Plan Zeus Output

The Army Rocket and Guided Missile Agency, Army Ordnance Missile Command, is exchanging information with Navy and Air Force missile agencies on the manufacture of solid-propellant motor cases. The aim is to use the best available methods in the *Nike-Zeus* antimissile missile.

AOMC said one of the studies in progress is development of maximum industrial capacity necessary to speed the acquisition of the *Zeus* system once production has been authorized. The Army has recommended that production be started, but the Defense Department has refused authorization and the necessary funds.

D-65 Coating Protects Launch Sites

by Frank G. McGuire

LOS ANGELES — A heat-resistant coating with promise of wide application in the missile and space industry has been developed by the Plas-Kem Division of Dyna-Therm Chemical Corp. The new material, designated D-65, is an "intumescent coating containing phosphates and boron flame proofing chemicals dispersed in a flexible polyurethane binder."

Applied to launching pads at Vandenberg Air Force Base, the coating completely protected cables and other vulnerable equipment on the site during an *Atlas* launching. The protective layer of D-65 has been successfully applied to areas subjected to 5000°F for 90 seconds. The original AF request for such a coating specified an environment of 2000°F for five seconds, and was aimed at protecting the *Titan* ICBM umbilical cord.

D-65 is expected to be applied to most of the areas subjected to direct blast from the rocket engines of a large missile. Previously, much of the wiring, instrumentation and other items on a pad had to be replaced after each launching. Application of Dyna-Therm's new coating will eliminate much of this disadvantage, according to the company.

Field tests of D-65 conducted at Vandenberg have used *Thor* and *Atlas* ballistic missiles as "proof of the pudding." Test temperatures have run as high as 6000°F.

As a coating for re-entry bodies, it is anticipated that D-65 will significantly reduce the amount of ablation material necessary, perhaps by as much as half.

Companies active in major ballistic missile programs have expressed satisfaction with the material's performance, and additional applications for it are being evaluated.

Firms testing the coating include RCA, Martin, Space Technology Laboratories, Douglas, Lockheed, and others, as well as the Air Force.

In operation, the coating, nominally .005" thick, swells and bubbles, then chars, to provide a layer of insulation on the surface of the equipment. Temperature extremes cannot penetrate the superficial char and the underlying layer of D-65.

COPPER coin is melted with acetylene torch on surface of D-65. Elbert Davis, Dyna-Therm vice-president, invented it.

Preparation for use of the coating is similar to applying paint, which the product resembles. After stirring, the basic D-65 formula is mixed with a thinner, D-65-1, to obtain the desired consistency for application. Under average conditions, the company says, this will vary from 10 to 50%, but extremely dry weather may necessitate a mix of two parts thinner to one part D-65. Application may be done with either brush or spray.

Drying time is about 18 hours for operational use, but only 20 minutes for setting to touch.

The liquid D-65 is 30% solids, and weighs 8.2 lbs. per gallon. Flexibility is such that no cracking is experienced over a ⅛" mandrel. The material is stable during storage and no skinning, gelling or caking occurs over a period of six months. Elongation of a .050" film is 300% minimum.

Orders for the D-65 coating currently amount to well over half a million dollars. Exclusive sales agent for the product in this country and Canada is Swedlow, Inc.

Gamma Device Finds Flaws In Solid Rocket Motors

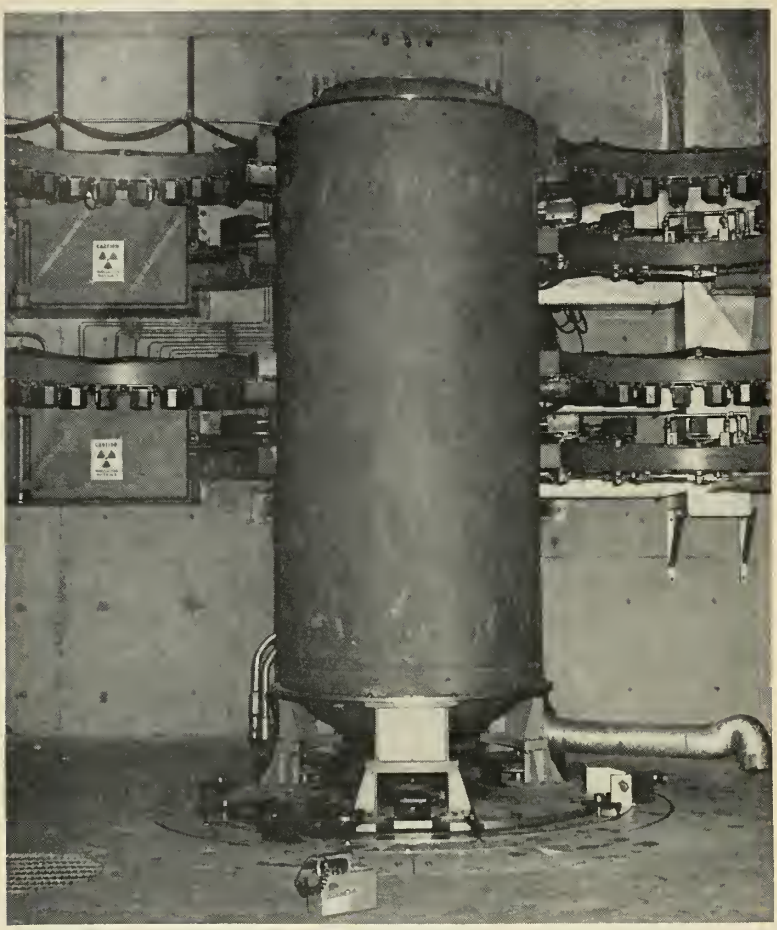
SACRAMENTO, CALIF.—A gamma radiation device to exercise tight quality control over solid propellant rockets has been developed by Aerojet-General and the Navy. The device, named GIGI (gamma installation for grain inspection), uses a cobalt-60 source and can detect flaws as small as .03 inches in a rocket motor several feet in diameter.

Thus far, tests have been conducted with the *Polaris* fleet ballistic missile, using the permanent facility here. Two mobile units have also been produced, one for Cape Canaveral and one for the Naval Weapons Annex at Charleston, S.C.

The inspection process consists of placing the motor in a concrete test cell, sealing it to protect operating

Physical Properties of Dyna-Therm D-65

Percent solids	(percent)	30, plus or minus two
Weight per gallon	(pounds/gallon)	8.2
Viscosity, Stormer	(400 grams, 30 seconds)	104 KU
Viscosity, Brookfield	(#4 spindle, 20 rpm)	2500 centipoise
Drying time	(Average brush coat, 5 mils dry)	
Set to touch		20 minutes
Through dry		18 hours
Shore A Hardness		70, plus or minus 5
Color		White
Reflectance	(15 mils thickness)	77 percent at 45°
Flexibility	(.050" film)	No cracking over ⅛" Mandrel
Can Stability		No skinning, gelling or caking over a period of six months
Elongation	(.050" film)	300 percent minimum
Dielectric strength		97-130 volts per mil



FIRST-STAGE Aerojet-General solid propellant rocket motor for *Polaris* is ready for inspection by "GIGI." "GIGI's" arms, containing 48 detectors, circle the motor. Gamma photo beams, generated from cobalt 60 sources, pass through motor and propellant and are picked up by detectors. Analysis of pulses determines whether there are voids or cracks within the propellant.

personnel, and then hydraulically placing a cobalt-60 pill in the rocket motor's core. Radiation detection devices, located on encircling arms, are located about the motor to measure intensity of the gamma radiation getting through the propellant and casing.

After completing measurements in this initial position, personnel move the motor hydraulically to the next position, and a new set of measurements is completed. This is continued until the entire motor is inspected.

Data from the various readings are placed on IBM cards and run through a computer for evaluation and analysis.

Normal motor conditions will allow a steady rate of scintillation to be measured, and a sudden rise in this rate gives notice of a void in the propellant. Sensitivities have been demonstrated to 0.1%.

The Sacramento installation uses two radioactive sources of 70 Curies strength each. For propellant-to-case bonding inspection, two 20-Curie sources are used.

Hydro-Tests Made On *Minuteman, Polaris* Cases

Some of the problems in the fabrication of second and third stage *Minuteman* motor cases and second stage *Polaris* chambers have been solved in an extensive series of hydrotests on sub-scale models at the Lycoming Division of the Avco Corp., Stratford, Conn.

Experimental tubes in two sizes were burst by internally induced water pressure in a study designed to determine the exact heat treatment necessary for maximum strength.

All of the tubes were of the same low alloy high strength steel as the full sized chambers but the heat treatment of each was different. One of the problems was the accurate prediction of the point of failure on the miniature cases.

Water pressure in the test cases was gradually increased until rupture occurred. Three axial and three hoop stress gauges continually recorded the stresses within the test model throughout the run. All of this information plus the crack patterns and precise points of failure were evaluated to determine the exact heat treating method now used in the production of the full scale cases.

Lycoming is producing the *Minuteman* and *Polaris* cases for Aerojet-General, Sacramento, Calif.

Huge New Furnace to Treble Vacuum-melted Ingot Size

Vacuum melted ingots up to 50 inches in diameter and weighing over 40,000 lbs. will be possible with the completion of the world's largest vacuum-melting furnace at Allegheny Ludlum's Watervliet Works in New York.

Clark W. King, executive vice president, said that ingots more than three times the size of those currently available can be produced with some modifications of the auxiliary facilities of the new furnace.

The consumable electrode vacuum melting process consists of the remelting, under vacuum, of cylindrical electrodes of a specified alloy initially formed in a conventional electric furnace. The vacuum serves the dual purpose of eliminating contaminating elements and drawing off the undesired gases formed during the remelting.

The result is a high degree of metal cleanliness, improved ingot soundness and workability, and general improvements in the mechanical properties.

The new furnace will be built by the Lectromelt Division of the McGraw-Edison Co.

New Facilities for Shock Testing Completed

Extremely rapid temperature shock testing of missile components has been made possible at the American Laboratories Division of American Electronics, Inc., through the installation of the largest liquid CO_2 systems on the West Coast.

Designed and built by the Cardox division of Chemetron Corp., the 22-ton unit permits maintaining 65°F. in a chamber 37 ft. by 15 ft. by 11 ft. with heat loads up to 500,000 BTU per hour.

American Laboratories specialize in environmental testing for military commercial and industrial uses with emphasis on electronic and space applications.

Novel High-Performance Plastic Made by Pennsalt

A new polyvinylidene fluoride resin has been developed by Pennsalt Chemicals Corp.

The polymer has high resistance to heat, light and chemicals. Mechanical strength, thermal stability, ultraviolet radiation stability and ease of fabrication round out the substance's properties.

Designated RC-2525, the resin is a crystalline, high-molecular-weight polymer of vinylidene fluoride. Containing over 59% fluorine by weight, it has the stability and inertness characteristic of highly fluorinated hydrocarbons.

RC-2525 is not available commercially, but Pennsalt has a large pilot plant in operation. Field test results by industry will provide further information on its uses.

Auto-Information System At Military Agency

The groundwork and first phase of a massive transition to automation is underway by the Armed Services Technical Information Agency at Arlington Hall, Va. The agency, which supplies Department of Defense agencies and their contractors with copies of research reports submitted by and for military agencies, has nearly a million documents on file.

ASTIA started off with a Remington-Rand USS-90 Univac Solid State Computer. This punch card system has as its first objective speed-up of the flow of informational tools to military contractors. Magnetic tapes will be added next July to automatically identify reports without mention of ASTIA catalog numbers.

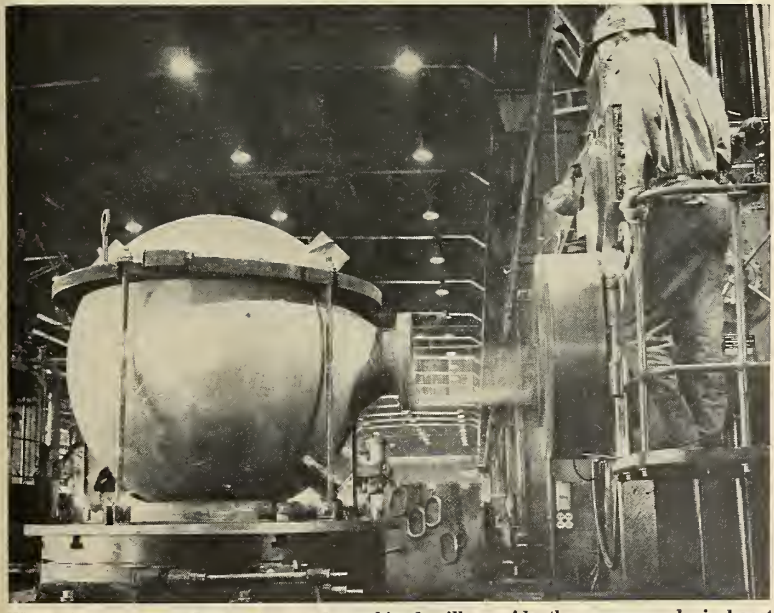
Tapes will also accelerate checking for duplication, mechanized compilation of cumulative indexing of the agency's bulletin and information retrieval. Within another year, ASTIA hopes to copy all 7 million-plus catalog cards on magnetic tape—making possible automatic printout, at 600 lines per minute, of bibliographies together with a full descriptive abstract of each reference.

The final stage will be a Randex (random access) system—providing greater flexibility in compiling reference information. Until an automatic data processing system went into operation last month approximately 1,200 copies of reports had to be hand tailored every day.

Thiokol Improves Solid Propellant Fuel Binder

Thiokol Chemical Corp. has developed an improved version of its polysulfide solid propellant fuel binder. The new fuel, C-12, was developed at the Trenton, N.J., research center. It contains more hydrocarbon than earlier formulations, increasing specific impulse.

Preparing Polaris Popping



THIS GIANT steel flask being neck-machined will provide the compressed air boost needed to pop a *Polaris* missile out of the water when fired by a submerged nuclear vessel. Manufactured by Lukens Steel Co., Coatesville, Pa., the flasks are to be installed in each of the sub's 16 firing tubes.

French Put *Veronique* Through Tests

by Jean-Marie Riche

PARIS—Considerable high-altitude scientific testing has been done the past few weeks with *Veronique* exploration rockets at the Colomb-Bechar Missile Range in the Sahara Desert.

The French rockets are equipped to emit a vertical "candle-shaped" cloud of sodium-potassium through which the direction and speed of winds are studied as well as the temperatures, pressures and densities of air in the upper atmosphere.

Designed by the Laboratoire de Recherche Balistiques et Aerodynamiques of Vernon, the *Veronique* has been sponsored by the Direction des Etudes et Fabrications d'Armament (Army) for the Comité d'Action Scientifique de la Défense Nationale.

Testing began seven years ago, with 15 launchings made to develop the vehicle itself. It was not until March, 1959 that the missile carried a scientific payload.

Veronique is a single-stage test vehicle, 23 ft. high, 27 in. in diameter. It has a conic head and rectangular fins, and is propelled by nitric acid and terebenthine. Total weight is 3086 pounds—excluding payload—882 for the casing, 2204 for propellant.

• **Wire guided**—Launched vertically from a subsurface launcher (71 in. deep), the rocket is initially guided by wires for about 300 ft. Accelerations vary from 2 to 9 g.

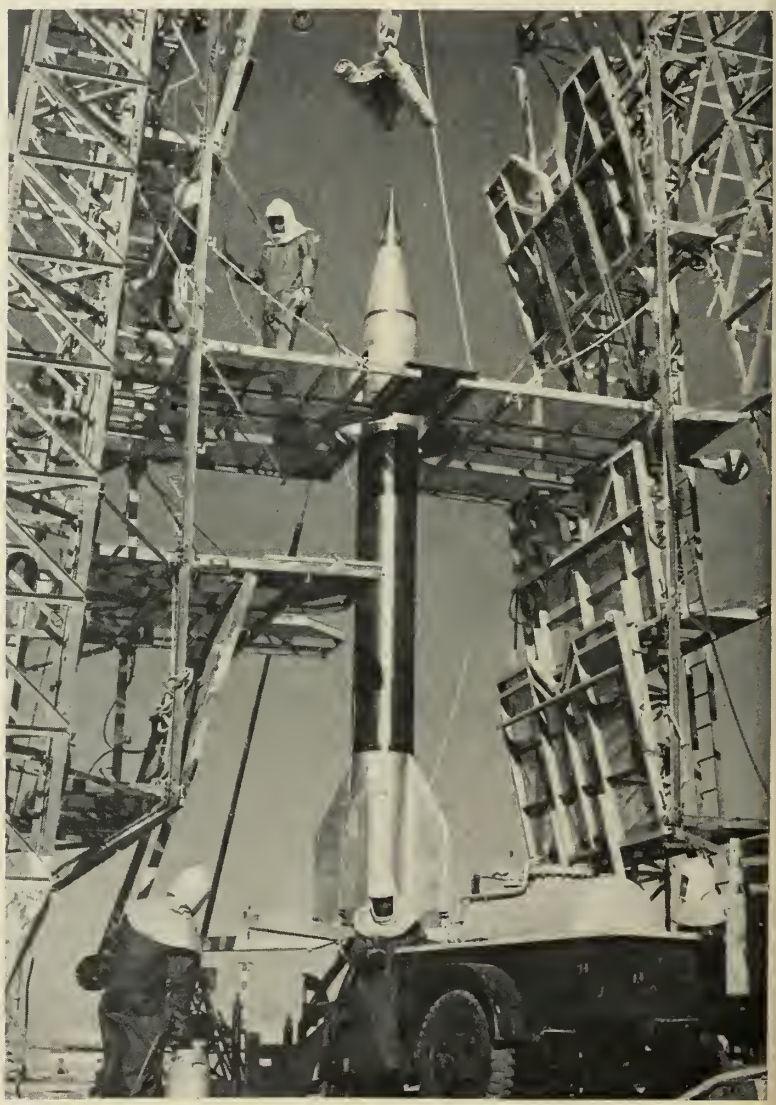
An altitude of 125 miles has been reached by a *Veronique* during recent experiments, and total capability is 137 miles with a 132 lb. payload.

A small transmitter installed in the rocket sends readings from the scientific instruments carried in the nose cone and higher part of the cylindrical body. Information about acceleration speeds, vibrations, temperatures, etc. of the rocket itself also are relayed to observers.

The smoke emitter contains an inflammable mixture, "thermite," consisting essentially of aluminum powder and iron oxide. Inflammated by powder 60 seconds after takeoff, a sizeable quantity of heat is released which vaporizes small die-shaped bits of solid sodium contained in the mixture. At an altitude of about 31 miles, this gas is emitted through small holes in the nose cone of the rocket, creating the "candle-shaped cloud."

Through photographic, photogrammetric and cinematographic observations of variations of the cloud, deductions are made about the speed of the winds as well as about the pressure and temperature of the atmosphere.

• **Launch at Dawn**—Conditions for the launching of the *Veronique* vehicles are very strict. A perfect vertical position must be assured. Success of the scientific experiments is best achieved if launching is at dawn or twilight when the sun is at a maximum of 9° under (dawn) or at least 6° under (twilight) the horizon, when visibility of the cloud is best. The "candle-shaped" cloud cannot practically be observed before the rocket reaches a height of 50 miles, an altitude corresponding to the dissociation of molecular oxygen into atomic oxygen. Under this altitude, sodium atoms are not "excited" by the sun and



HOODED CREWMEN refuel a *Veronique* in position under blazing Sahara sun.

the cloud is not bright enough to be observed.

Veronique will serve other scientific purposes in the future. Studies of the propagation of electromagnetic waves in the high atmosphere (in liaison with the Centre National d'Etudes de Telecommunications) for the measurement of diffuse light, the utilization of a spectrograph of mass and biological experiences including the transportation of live animals and the recording of their physiological reactions and other studies are planned.

Data obtained from all tests also will be used in the preliminary work now being done in France on the design of an IRBM.

Sweden To Get US *Nikes* For High-Altitude Research

STOCKHOLM—Professor Hannes Alfven of the Institute of Technology, Stockholm, has announced that the U.S. has agreed to sell Sweden a number of *Nike* rockets.

The rockets will be used in a high-altitude research programme planned by the International Meteorological Institute, Stockholm (particularly in connection with an investigation of the noctilucent clouds) and in the measurements of ionized radiation associated with the Northern Lights to be made by the Kiruma Observatory.

British Get *Honest John*

Within the next three months, the first shipments of the U.S. *Honest John* missile will be in the hands of the British Army. It will be supplied to the 39 Heavy Regiment, Royal Artillery, which arrived at Sennelager, Germany, last month with no artillery equipment.

Fourth British Missile Destroyer Keel Laid

LONDON—The fourth of the guided missile destroyers being built for the Royal Navy was laid down at the Belfast yard of Harland and Wolff, March 1. It is to be called the Kent, since all vessels will be named after British counties.

On Feb. 26, the third destroyer's keel—the London—was laid down at the Wallsend-on-Tyne (Northumberland) yards of Swan, Hunter and Wigham Richardson Ltd.

Devonshire, the first of the class was laid down on March 9, 1959 at the Birkenhead yards of Cammell Laird and Co., and is due to be launched this summer. Next will be the Hampshire.

These four ships will be the first to join the British fleet armed with the long-range guided missile *Seaslug* and the short-range *Seacat,* which are now in production.

British Missile Costs Soar

by G. V. E. Thompson

LONDON—Great Britain is finding that the cost of missile defense will be considerably more than she had envisioned. A report written by Sir Edmund Compton, Comptroller and Auditor-General came in the nature of a rude shock to budget-minded Britons.

The development cost of the first weapon, which he calls Type A (probably *Seaslug*), was originally estimated at between $2.8 and $4.2 million, to be spread over a period of years. This contract was issued February 1949—actual expenditure under the main contract up to the start of intensive firing trials was $25 million—or $17 million at 1949 values.

However, it appears that the Treasury had not understood that the original estimate referred to payments to the main contracts only and to development up to but not including the intensive firing trials. The latest estimate of the direct cost of developing the missile and its control and guidance systems is over $110 million.

• **Profits reduced**—Complaints of unsatisfactory progress were made on more than one occasion between 1953 and 1956. In August 1956, the Director of Contracts of the Ministry of Supply negotiated a reduction of over $100,000 in the profit allowed to the contractor. The Ministry then assumed responsibility for coordinating the activities of all firms concerned in the project. Delivery of the missiles for service is now planned to begin at a date five years later then originally called for, but still in time to meet the dates when the service department will actually require them.

Type B (probably *Thunderbird*) is now expected to have a development cost of $75 million. In 1950 it was tentatively estimated to be $7 million, but this figure made no provision for the cost of manufacture or for evaluation of missiles for acceptance trials.

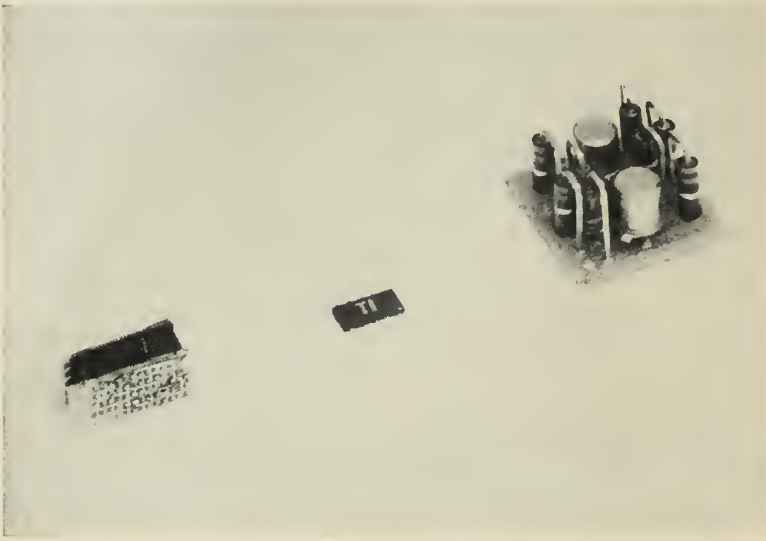
No firm prices for production of the missiles have yet been agreed, but the Ministry's estimated price in Nov. 1958 was more than double the estimate given to the War Office in Sept. 1956.

In the case of a third weapon, Type C (probably *Firestreak*) a contract for design and development was placed in 1952, when the cost was expected to total about $11 million, spread over five years. However, the Ministry emphasized that they had no real experience on which to base cost calculations.

During development it became possible to build improved performance into successive models, and eventually the *Mark IV* weapon represented so substantial a change from the original concept that fresh approval for the project was obtained and a separate development contract made.

The U. K. Treasury then gave their approval in principle for the *Mark IV* weapon at an estimated total cost of $56 million. This was in addition to a revised total estimate for the *Mark I* of $65 million. *Marks II* and *III* were discontinued.

The size, complexity and urgency of the Spadeadam project (rocket test-bed facility in Cumberland, managed by Rolls-Royce, and at which the large engines for *Blue Streak* are tested) precluded pre-contract design. It was considered necessary to employ a consortium of building and engineering contractors on a cost-plus fee basis under a Ministry of Works team. Spadeadam is now expected to cost $70 million instead of the original $28 million. An enquiry into the whole financial position was held last summer and control is now said to be functioning satisfactorily.



Semiconductor Line Introduced

With an eye to the opening of the annual IRE Convention and Exposition in New York, Texas Instruments, Inc., announces a vastly increased line of semiconductor products.

Of greatest import is the appearance of a standard "Solid-Circuit" semiconductor network. Developed over a year ago as a prototype item, the TI type 502 binary multivibrator, is a commercial off-the-shelf item, three years ahead of industry predictions, according to the Semiconductor-Components Div.

Expected to find wide application in missile and airborne circuitry, other typical Solid Circuit networks have already been utilized; they include logic blocks, gates, oscillators, NOR circuits and multivibrators.

The type 502 multivibrator can operate at a 200-kc repetition rate. The device measures only 0.250" x 0.125" x 0.031" and contains the equivalent of 16 conventional components, one-hundredth the size of an equivalent transistorized printed circuit device. The unit is designed to operate with a 6-volt power supply. Necessary input and output characteristics have been provided so that the type 502 unit can be interconnected for use as a shift register, binary counter, or set-reset flip-flop.

Solid-Circuit semiconductor networks are produced by techniques which are extensions of TI-developed mesa transistor production techniques. Diffusion, oxide-masking, evaporation, and chemical forming are used to make a single-crystal semiconductor wafer perform the function of a complete circuit. Ultrapure materials are used throughout to reduce contamination and increase reliability. The unit is encased in a glass-to-metal hermetically sealed package. Quantity prices: less than 100, $450; 100 or more, $300.

Other new produces include sensors, diodes, and regulators of silicon and gallium arsenide.

• **Photovoltaic sensors**—An entire line of photovoltaic silicon sensors was announced that includes diffused silicon solar cells, available either singly or in a shingle array, miniature vertical and horizontal light sensors for punched-card readers and a unique null-sensing device for use in ultrasensitive instrumentation.

The silicon null-sensing device, LS 221, consists of two matched sensors mounted in a subminiature dielectric case only 0.44 in. long. The sensors are connected to indicate a null when an equal amount of light is falling on each sensor. Positioned behind a moving needle or in front of a moving beam of light, the device is capable of remotely indicating minute variations in intensity. It is expected to find wide application in photo-mechanical tracking systems, servo systems, gravity meters, galvanometers, curve followers and balanced choppers.

The type LS 222 horizontal light sensor for card reader is packaged in a subminiature glass case measuring only 0.50" long by 0.08" in diameter. It produces an output of more than 250 microamps with a load of 1000 ohms under 1250 foot-candles of light.

• **Tunnel diodes**—Four new gallium arsenide tunnel diodes have been designed for specific applications in high-speed computer circuitry such as logic circuits, amplifiers, oscillators, and general computer purposes.

The IN650 Series, packaged in the lightweight standard JEDEC TO-18 case, provides guaranteed peak currents up to 10 milliamperes ±2%, large voltage swings, highest peak-to-valley ratios (greater than 15 to 1), guaranteed forward voltages up to 1.1 volts ±5%, and high-temperature operation up to 150°C.

These new gallium arsenide tunnel diodes, already in full production at Texas Instruments, are priced competitively with germanium tunnel diodes presently available to industry only on a sample basis.

• **Other diodes**—A gallium arsenide diffused junction varactor diode—believed to be the first—is designated the varactor XD 500. It is encased in a reversible-polarity, double-ended, ceramic microwave package.

The XD 500 offers a junction capacitance of 0.1 uuf min to 1.0 uuf max at zero bias, a Q of 30 measured at 2 kmc at −2 volts. When referenced to −6 volts at 2 kmd, Q is typically 45. The cut-off frequency is 60 kmc at −2 volts and 110 kmc or greater when measured at breakdown voltage. The shunt capacitance variation of the XD 500 varactor follows the minus ½ power law. The XD 500 has an extremely low inductance with a 0.4 uuf package capacitance measured at 100 kc.

Circle No. 225 on Subscriber Service Card.

1000 Hour Gyros

A new type of rate gyro for missile and aircraft systems with a guaranteed operating life of at least 1000 hours has just been announced by Gyro Dynamics Division of Darco Industries, Inc., a wholly owned subsidiary of United States Chemical Milling Corp.

Basis for the unusually long life of these gyros is an inverter actually built into the package which permits the use of A.C. motors for power. The gyros will operate directly from any D.C. current source without modification.

Until now, the average operating life of a gyro was approximately 200 hours, due mainly to the use of D.C. motors, which by the nature of their design, wear at a fairly rapid rate. It

was recognized that A.C. power was much more satisfactory but most missiles carry only D.C. current. This meant that an inverter had to be designed into the system before A.C. motors could be used, which resulted in more weight and additional space requirements.

The Gyro Dynamics product was designed around an entirely new concept which includes a built-in inverter as part of the basic unit without increase in overall size and with an actual reduction in weight over standard gyros of similar capacity. Environmental and in-use tests have shown that these gyros will perform to specification for at least 1000 hours. This new product is being offered on an "off the shelf" basis or may be modified to meet any special specifications.

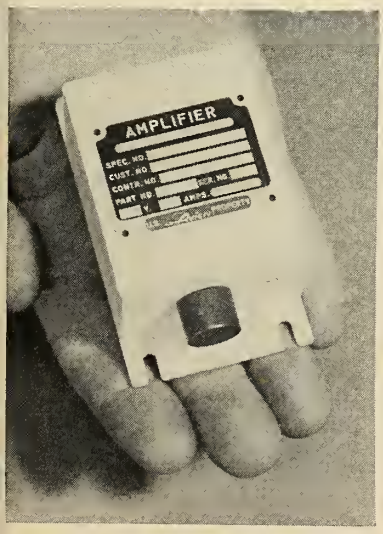
Circle No. 226 on Subscriber Service Card.

Miniaturized Amplifier

Development of a miniaturized D.C. Amplifier, designed expressly for low-level signal amplification in telemetry and other applications, has been announced by Avien, Inc. First use of the new unit will be as part of the flight instrumentation package on the Air Force *Minuteman* missile, now under development at Boeing Airplane Company.

The Company also announced that the characteristics which qualify the product for the *Minuteman* make the unit equally adaptable to a wide range of other missile projects.

The D.C. Amplifier is 6.5 cubic in. in size and weighs 10 oz. It has been designed to eliminate the problem of instability normally associated with amplification of D.C. signals. This has been done by first converting the signal to A.C., and, after amplification, transforming it back to D.C.



A solid-state modulator is employed for the conversion to A.C. Operational difficulties characteristic of mechanical choppers are avoided by the absence of moving members and contacts in the modulator.

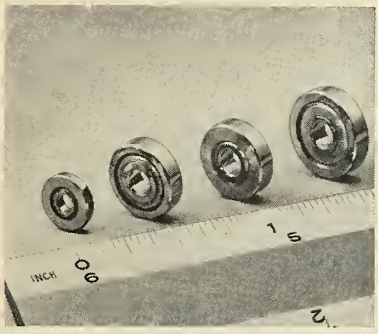
Less than 1.4 watts are required for performance of the Amplifier, which has an output impedance of less than 1000 ohms, and an input impedance of over 50,000 ohms. A linearity of 0.1% of best straight line is achieved, voltage gain is 50 to 200 and output voltage is 0-5 volts.

Circle No. 227 on Subscriber Service Card.

Thin-Width Bearings

A series of thin-width precision instrument bearings designed for use in synchros, gear trains, potentiometers, servos and small motors is now available from Miniature Precision Bearings, Inc.

Featuring a high outside diameter/-width ratio, the new MPB bearings were developed originally for use in



synchros where precision and reliability are prime requisites. Found to be suited for other applications, nine thin-width bearings were incorporated into the standard series which is available without premium charge. The relatively large O.D. enables designers to use economical through-bored and through-ground housings, resulting in more efficient production and improved bearing alignment. The narrow width of the new bearings saves space, making possible the use of longer stators and rotors in synchros and small motors, increasing power without adding to the overall length or diameter of the unit.

Made to ABEC class 7 tolerances, thin-width bearings are available from MPB factory and area office stocks in nine sizes with outside diameters from .2750 in. to .5000 in. and bores from .0937 in. to .1875 in. The new bearings are manufactured to the same exacting specifications as standard MPB bearings. For this reason the new bearings have the same levels of low torque and the smooth running characteristics of other MPB bearings. Standard material for balls and rings is 440C stainless steel. Open, single and double-shielded bearings are included in the series.

Circle No. 228 on Subscriber Service Card.

Digital Logic Module

Featuring versatility, compactness, and ruggedness, the Tele-Dynamics Type 6000A Logic Module is now available for a wide range of applications in digital systems and test equip-

ment. The module, containing two solid-state switching circuits, can be interconnected to form all of the major building blocks required for digital systems.

Each switching circuit contains a 4-input diode gate, an inverting amplifier, and a transition-triggered pulse generator. Used singly, or in combination, the logic module functions as a NOR gate, flip-flop, binary counter, delay flop, or as a shift register stage.

The logic module operates at a maximum pulse repetition rate of 5 megacycles. The inverting amplifier output has a 40 millimicrosecond rise time and an 80 millimicrosecond fall time. The pulse output occurs on a positive-going transition. The pulse has a half-amplitude duration of 100 millimicroseconds. Power consumption is less than one watt per module.

Circle No. 229 on Subscriber Service Card.

Audio Signal Generator

A dual function (sine and square wave) audio signal generator, Model 50, has been designed by Packard Bell Electronics specifically for measuring distortion in hi-fi amplifiers and the frequency response of test equipment, hi-fi amplifiers, tone controls and phonograph equalizers.

The Model 50 also provides precise measurement of amplifier input and output impedances and loudspeaker resonant frequencies. It is continuously tunable from 21 cps to 250 cps (fre-

quency reference of 200 cps), and can be used for tuning bass-reflex enclosures and for determining unknown audio frequencies and the resonant frequency of LC circuits.

Specifications: fully regulated power supply (105V to 130V); continuously variable output signal to 15V rms MAX; hum level .001% of maximum output; 2% or less harmonic distortion from 30 cps to 100 kc; accurate to plus or minus 2% or better.

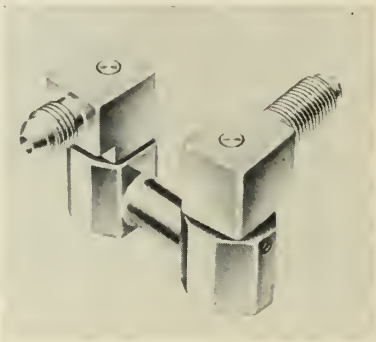
Circle No. 230 on Subscriber Service Card.

Swivel Connectors

Airaterra, designers and marketers of products manufactured by Roylyn Inc., announces that its new line of ball bearing swivel connectors is now available for aircraft, missile and industrial pneumatic or fluid applications.

These advanced design connectors boast low rotating torque values under full operating pressure due to the balanced pressure feature incorporated by Airaterra engineers.

Lightweight, and available in most materials, the Airaterra Swivel Connec-



tors may be obtained in single or multiple swivels.

An example of Airaterra's new line is this twin mounted swivel, designed and qualified in accordance with MIL-J-5513 A. The connector is compact, made of stainless steel and weighs but 9 oz. It is bulkhead-mounted to allow for misalignment of connecting lines. This Airaterra design operates from 0 to 3000 psi, with proof at 4500 psi, and burst at 7500 psi. The temperature range is from minus 65°F to plus 275°F.

Circle No. 231 on Subscriber Service Card.

Servo Valve Package

A servo valve-hydraulic motor package announced by Vickers Inc., Division of Sperry Rand Corp., is used to control accurately velocity and position of radar drives, missile guide vanes, reels, winches, hoists, flight controls, stabilization devices and other missile and ground support applications. The servo valve modulates flow to the motor producing speeds proportional to electrical input signals.

The Vickers miniaturized servo valve weighs only .53 pounds, which holds the valve-motor package size and weight to a minimum dry package weight of 2.7 pounds. The entire valve-motor unit occupies approximately 60 cubic inches of space. Models with integral relief valves weigh 2.9 pounds with no sacrifice of additional length.

The package is designed to cover any speed range between 10 to 20,000 rpm with a maximum output running torque or approximately 30 inch pounds at 3000 psi supply pressure.

A differential current of only —8 milliampere actuates the valve control spool. Valve configuration assures a high degree of linearity, low null shift with temperature, low hysteresis and increased reliability due to elimination of unnecessary tubing and fittings.

Circle No. 232 on Subscriber Service Card.

New Literature

OIL TANKS. Engine oil tanks for air missiles are discussed in a new 8-page catalog from United Aircraft Products, Inc. Since tanks are normally custom fabricated, the literature deals primarily with UAP capabilities in tank design, production, and testing. Engineering requirements are listed and illustrated, and a number of unusual configurations are shown. The literature also details UAP's quality control and qualification testing procedures, while the back cover is devoted to a glossary of oil tank terms and a specification table of the various tanks made by the firm which range from 1 to 15 gallons in capacity.

Circle No. 200 on Subscriber Service Card.

COOLING SYSTEMS. Four new liquid nitrogen cooling systems for infrared detector devices are described in a 6-page folder available from Linde Company, Division of Union Carbide Corporation. These cooling systems, developed to customer's specifications, increase the range and long wave length response of IR ray detectors. The four types are: integrally-mounted cell; liquid feed-vacuum insulated line; liquid generator to cryostat; and liquid feed-uninsulated lines. The folder contains information on design features, performance data and specifications.

Circle No. 201 on Subscriber Service Card.

VOLTMETERS. Panel-mounting electronic voltmeters ("PMEVs") expressly designed for continuous monitoring of critical parameters in systems and consoles, are described in a new folder of data sheets issued by Metronix, Inc.

Circle No. 202 on Subscriber Service Card.

radiation study attempt . . .

Explorer VIII Launching Misfires

Upper-stage ignition failure apparently defeated NASA's try last week to put a pint-sized *Explorer VIII* radiation satellite into an elliptical earth orbit.

Billed as the most significant "radiation" belt experiment sent aloft to date, *Explorer VIII*'s payload and elliptical orbit were to have been much like those of the larger "paddlewheel" satellite *Explorer VI*. A correlation of the information from both satellites was to have given scientists definitive dimensions and accurate velocities of the charged-particle belts enveloping the earth.

The satellite was launched toward a highly elliptical orbit of 28 degrees from the equator; its elliptical orbit would have carried it out to about 33,000 miles at apogee and within 200 miles of the earth at perigee, with an orbital period of 17 hours.

The launch vehicle was a *Juno II*, consisting of a modified *Jupiter* provided by ABMA, and a three-stage JPL high-speed cluster.

Explorer VIII's payload, devised and built by Dr. James A. Van Allen's Physics Department of the State University of Iowa, was a 21-by-7-in. cylinder containing solar cells for a permanent energy source and five sensitive energy particle detectors.

These five detectors were capable of detecting electrons below 20,000 electron volts—the first payload with such a capability—and also detecting the charges of the highest-energy particles. The detectors—singly and in combination—were designed to reveal the structure of the charged particle belts and their fluctuations, this information available after the satellite had made many passes through the belts, observing them in various stages of quiescence and activity.

Another experiment, rapidly becoming a standard item in newer satellites, was to measure internal and external temperatures.

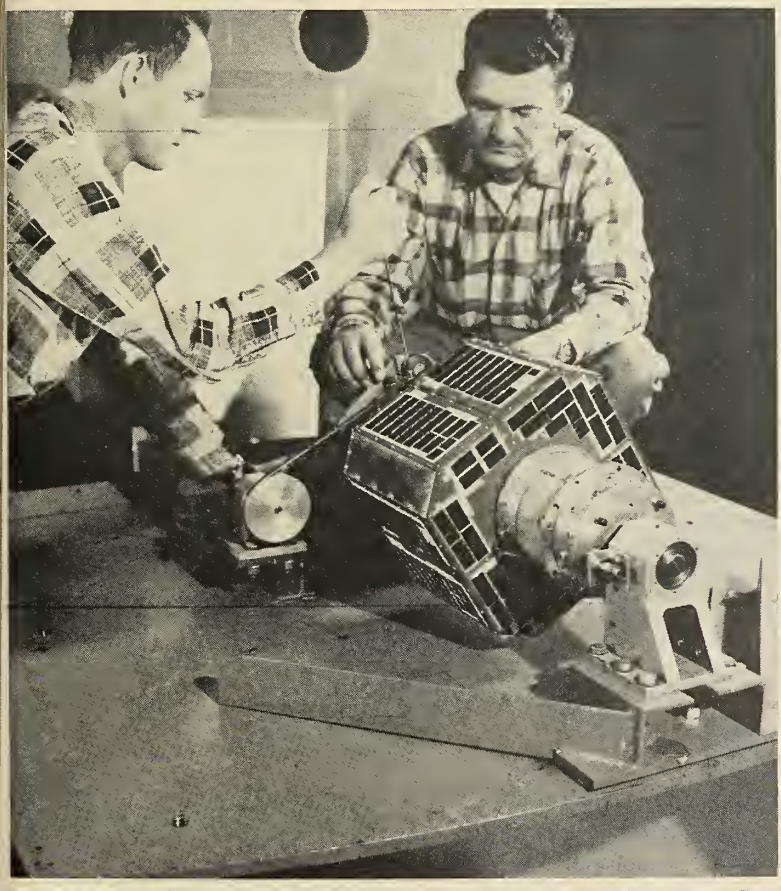
Data reports to ground stations were to be by a 300-milliwatt transmitter operating at 108.03 megacycles. This type of transmitter is capable of broadcasting five channels of information continuously.

The basic power supply was two pounds of nickel cadmium batteries, recharged by 1184 solar cells mounted on the box-like structure surrounding the cylindrical instrument package. The cells are protected by glass slides .006 of an inch thick, and are made by Hoffman Electronics.

A destruct mechanism operated by a timer would have silenced the transmitter after one year of operation.

Explorer VIII marked the sixth firing of the Von Braun team's *Juno II*, which previously has launched such successes as *Pioneer IV* and *Explorer VII*.

Responsible for tracking *Explorer VII* and recording its findings was the Goddard Space Flight Center's Space Operations Control Center. Micro-lock stations participating in the experiment include those at Aberdeen Proving Ground, Md., Cape Canaveral, Fla., Huntsville, Ala., Atlantic, N.C., Bermuda, Fort Monmouth, N.J.; and Mayaguez, Puerto Rico.



ILL-FATED *Explorer VIII* **satellite shown being prepared for centrifuge test at Cape Canaveral prior to the March 23 launching.**

NASA Readies Broad Report on Its Activities

A NASA handbook of interest to the missile/space industry will be available from the Superintendent of Documents, Government Printing Office, Washington, 25, D.C., in the near future.

Entitled the "Second Seminnual Report to The Congress," the 269-page manual contains a history of NASA activity, including the launches to date, the contracts and research grants let, and the research papers published.

—contracts—

NAVY

$356,000—**Sylvania Chemical and Metallurgical Division**, for development of molybdenum alloy in sheet form for rockets and missiles.

$40,000—**Southwestern Industrial Electronics Co.**, Houston, for producing equipment for use in power supply systems for *Polaris*.

ARMY

$22,647,800—**Nortronics Div., Northrop Corp.**, for continued production and engineering work on *Hawk*. ($20,883,000 for follow-on production of missile airframe items and ground handling equipment, balance for research and development.)

$18,821,851—**Pan American World Airways, Inc.**, for setting up and operating an "electronic environmental test facility" at the proving ground near Ft. Huachuca, Ariz. **Bell Aircraft's Avionics Div.**, subcontractor received $7,600,000 for its part in the program.

$2,250,000—**Lear, Inc.**, Santa Monica, Calif., for gyroscopic reference units for *Nike-Zeus*. Subcontract from **Bell Telephone Laboratories, Inc.**

$1,491,499—**Western Electric Co.**, New York City, for replenishment spare parts, repair parts and components for *Nike*. (Sixteen contracts.)

$528,429—**Douglas Aircraft Co.**, Santa Monica, for replenishment spare parts, repair parts and components for *Nike*. (Six contracts.)

$300,324—**Hayes Aircraft Corp.**, Birmingham, Ala., for engineering, design, layout development, documentation, fabrication, assembly and test work, ground services equipment, *Saturn*.

$212,370—**Southwestern Industrial Electronics Co.**, Houston, for airborne DC amplifiers for *Saturn*.

$195,950—**Hayes Aircraft Corp.**, Birmingham, Ala., for engineering, fabrication and manufacturing services for *Saturn* second-stage adapter, components, subassemblies and related tooling.

AIR FORCE

$2,322,000—**Radiation, Inc.**, Melbourne, Fla., for airborne telemetry systems for the *Titan*. Subcontract from **AC Spark Plug Div. of General Motors.**

$236,408—**Southwestern Industrial Electronics Co.**, Houston, for production of components for *Titan*. Subcontract from **Martin Co.**, Orlando.

$118,938—**University of Minnesota**, for electron-spin resonance studies of selected solids.

$60,000—**Western Reserve University**, for research on positron annihilation reactions in condensed materials.

$54,958—**Oklahoma State University of Agriculture and Applied Science, Research Foundation**, Stillwater, for research directed to the development of experimental apparatus for measurement of micrometeorite damage to surface of surface of space vehicles.

$46,467—**Barkley & Dexter Laboratories, Inc.**, Fitchburg, Mass., for study of global gravity measurements.

$45,254—**New York University**, for continuation of research investigation in control systems.

$40,175—**University of Pittsburgh**, for research on "flash spectroscopy and flash fluorimetry in photosynthetic studies."

$40,000—**Northeastern University**, Boston, for design, construction and testing of instrumentation for investigation of the upper atmosphere.


VERMILYEA

George S. Vermilyea: former executive vice president, named president, Nems-Clarke Co., a division of Vitro Corp. of America. He succeeds **Allen S. Clarke,** president since 1954, retiring after 47 years in communications and electronics. Clarke will continue with Vitro as marketing and product development consultant to Nems-Clarke.

Vitro also announced these changes: **Vernon M. Setterholm,** formerly director, Vitro's Silver Spring Laboratory, promoted to vice president, Nems-Clarke; **Wayne G. Shaffer** promoted from associate director to Silver Spring Laboratory director; **John C. Geist** promoted from technical operations director to associate laboratory director.

David S. Lewis: named senior vice president-operations, of McDonnell Aircraft. He will have responsibility for engineering, manufacturing, procurement and quality control, customer service, foreign service, contracts and project management.

Charles J. Foskett: now manager of the Radio Corp. of America's new BMEWS Operations Liaison Office at Laurence G. Hanscom Field in Bedford, Mass. Foskett previously held the position of manager of programing and manufacturing coordination, in which he is succeeded by **Harold M. Emlein,** former operations manager of the Industrial and Automation Division.


PRINCE

Dr. Morton B. Prince: Formerly vice president - research and development, appointed vice president and general manager of Semiconductor Division, Hoffman Electronics Corp. Former vice president **Maurice E. Paradise** has been named to corporate vice president in charge of product planning. Prior to joining the firm in 1956, Dr. Prince was a member of the Bell Telephone Laboratories team that developed the first silicon solar energy converter.

Benjamin H. Ciscel: chosen general manager of Vought Electronics Div. of Chance Vought Aircraft, Inc. Ciscel is former senior vice president and member of the board of directors of Electronics Specialties Co. of Los Angeles.

Borg-Warner Corp.'s Pesco Products Division announces three appointments in the engineering department: **J. F. Murray,** to director of engineering; **Thomas D. Carpenter,** manager, future products planning; and **Louis J. Schafer,** project manager.

Leonard J. Sacks: succeeds **Dean Daniels** as Western District Sales Manager for General Electric's Silicone Products Dept. Daniels moves to Sales Manager for GE's Insulating Materials Dept.


DICE

Harold H. Dice: general manager of the Allison Division since March 1, elected vice president of General Motors Corp. by GM's Board of Directors. Dice was Allison assistant general manager for seven years preceding his promotion to general manager, and has been with GM for more than 30 years.

Richard B. Uhle: named to the new post of executive assistant, planning, to the vice president and general manager of Defense Operations, Avco Crosley Division.

John F. Carr: appointed director of contracts for AC Spark Plug, the Electronics Division of General Motors. He succeeds **Alvin B. Goodspeed,** recently promoted to director of sales, AC-Milwaukee.

The promotions of **John R. Halligan** to vice-president and secretary and **Edward Bishop, Jr.,** to treasurer have been announced by The Hallicrafters Co., Chicago electronics firm.

James E. Kirch: new navigation section head for Motorola's Western Military Electronics Center. He will supervise R&D projects relating to advanced hyperbolic navigation systems, new types of propagation and field strength instrumentation and similar low frequency areas of interest.

E. B. Newill is retiring as general manager after 17 years with Allison; he has been a GM vice president since 1948.

Walter H. Wiewel: retires from active service as senior vice president, Crucible Steel Co. of America, but will continue to be associated with the company as a consultant. His retirement culminates a 50-year career in the steel industry.

REPUBLIC AND FOKKER CONTRACT: Republican Aviation Corp. has acquired a substantial minority interest in the Royal Netherlands Aircraft Factories.

Although major projects for the European combine will be aircraft for NATO and the USAF in Europe, it is expected that in the future other modern weapons systems will be added. A drone reconnaissance vehicle and development of vertical and short takeoff aircraft have been mentioned.

Fokker is at present responsible for the Hawk missile in Europe, as well as the F-104G Starfighter and the Breguet 1150 Atlantic and the F-27 Friendship.

Current U.S. and European spares production may be placed at Fokker pending the transfer of U.S. Government-owned tooling.

KOLLSMAN ACQUIRES: Kollsman Instrument Corp. will operate Richardson-Allen Corp., College Point, L.I., as a wholly-owned subsidiary to manufacture silicon rectifiers and transformers. Kollsman is a Standard Coil Products Co., Inc. subsidiary.

CABLE FIRM ORGANIZED: Phelps Dodge Corp., Northrop Corp., Page Communications Engineers, Inc., (Northrop subsidiary), and Felten and Guilleaume of West Germany have jointly formed the United States Underseas Cable Corp. to design and construct long-distance underwater cable systems. The company has no plans to operate as a common carrier.

DYNA-MATICS INC. FORMED: Making headquarters in Sun Valley, Calif. the firm will manufacture control equipment, valves, regulators, turbine flow meters and pumps for aircraft, missiles and ground support systems.

Dyna-Matics president is J. H. Overholser, former VP-sales and engineering and director of Poly Industries, Inc., as well as president and founder of Hydrodyne, Inc. Executive vice president is E. H. Haag, previously a partner in Air Products Co., and general manager, Bruce Engineering Corp.

R&D ORGANIZATION STARTED: The Princeton Chemical Research Co., a contract research and development organization specializing in petrochemicals, polyolefins, and catalysis, began operating in Princeton, N.J. March 1.

$1-MILLION R&D LAB OPENS: Electro-Optical Systems, Inc.'s $1-million research and development laboratory in Pasadena is now complete and will work on the development of an ion engine, molecular electronics, exploding wire techniques, optical homing and guidance systems, high-speed switching techniques, solid-state transducer development and space defense systems.

WESTINGHOUSE EXPANDS: Joining other firms in the R&D race, Westinghouse is breaking ground for a new center. Two new buildings in Churchill Borough, Pittsburgh, will house materials, new products, manufacturing and controls laboratories and patent department.

LFE OPENS DIVISION: Laboratory For Electronics, Boston, is opening an Advanced Development Division for research and development of advanced communications systems and techniques, navigation of space vehicles, reliability and data retrieval and recognition.

SPACE PACKAGES OFFERED: Space Instrumentation Division of Acton Laboratories, Inc. has been created to engage in research, development and fabrication of packaged rocket and satellite precision instrumentation. Technology Instrument Corp. is Acton's parent company.

financial news

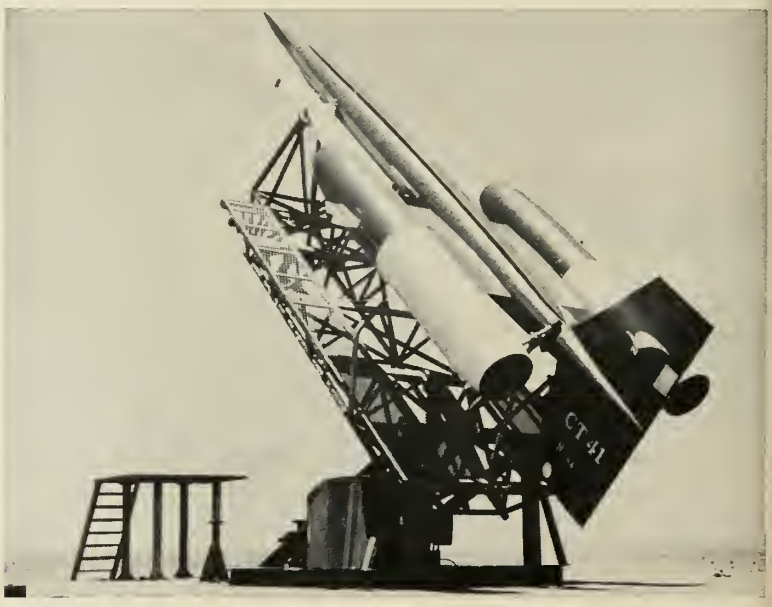
THE MARTIN CO.—Completing its transition from manufacturer of military aircraft to modern weapons systems, it reports a sales increase for the ninth consecutive year.

Sales in 1959 were $523.7 million, compared to $483.6 million in 1958. This marked an 8% rise. Backlog at end of 1959 totaled $900.5 million, compared to $831.5 at the end of 1958.

A substantial rise in net income was also realized, with 1959's income $13.3 million topping that of the previous year by 13%.

• **Burroughs Corporation**—Revenue from the sale of military products reached a record high in 1959, accounting for about 27% of total revenue. Net income for 1959 totaled $7.1 million compared to $6.4 million in 1958.

Bell To Build French Birds



BELL AIRCRAFT is moving into the missile target drone business. The company has signed an agreement with Nord Aviation of France for U.S. manufacturing rights to the *CT-41* Mach 2.5 radio-controlled drone (above) and the subsonic *CT-20* target missile. The *CT-41* is launched by two solid-propellant boosters and powered in flight by twin ramjets. It is 32 ft. 2 in. long, 20 in. at its largest fuselage diameter and has an 11-ft. 11-in. wing span. Speed ranges up to 1650 mph at altitudes of more than 70,000 ft. Bell says it is "actively exploring" possible interest in the two missiles by the Army, AF and Navy.

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reviews

LETTER SYM8OLS FOR ROCKET PROPULSION, ASA Y10.14-1959, American Standards Association, 70 East 45th St., N.Y., N.Y. $1.50.

A one-volume collection of all the symbols for terms and concepts frequently used in the design, manufacture and operation of rockets. Where more than one symbol is in common usage, the standard designates one as the preferred symbol but includes the others as alternates.

THE EFFECT OF RAPID LIQUID-PHASE REACTIONS ON INJECTOR DESIGN AND COMBUSTION IN ROCKET MOTORS. Gerard W. Elverum Jr., and Peter Staudhammer, Jet Propulsion Laboratory, California Institute of Technology. Order N-79234, JPL from NASA Technical Information Division, Code BID, Washington 25, D.C.

Data are presented indicating rates and magnitudes of energy released by the liquid-phase reactions of various propellant combustions.

The data show that this energy release can contribute significantly and thus aid the combustion process. Color photographs of open flames using various injector elements are given.

HIGH-TEMPERATURE INSULATION FOR WIRE (part 2), J. N. Harris and J. D. Walton, Georgia Institute of Technology. Order PB 151944 from OTS, U.S. Dept. of Commerce, Washington 25, D.C. 40 pp. $1.25.

This report covers the second year of a research project aimed at development of efficient insulation for electrical wire to be used at temperatures of –85° to 1500°F.

Performance standards require that the insulated wire be as light in weight as possible and flexible at room temperature for ready installation.

Tests indicated that colloidal silica impregnation may be an improvement over silicone resins for sealing anodized aluminum wire.

AIRCRAFT AND MISSILE DESIGN AND MAINTENANCE HANDBOOK, Charles A. Overbey. The Macmillan Company, New York. 369 pp. $9.75.

The handbook contains over 160 tables and 40 figures to illustrate the standard methods of equipment installation and maintenance.

The text explains the standards and gives hundreds of tips on the proper handling of materials and tools.

Topics covered are electrical and plumbing systems, materials of construction, aircraft and missile hardware, color codes and conversion systems, and processes such as metal spraying, anodizing, rust-proofing, plating, welding, and brazing.

HIGH-TEMPERATURE ELECTRICAL INSULATING INORGANIC COATINGS ON WIRE (part 2), C. G. Bergeron and others, University of Illinois for WADC. Order PB 151943 from OTS, U.S. Dept. of Commerce, Washington 25, D.C. 55 pp. $1.50.

The report covers the second year of research on a project to develop effective wire insulation able to withstand temperatures to 1500°F. Tests included flow-coating 0.020-in. copper wire in continuous motion through a ceramic slip.

The researchers found that oxidation of copper into the coat was actually desirable for better electric conduction at high temperatures.

Tests indicated 0.1 mils or less to be the desired thickness of a coat. Yet the cracks formed in testing a thicker layer did not reduce insulation strength.

ULTRAHIGH TEMPERATURE (500° C) POWER TRANSFORMERS AND INDUCTORS, H. B. Harms and J. C. Fraser, GE for WADC. Order PB 161046 from OTS, U.S. Dept. of Commerce, Washington 25, D.C. 576 pp. $7.

The report covers the second phase of research aimed at production of lighter, more compact and efficient electronic power transformers to operate in an environment of 500° C plus the heat induced in them by intense radiation.

Much of this phase of the research project was concerned with hermetically sealing a transformer. It was found that contouring the hermetic to the core and coil saved considerable size and weight.

A very thin ceramic film insulation of nickel-clad copper wire was developed. The discovery proved to be an important additional contribution to research on ultrahigh-temperature magnet wires.

TECHNICAL RESOURCES DIRECTORY-MISSILE GROUND SUPPORT EQUIPMENT, Office of the Director of Defense, Research and Engineering. Order PB 161103 from OTS, U.S. Dept. of Commerce, Washington 25, D.C. $.50.

The directory, divided into Army, Navy, and Air Force sections, lists various components, such as "axles and differentials," "bearings-ball and roller," and "bodies-truck and trailer," then lists the agency and the name of the individual within the agency who has cognizance over the item.

DESIGN INFORMATION ON 5CR ALLOY STEELS FOR AIRCRAFT AND MISSILES, F. R. Morral, R. J. Favor, and W. P. Achbach. Order PB 151072 from OTS, U.S. Dept. of Commerce, Washington 25, D.C. $1.25.

The 5-Cr-Mo-V (H-11 type) steels are characterized by a high-strength/density ratio in the 1000° F range, sufficient harden-ability to permit air quenching, and tempering temperatures of 1000° to 1100° F.

They also have slightly less tendency to scale in air and better thermal shock resistance than low-alloy steels. These characteristics make them promising for many uses in aircraft and missiles.

THE ALL-BETA TITANIUM ALLOY (TI-13V-11CR-3AI), R. A. Wood and H. R. Ogden. Order PB 151066 from OTS, U.S. Dept. of Commerce, Washington 25, D.C. 199 pp. $3.

Technical information on an all-beta titanium alloy is summarized.

The alloy is a relatively new type containing 25% alloying ingredients. These additions to the titanium base produce an alloy with a very sluggish beta-phase decomposition.

Space Goal—A Nuclear Moon Rocket

A forthcoming report on hearings held by the Joint Committee on Atomic Energy this past week can have a great effect on the nation's space program and whether we permit the Russians to gain an insurmountable lead.

At stake, among other things, is Project *Rover*—a nuclear propulsion system capable of carrying a manned expedition to the moon and return; conceivably the same system or its successor could carry men to Mars and Venus.

Conceivably also, Project *Rover* could accomplish the manned moon expedition within 10 years if it were supported and pushed. While there are other possibilities—the clustered *Nova*, for instance—most space scientists in the country today feel that nuclear power represents the only really feasible method of lifting the enormous weight a moon expedition would require.

A strong report from Senator Clinton Anderson's committee could lift *Rover* from the limbo where it has resided for five years and give the United States a major goal in space—a goal it completely and sadly lacks now.

Rover began in 1955 as a joint AEC-Air Force project with a 1960 target date for ground tests on the engine. The project was downgraded in 1957 and stretched out again last winter when the President moved the ground feasibility test date to 1964. Its budget diet has been one barely sufficient to sustain life.

When NASA was formed the project was transferred there from the Air Force. NASA now is responsible for the non-nuclear components of Project *Rover* and has in effect subcontracted the nuclear portion to the AEC. Industry has a few small related contracts.

As of the moment, the project stands about like this:

The AEC wants a high-gear program with a goal of a manned expedition to the moon (20,000 pounds payload) in 10 years or less.

NASA, which did not even include *Rover* in its 10-year space program published recently, favors a cautious approach—full speed on ground testing, but not so full for flight testing.

The Administration, or Bureau of the Budget if you like, wants a further slowdown, cut the 1961 AEC budget allocation for *Rover* and forced AEC to substitute other funds to keep it alive.

There are other differences, too, between AEC and the NASA, but they are mainly technical and apply to testing methods.

Sen. Anderson tends to side with the AEC. Even further, he has suggested the industry-service approach which produced the atomic-powered submarine. The Senator wants some action and is seeking a way to get it.

Some things appear self-evident in our pat-a-cake space program. One of them is that we desperately need a national goal in space toward which the bulk of our efforts could be directed.

In the thinking of most space scientists, that goal should be a manned expedition to the moon.

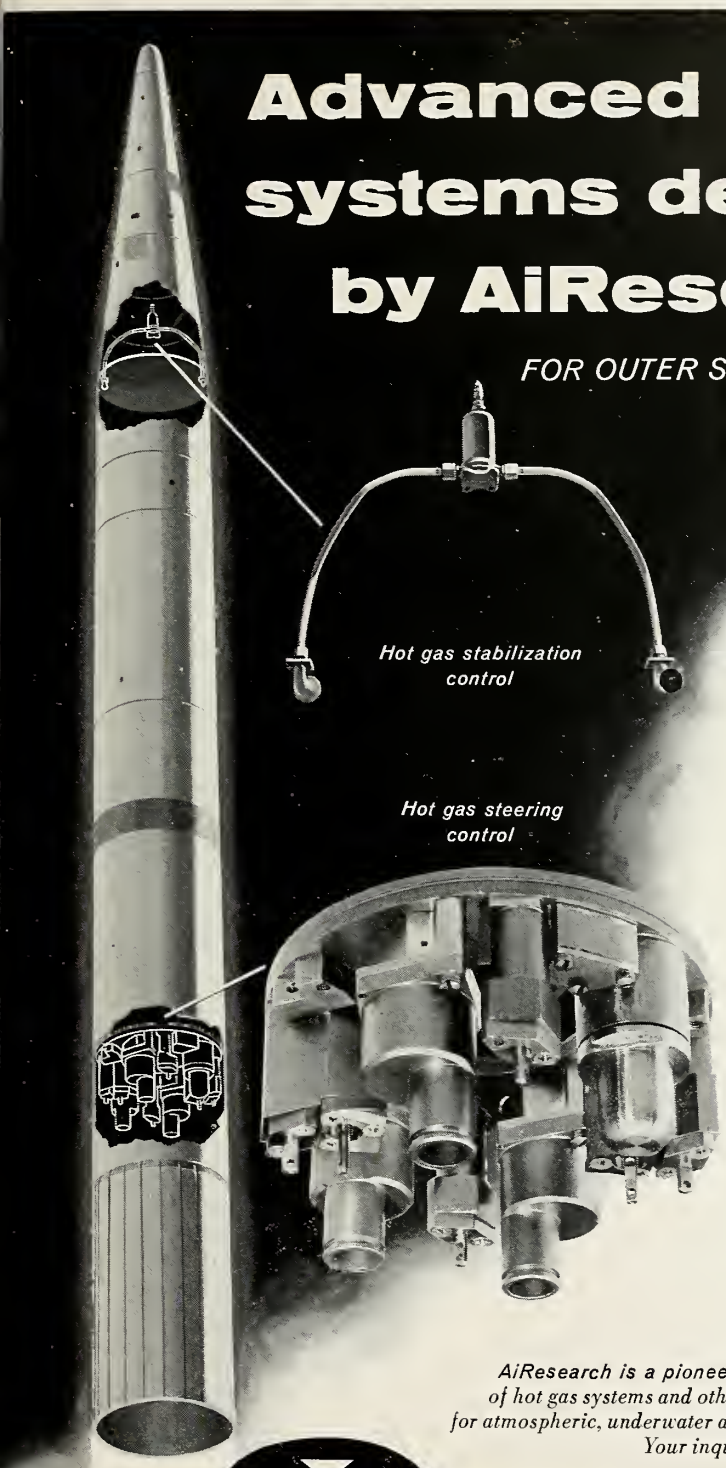
With that as a goal, all other space exploration projects fall into place. Communications, reconnaissance, space platform laboratories, space rendezvous and refueling, and human factors all assume their proper perspective as supporting elements of such a goal.

Senator Anderson and his committee cannot directly force fast and purposeful action on a nuclear rocket which could place an American team on the moon in reasonable competition with the Russians—but they can, and we hope will, direct enough public attention to the project to make such action imperative.

Clarke Newlon

Advanced hot gas systems delivered by AiResearch

FOR OUTER SPACE, ATMOSPHERIC AND UNDERWATER STEERING



AiResearch is now in production on two greatly simplified hot gas steering control systems: a reaction control system for outer space flight stabilization and a hot gas actuator control system for terrestrial steering (in the atmosphere and under water).

Both systems eliminate any need for pumps, heat exchangers, accumulators and other apparatus required in earlier control systems. And both systems utilize hot gas, operating off either the main engine or a separate fuel source.

The gas in the outer space reaction control system is fed into a set of nozzles which imparts spin to the missile to stabilize its flight through space.

In the terrestrial hot gas actuator control system the gas is fed into an on-off controlled linear actuator which moves the fins controlling the missile's attitude in the atmosphere or under water. This system also utilizes a concept developed from the AiResearch hydraulic "printed circuit." This approach eliminates complicated plumbing, thereby decreasing the weight and increasing the reliability of the system.

AiResearch is a pioneer, leading developer and manufacturer of hot gas systems and other nonpropulsive power systems for atmospheric, underwater and outer space missions. Your inquiries are invited.

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STEPS IN THE RACE TO OUTER SPACE

Escape In Space

The space-assembled super satellites of the future will periodically encounter disaster—collision, mechanical failure, military attack, or the long chance of being hit by a meteorite. When this happens, "life boats" like the one shown here will bring their crews safely back to earth.

Here is the operational sequence of an escape in space:

1. Crew members don pressure suits and strap themselves into decelleration beds within the pressure-intact unit.

2. At the "Abandon Ship" signal, low-power, RATO-type launching rockets blast the sealed capsule from the threatened station (upper right illustration).

3. Acting on orders from an astrogational computer, the retro-rockets check the capsule's speed and break it out of orbit. (Foreground. Note details of offset heat shielding, hatches, slow-down parachute covers.)

4. As the capsule enters the outer atmosphere, the heat shield protects the astronauts. The life boat's momentum slows even further, and the shield is jettisoned as it cools.

5. Four parachutes are released, acting as air brakes. After a computed interval, other chutes are released.

6. The capsule lands in a predetermined sea rescue area, and a ring of flotation bags inflate. A radio broadcasts the craft's location, and a bright sunshade serves as a visual and radar target for rescuers.

ARMA, now providing the inertial guidance system for the ATLAS ICBM and engaged in advanced research and development, is in the vanguard of the race to outer space. For this effort, ***ARMA*** needs scientists and engineers experienced in astronautics. ***ARMA***, Garden City, New York. A Division of American Bosch Arma Corporation.

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