JULY 20 1959

LEWIS LAB WIND TUNNEL

missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS

IRD ANNUAL

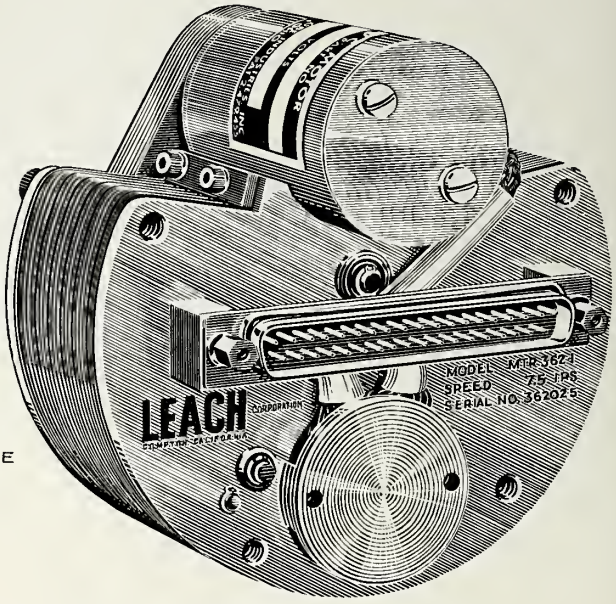
gineering Progress Issue

d World Guided Missile Encyclopedia

AN AMERICAN AVIATION PUBLICATION

tells the whole story...with impact!

miniature tape recorder



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Testing under severe environments . . . in extremely limited space? Inet's rugged new Miniature Tape Recorder simultaneously records data on 1 to 14 in-line channels, never loses a record because it's built to survive high impacts.

Here are the features to look for: precision in-line recording head; adjustable motor speed and tape tension; molded rubber pressure roller and driver wheels; and precision ball bearings at both ends to support all revolving parts.

Weighs just 24 ounces and operates at tape speeds of from ¼ to 15 inches per second in a temperature range of —50°F. to +200°F. Among its applications: in-flight and static tests; atmospheric, blast, explosion, and wind tunnel studies; and acceleration and actuation tests. *Write today for complete specifications.*

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Crosley's technical competence, dependability, and coordinated project administration are ready to serve the Free World's defense requirements wherever needed most.

For more information, write to: Vice-President, Marketing— Defense Products, Crosley Division, Avco Corporation, 1329 Arlington Street, Cincinnati 25, Ohio.

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Creative research and development engineers experienced in electronics, mechanics, weapons systems, and ordnance warheads are urged to investigate the wide range of opportunity at Crosley. Write to: Director, Technical and Scientific Personnel, Dept. M-79E, Avco/Crosley, 1329 Arlington Street, Cincinnati 25, Ohio.

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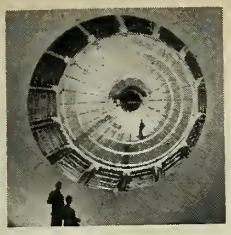
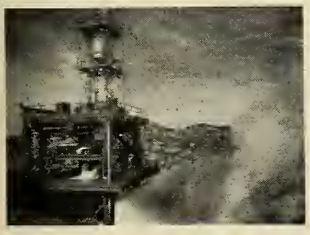
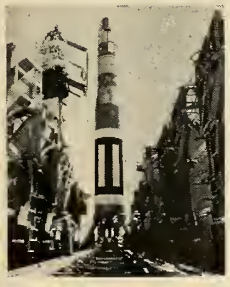


COVER: upstream view of the No. 2 cooler of the Unitary Plan Wind Tunnel at the Lewis Flight Propulsion Laboratory, NASA facility at Cleveland, Ohio.

EARTH'S inner and outer radiation belts, named for Van Allen, are shown in a new artist's conception. (See the Astrophysics report, p. 43.)



TEST firing of individual H-1 engines is carried out at Rocketdyne's Propulsion Field Laboratory in the Santa Susana Mountains. (See the report on liquid engines, p. 53.)



POWERFUL *Titan* ICBM is readied for static testing at one of Martin-Denver's four static test stands. (M/R's annual missile encyclopedia is included in this issue—see p. 137.)

missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS

ANNUAL ENGINEERING PROGRESS ISSUE

ANNUAL MISSILE ENCYCLOPEDIA

NEW MISSILE PRODUCTS

THE MISSILE WEEK

DEPARTMENTS

SKY HIGH

integrated hurricane hunting

A sky-high vantage point will be the key to the detection of spawning hurricanes over vast ocean areas such as the Caribbean Sea. Weather satellites equipped with special sensing devices will be able to report cloud patterns and rising columns of warm moist air which indicate the formation of these tropical storms.

Alerted by satellite information, weather reconnaissance aircraft will be dispatched to investigate the hurricane area. These aircraft, with the Bendix AN/AMQ-15 system, will employ high altitude rocketsondes, dropsondes, aircraft sensors, and cloud and storm radars to measure the meteorological and geophysical parameters that make it possible to predict storm intensity and motion.

Measurements of weather phenomena relayed from the AN/AMQ-15 system will be combined with data from land-based weather stations and upper air sites. These data will be integrated and processed by advanced weather computing centers to yield forecasts essential to military operations, commercial aviation and our civilian life.

Advanced weather and geophysical forecasting is the ultimate objective of the AN/AMQ-15 system and related projects being carried out at the Bendix Systems Division. These programs, air defense projects and the EAGLE Air-to-Air Missile program, will provide the integrated systems of tomorrow. Opportunities are available for better engineers and scientists also looking to the future.

Bendix Systems Division
ANN ARBOR, MICHIGAN

Bendix
AVIATION CORPORATION

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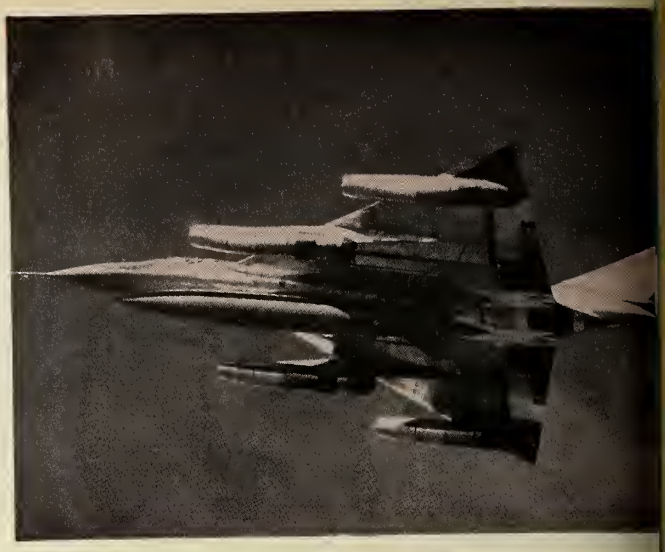
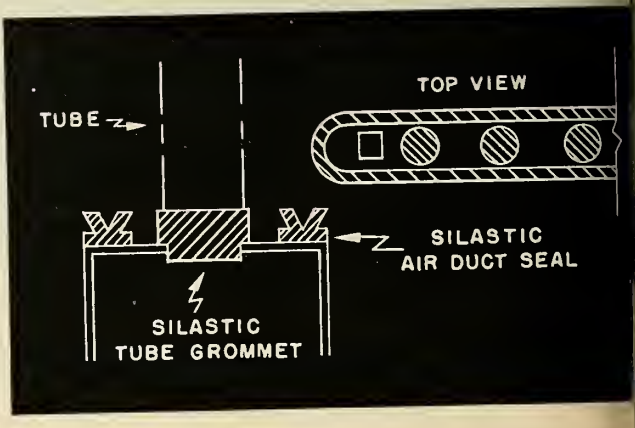
The PLANE

America's newest production bomber, the Convair B58 Hustler. This delta-wing jet employs an area-ruled fuselage for supersonic regime efficiency, and has reportedly been flown in excess of Mach 2 at 50,000 feet. Engines are four J 79's, in pods below the wings.



The PROBLEM

Sealing and cushioning vacuum tubes in cooling air ducts for the B58 Fire Control System, designed and produced by The Emerson Electric Manufacturing Company. Difficulties involved include heat —the sub-miniature tubes operate as high as 350 F— and severe cold when the units are inactive during flight. Protective material must stay resilient despite these extremes.



The PART

SILASTIC
SILICONE RUBBER

Tubes and other electronic equipment in the B 58 are cushioned by molded parts of Silastic®, the Dow Corning silicone rubber. Silastic stays rubbery, has excellent electrical properties.

TYPICAL PROPERTIES OF SILASTIC MOLDED PARTS

Temperature range, °F	—130 to 500
Tensile strength, psi	600 to 1400
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For further information write Dept. 7619.

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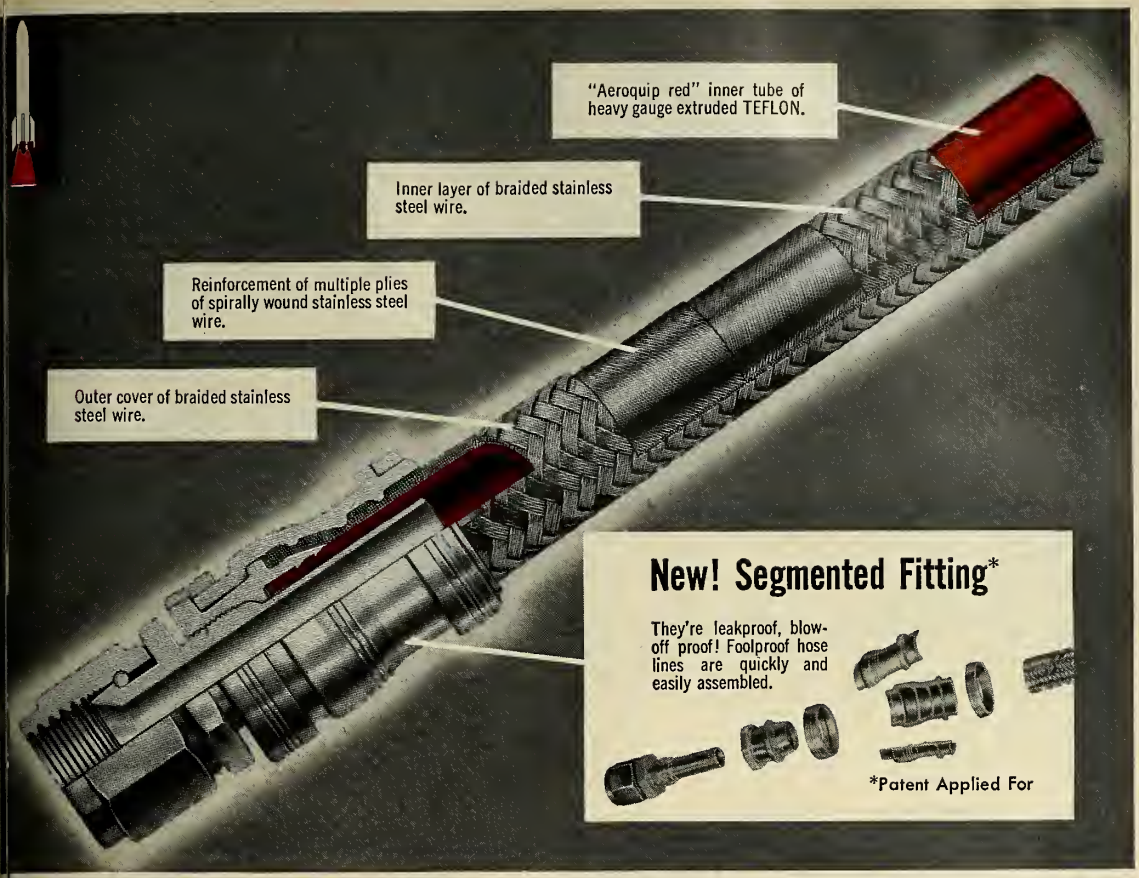

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OPERATING PRESSURE: 6000 psi.

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With an inner tube of TEFLON, which has zero moisture absorption and an anti-adhesive surface, Aeroquip 678 Hose allows fast, easy purging and dehydration. The hose has superior resistance to vibration, low volumetric expansion and high temperature resistance. Return the coupon for complete information.

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Hose part number	678-6	678-8
Hose size I.D.	.312	.437
Hose size O.D.	.609	.812
Oper. press., psi.	6,000	6,000
Burst press., psi.	24,000	24,000
Bend radius at pressure	5	10

All dimensions in inches

Aeroquip Corporation, Jackson, Michigan
Please send me a copy of Engineering Bulletin AE8-23. MR-7

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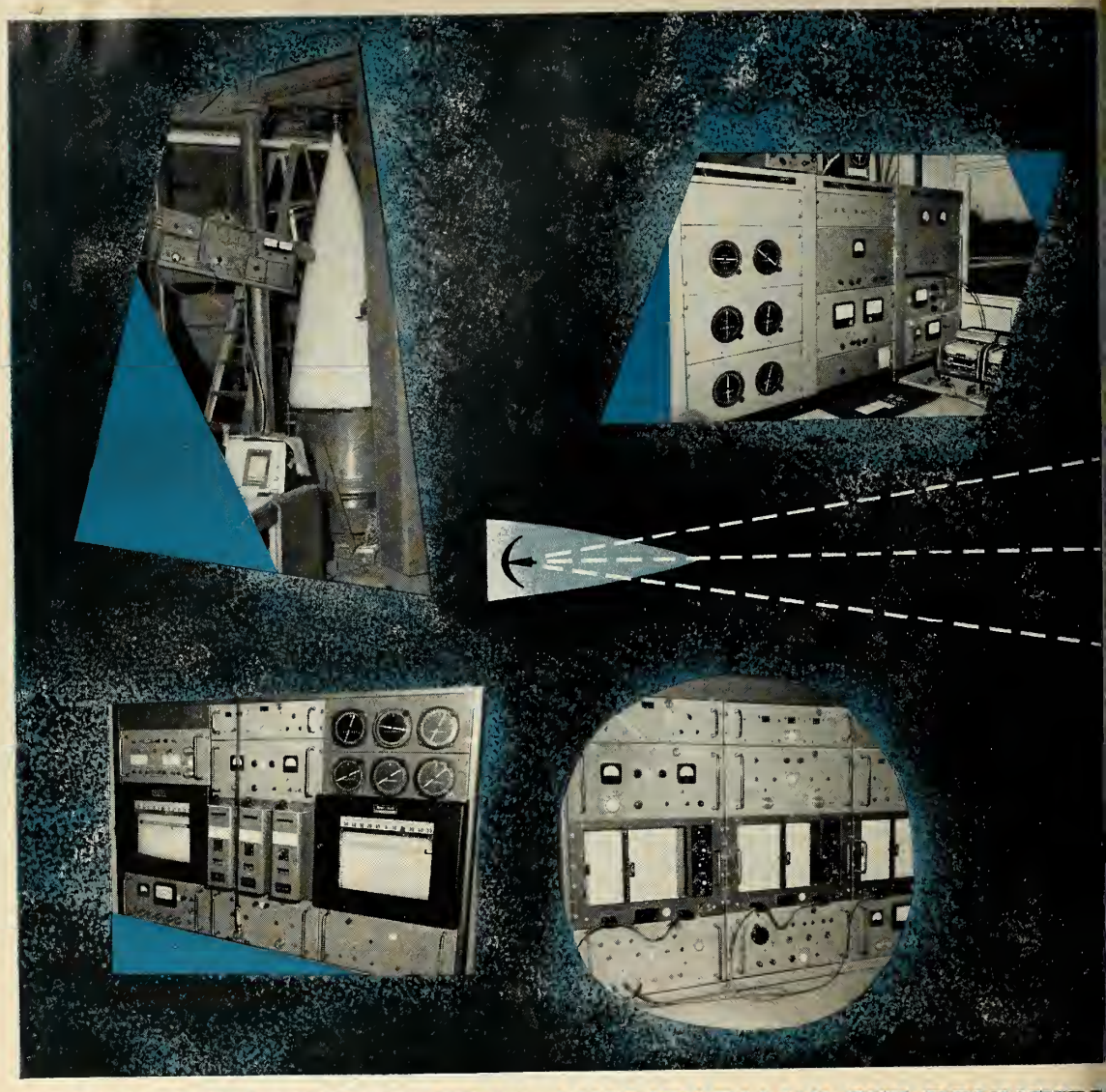

BORESIGHT ACCURACY TO 1/15 MILLIRADIAN? SEE BRUNSWIC

Brunswick-built radomes are setting new highs not only for strength-to-weight ratios, but accuracy as well. The reasons for the accuracy are simple: Brunswick has the test facilities and know-how that are without peer in the industry. Three radome ranges which automatically detect boresight error to an accuracy of 1/12 to 1/15 milliradian are now in full operation at Brunswick.

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with pressure vessels by Butterworth in the instrumentation and launching systems

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Pressure vessels by Butterworth meet the most rigid requirements for high and low temperature operation. Butterworth experience in the design and building of molds for Naval solid propellants is also available to prime contractors in the missile and rocket field.

Talk to a Butterworth engineer. Or write for "The Butterworth Story", a quick-tour of our complete metalworking facilities.

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The high-heat insulating material proved in actual production for 5 years

Now, provide positive protection and high-heat insulation for metal surfaces with FLAMEMASTIC. For five years, FLAMEMASTIC has been used exclusively on one of the major production missiles. Also applied extensively on allied test and launching equipment. Protects against high-velocity combustion heats, ranging from 3000°F upward. Gives positive protection for electronic equipment. Readily applied by conventional methods.

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Culver City, California

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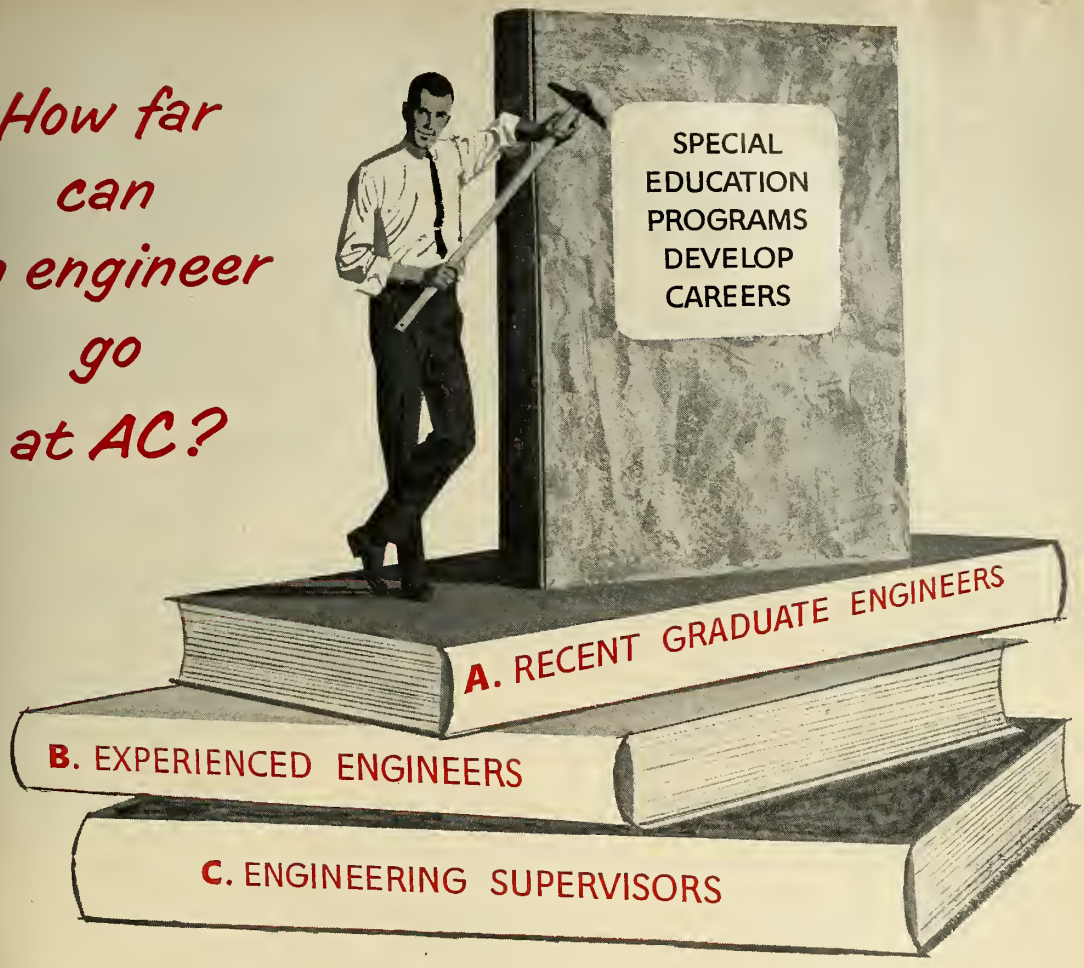

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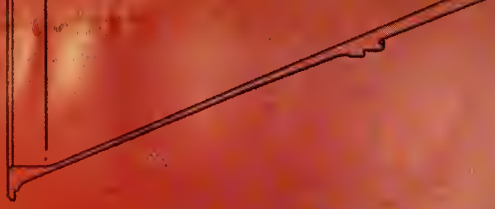
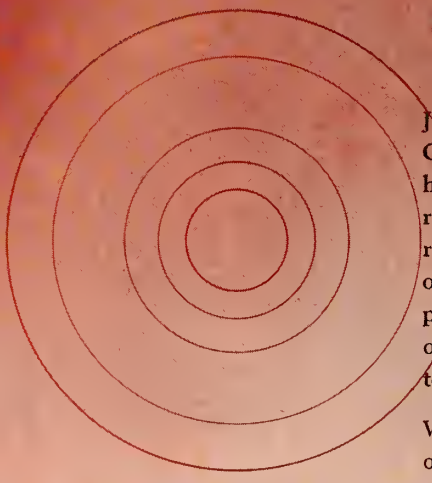


A NEW HIGH

IN METALLURGICAL PROPERTIES FROM EXOTIC METALS



JET ENGINE TURBINE DISC — MATERIAL: INCO 901

	T.S.	Y.S. .2%	E.L.	R.A.	S.R. 1200° F. 80,000 lb./sq. in.
	175,000	128,000	20	23	225 hrs.
Spec.	150,000	100,000	12	15	23 hrs.

Jet engine components made from Cameron forgings have hit a new high in forming and in metallurgical refinements, developing not only room temperature properties 20% over specifications but, more importantly, producing these same over-specification values at elevated temperatures.

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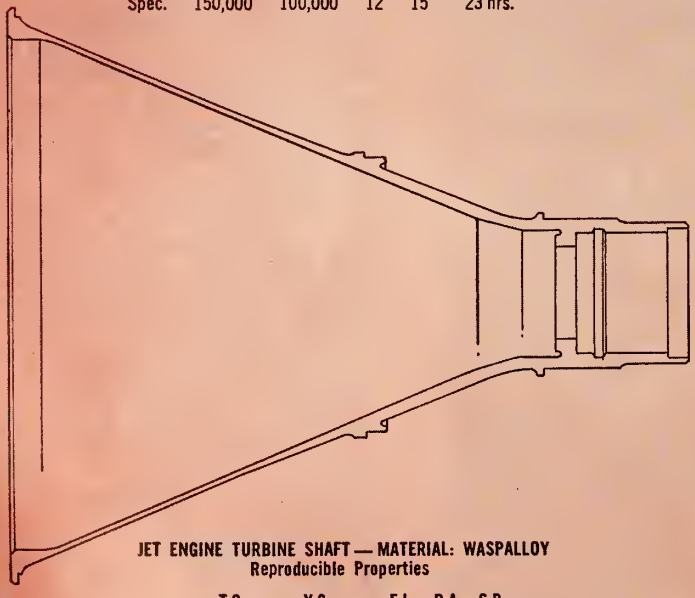
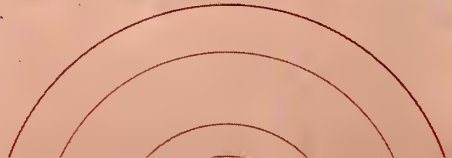


JET ENGINE TURBINE SHAFT — MATERIAL: WASPALLOY
Reproducible Properties

	T.S.	Y.S. .02%	E.L.	R.A.	S.R. 1350° F. 70,000 lb./sq. in.
	196,200	131,700	23	32	71 hrs.
Spec.	160,000	90,000	15	18	23 hrs.

All this, of course, gives our customers a better component functionally and economically. Check the accompanying comparison of the specification values and obtained values on the two jet turbine rotating components shown—let us show you what we can do with your problem forgings—just CALL, WRITE, or COME BY



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PRODUCT SUPPORT ENGINEERS

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Service Training Planners – Men with 2-5 years experience in the planning of industrial and/or armed services training programs are needed for the planning, preparation, editing and publishing of training material for the Air Force. This assignment will also include training standards, syllabuses, lesson plans and training projects.

TRAINER DESIGN – Trainer design engineers (electronic and mechanical) with degrees in ME, AE or EE are needed to design simulators to be used in the training of Air Force personnel on the Atlas weapon system.

FIELD SERVICE – Engineers, preferably with degrees in ME, AE or EE, and field or in-plant hardware experience are needed to act as technical representatives to the Air Force on the Atlas ICBM. Most assignments will be at Vandenberg AFB, Santa Maria, Calif. There will be other assignments as additional Atlas bases become operational. A limited number of San Diego openings also exist in the areas of Field Service Support. A field service bonus of $210.00 per month is authorized for field assignments in excess of six months. Per diem paid for assignments under six months.

TECHNICAL WRITING – Engineering degree preferred, plus 1-3 years of technical writing experience. Assignments include the writing of engineering reports, maintenance manuals and operation manuals.

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from Donald W. Douglas, Jr.

President, Douglas Aircraft Company

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For example, we now have pressing needs for mechanical, structural, electrical and electronics engineers in addition to aerodynamicists, physicists and mathematicians. Whatever your background in the engineering profession may be, there are prime opportunities in the stimulating aircraft and missiles field.

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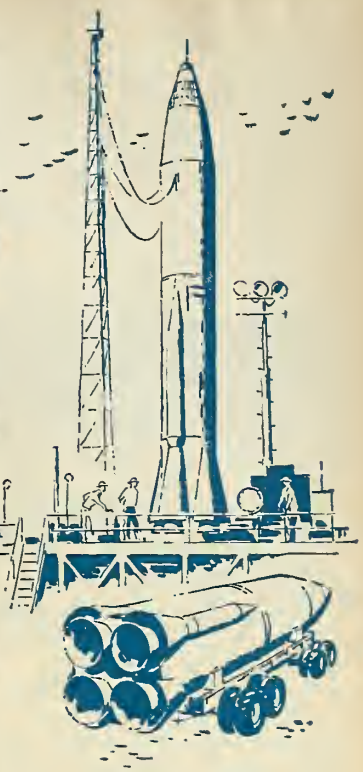
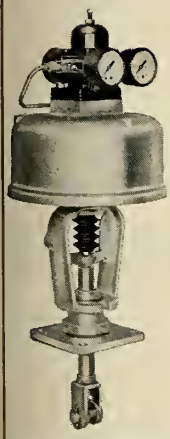
Your choice OF ADVANCED DESIGNS WITH MORE PRECISE POSITIONING AND DYNAMIC RESPONSE CHARACTERISTICS





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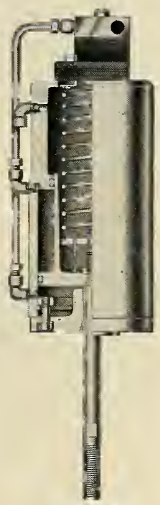
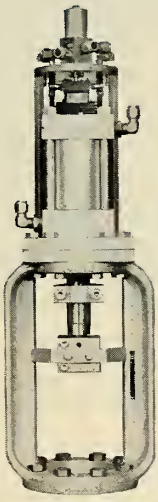


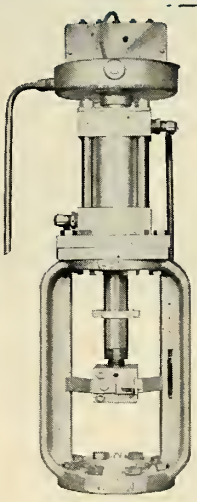
600 SERIES STROKE POSITIONING ACTUATORS

Offered primarily for the control of variable speed drives, rheostats, pumps and cams, as well as control valves, with strokes up to 6 inches and forces up to 2510 pounds of thrust. Compact and rugged, for easy mounting on existing equipment. May be operated from a standard 3-15 psi instrument signal, with a positional accuracy within 0.001" per inch of stroke.



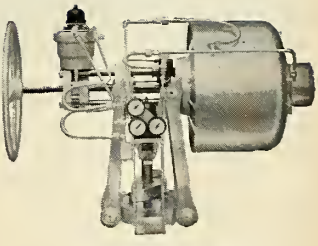
10,000 SERIES PNEUMATIC-HYDRAULIC ACTUATORS

For valves requiring strokes to 6 inches and thrusts to 100,000 lbs. Furnished on body assemblies where process conditions require very fine valve response, hi-speed and stability. Operate on 1500 psi oil supply system from any common instrument air signal.



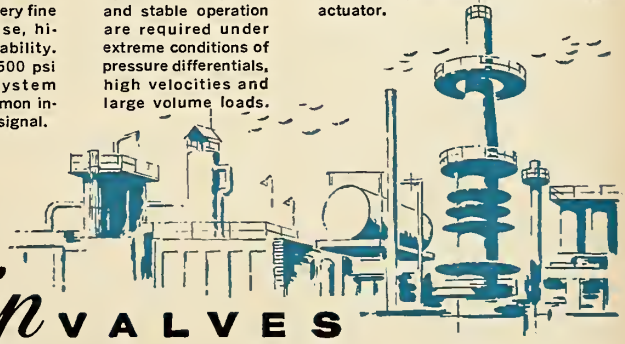
20,000 SERIES ELECTRO-HYDRAULIC ACTUATORS

Provide a means of converting an electrical signal to a powerful hydraulic positioning force, where high speed of response and stable operation are required under extreme conditions of pressure differentials, high velocities and large volume loads.



TOGGLE ACTUATORS

For process requirements where the unbalanced forces are extremely high, or where large through-puts are required. Three types are offered: pneumatic positioning, pneumatic on-off, and manual control, all embodying the toggle actuator; or a manual control arrangement can be combined with the pneumatic positioning or on-off toggle actuator.



Annin VALVES

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THE ANNIN COMPANY
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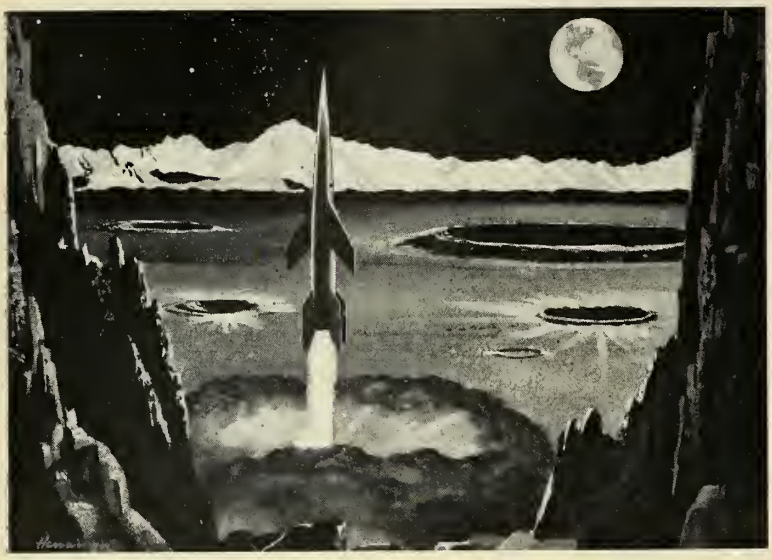
COUNT DOWN

for the conquest of space



"MISSION ACCOMPLISHED: DEPARTING LUNA 2205 ZEBRA"

This message, flashed across a quarter-million miles to Washington, D.C., will be awaited anxiously by millions.

But even then our first expedition to the moon will still face its most crucial test—the journey home to earth.

The success of that trip will depend in large part on rocket propellants—fuels and oxidizers that will have been stored for days in the tanks of the expeditionary vehicle and yet will respond instantly when needed.

Storable liquid propellants is one of the fields in which Rocketdyne has anticipated the future. For more than ten years, its propellant chemists have been studying, engineering, and testing combinations of storable fuels and oxidizers for greater storability and higher energy.

Storability PLUS high energy

Rocketdyne has tested these combinations in all production and experimental engines. The results prove that today's storable fuels and oxidizers have these important capabilities:

(1) High performance, even after months or years of storage; (2) Stability over a wide temperature range, permitting storage in missile tanks without rigid environmental controls; (3) Dependable performance, predictable even at extremes of heat and cold; (4) Instant readiness for firing at any time during the storage period; (5) Energy yields equal to or higher than those of conventional propellant combinations.

Second-generation missiles

The tests also prove that engines developed for conventional propellants can be converted to storable combinations rapidly and inexpensively—a significant consideration in the development of second and third generation strategic, tactical, and air defense missiles.

Significant, too, is the *potential* performance of storable combinations. Research points to energy yields as high as 400 seconds of altitude specific impulse—performance 20 percent higher than that of today's combinations. These high-energy yields will offer new capabilities and greater flexibility for America's scientific and military programs.

Stepping stones to Space

Rocketdyne has designed and built much of today's operating hardware in the high-thrust rocket field. Engines by Rocketdyne power most of the military and scientific projects sponsored by Air Force, Army, and NASA. This experience now becomes the point-of-departure for tomorrow's journeys into the unknown.

POWER FOR AMERICA'S MISSILES

Thrust chamber production line for Thor and Jupiter at Rocketdyne's Neosho, Mo., facility moves smoothly.

FIRST WITH POWER FOR OUTER SPACE

ROCKETDYNE

A DIVISION OF NORTH AMERICAN AVIATION, INC.

Washington Countdown

IN THE PENTAGON

Which military service will run . . .

the new satellite detection fence is up for decision at the Pentagon's top levels. The command could encompass all U.S. military tracking facilities around the world. All three services want the job.

• • •

Recent Soviet 'Zooniks' . . .

may have soared some 1000 miles into space before returning to earth. The Russians aren't saying, but this is the educated guess of a number of U.S. experts. The flights obviously are aimed at collecting data on survival in space.

• • •

Pentagon sources complain . . .

that the GAO—Congress' fiscal watchdog—is stepping out of bounds in checking up on military expenditures. They say GAO is not only checking up on fiscal matters but also making judgments on the reliability of weapons.

• • •

No extensive delays . . .

in the *Discoverer* satellite schedule are now expected to result from recent failures. ARPA and the Air Force had planned to launch *Discoverer V* about the end of July. The shot is expected to be a full equipment checkout. No wildlife.

• • •

Behind the scenes an AF fight . . .

is shaping up over handling of weapon systems development. The trend appears to be moving toward greater centralization. A top-level AF committee is studying the question.

ON CAPITOL HILL

The House-cut NASA budget . . .

probably will stay cut—at least in part. But NASA appears to have little to worry about. Whatever dollars are lost in the first round are fairly certain to be regained by slipping them into a FY '60 supplemental appropriations bill later on.

The Hébert Subcommittee investigation . . .

into hiring of ex-military officers by defense contractors is scheduled to get down to specifics in its new round of hearings. Among other things, the subcommittee wants definitions of such activities as "selling," "promoting," and "negotiating."

At NASA

Would an astronaut die . . .

if the **Convair** *Atlas* designed to boost him into space exploded on the launching pad and the *Mercury* escape system failed to blast him free? NASA experts say no. The heat-resistant escape capsule would save him anyway.

• • •

But, incidentally, the strain . . .

of the ride to safety in an escape capsule is nothing to look forward to. If the *Mercury* capsule is blasted free from ground level, the astronaut will have to sustain as much as 20 g's for about one second.

• • •

Testing of Big Joe . . .

the boiler plated capsule mounted on top of an *Atlas*, will begin in late summer. The shots, which will test the capsule's heat shield on re-entry, have been delayed because of the recent defects discovered in the *Atlas* vehicle.

• • •

Chrysler's *Jupiter* may be put back . . .

in the *Mercury* program for budgetary reasons. NASA would like to use *Atlases* for the early *Mercury* tests. But cheaper *Jupiters* may have to be used because of congressional cuts in NASA's budget.

AROUND TOWN

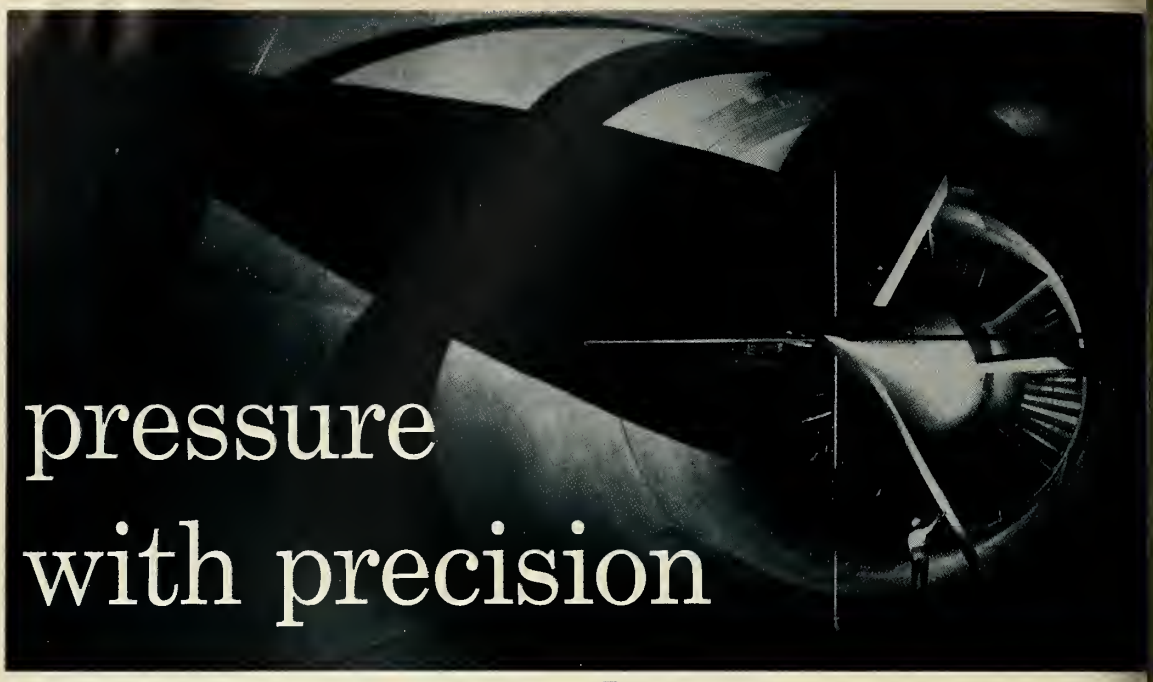
Some of the reports . . .

that are being passed as the "latest" in the nation's capital:

. . . The French will explode their first A-bomb in a matter of months and begin developing nuclear warheads for missiles.

. . . Officials are worrying about a new Red power play in troubled Latin America's Possible Soviet goal: missile bases at America's back door.

. . . Top civilian scientists fear they see a trend back toward starving civilian federal research programs in favor of military research.



pressure with precision

When critical pressures must be delivered or measured, Consolidated Systems are on the job, surpassing design specifications. Digital pressure measurement for windtunnels, automatic calibration of pressure transducers, missile propellant systems checkout with accuracies of one part in 2,000... these are being accomplished day-in and day-out, with precise pressures delivered at the turn of a dial. This type of performance is available for your application. Write for the complete story in Bulletin 3018-X5.

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Pressure transducer calibration system controls and measures pressures from 25 pickups in ranges from 1.5 to 500 psi. Linearity, hysteresis, zero, and sensitivity characteristics are determined at a specified temperature in 2½ minutes.

Propellant Utilization System Exerciser checks missile system performance by generating precise pressures for fuel and oxidizer channels at preselected points. Twenty-one similar systems are now in use at missile test sites.

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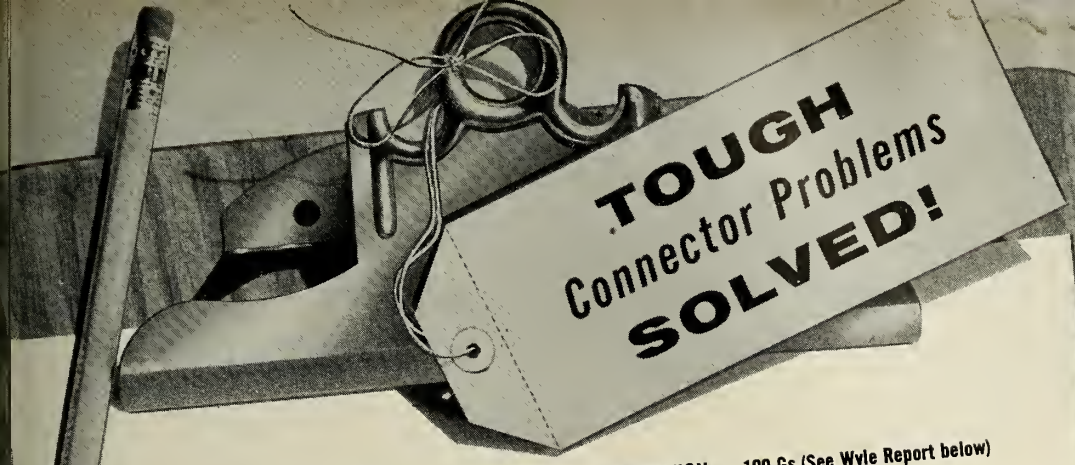

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- ✔ 1000 CONNECTIONS
- ✔ PRODUCIBLE in large or small quantities
- ✔ LOW PRESSURES for insertion and extraction
- ✔ HUMIDITY . . . 0% to 100%
- ✔ ATMOSPHERE . . . air, water, salt water, jet fuel, exhaust gases, oil, hydraulic fluid
- ✔ PRESSURE . . . 0 to 30 p.s.i.a.
- ✔ OPERABLE by mechanical manipulator
- * TEMPERATURE . . . —65°F to 1000°F
- ✔ VIBRATION . . . 100 Gs (See Wyle Report below)
- ✔ POSITIVE LOCK-UP and trip-free disconnect
- * RADIATION LEVEL . . . 1,000,000 Roentgens per hr.
- ✔ EXPLOSION PROOF
- ✔ DEAD FRONT
- ✔ SEQUENCE SWITCHING
- ✔ LIGHT WEIGHT
- ✔ HERMETICALLY SEALED
- ✔ TROUBLE FREE
- ✔ LOW TOOLING COST
- ✔ HIGH VOLTAGE

*Under development

Many tough electrical connector problems have been submitted to Cole Electric Co. in recent months. Because of the ability of revolutionary new Cole self-aligning ball-and-socket connector pins to operate under extreme conditions, all of these problems have been or are being solved. Special Cole Connectors with up to 1000 contacts have been developed to meet difficult environmental and operational requirements for aircraft, missiles, ground support, computers, nuclear, electronic and electrical equipment.

Whatever your connector problem might be, a special Cole Self-Aligning Connector may provide the practical solution. Virtually any size or configuration with any number of contacts can be made. Four pin capacities: 15, 30, 75 and 300 amp. Highly specialized fittings in stainless, phenolics, fiber glass, nylon, ceramic or other materials.

Our complete research and development facilities are at your disposal. Write or phone today.

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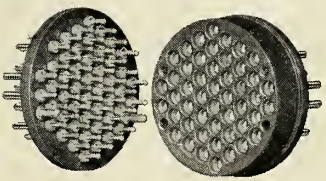


Tested to 100 Gs

In recent tests conducted by Wyle Laboratories of El Segundo, Calif., Model B-3106 Cole Connectors were subjected to vibration scan from 5 to 2000 cps. Each connector contained 15 contacts, wired in series. At vibrations up to 100 Gs amplitude there was no evidence of contact opening. Noise levels were exceedingly low. Full test report available on request.

Ability of energy to do work?

A mathematical convenience?

Gibbs' Free Energy?

What does it mean in isothermal electrochemistry?

The concept of energy availability in all its ramifications is becoming ever more important to Allison's energy conversion mission.

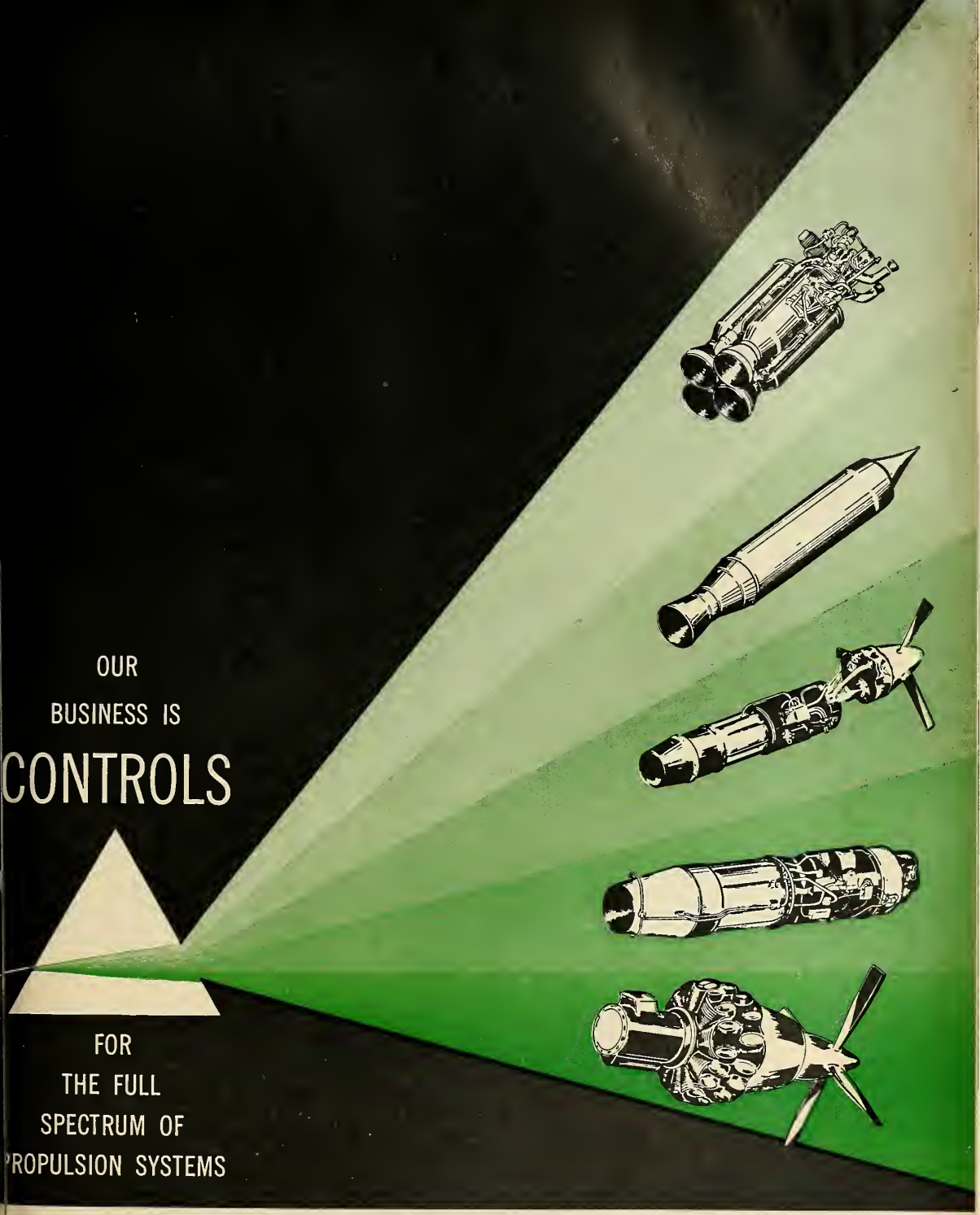
Current projects involving this concept include electrochemical conversion systems (for satellites, space systems, and perhaps even your future automobile), heat regenerator systems and photolysis regenerators.

In our inquiries we rely not only on our own resources but also on the talents of General Motors Corporation, its Divisions, and other organizations and individuals. By applying this systems engineering concept to new research projects we increase the effectiveness with which we accomplish our mission—exploring the needs of advanced propulsion and weapons systems.

Energy conversion is our business

ALLISON

Division of General Motors, Indianapolis, Indiana



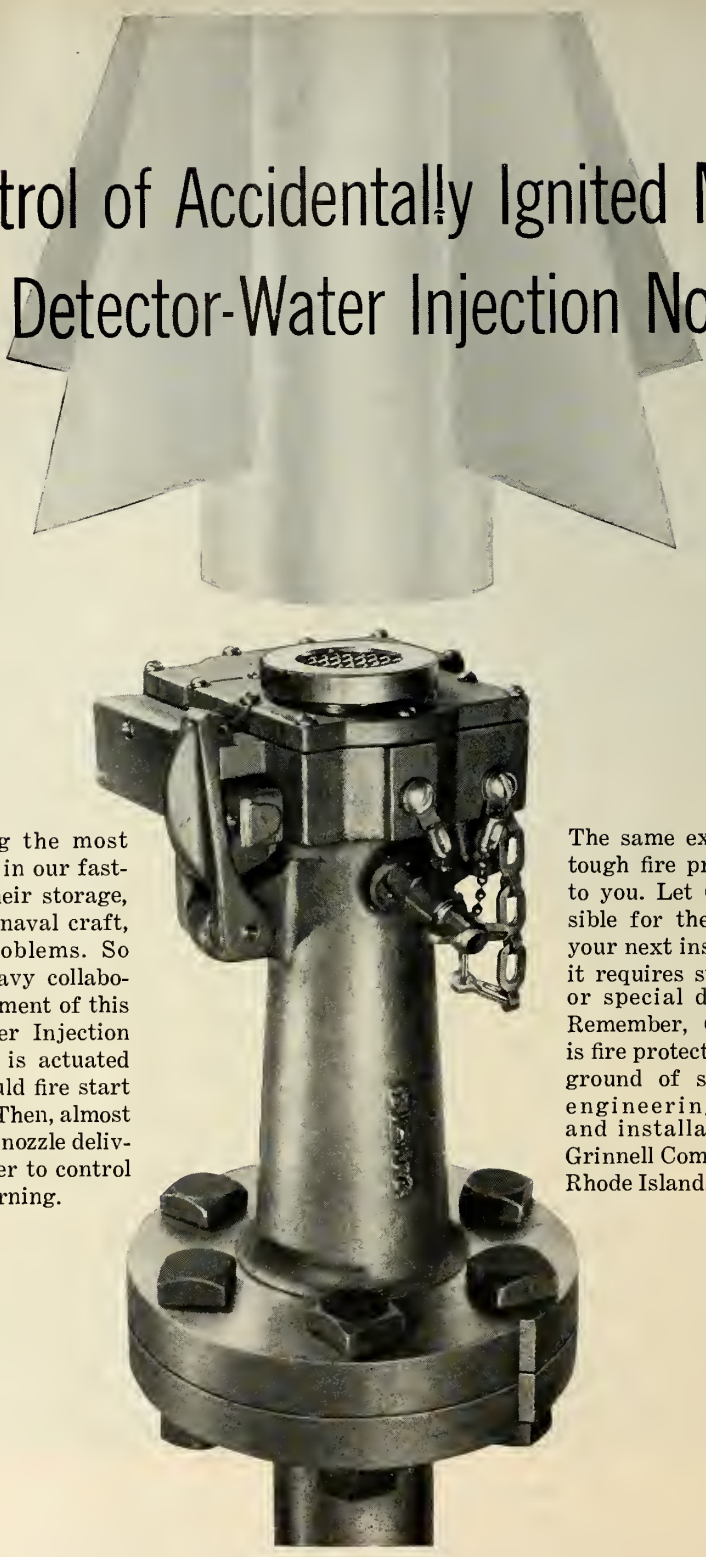
Bendix * has long been a leader in supplying controls and fuel systems for all types of aircraft engines. Today, Bendix is proving to be a natural for new challenges in related missile fields—on ram jets, rockets, nuclear power, and other advanced propulsion systems. So, when it comes to controls, remember that Bendix has the background—and is anxious to share it in solving your problems. *REG. U.S. PAT. OFF.

BENDIX PRODUCTS DIVISION **SOUTH BEND, IND.**

Bendix AVIATION CORPORATION

Circle No. 19 on Subscriber Service Card.

For Control of Accidentally Ignited Missiles ... Fire Detector-Water Injection Nozzle



Missiles are among the most destructive weapons in our fast-growing arsenal. Their storage, particularly aboard naval craft, creates critical problems. So Grinnell and the Navy collaborated on the development of this Fire Detector - Water Injection Nozzle. This device is actuated by shock waves should fire start in a missile booster. Then, almost instantaneously, the nozzle delivers a stream of water to control or extinguish the burning.

The same experience in solving tough fire problems is available to you. Let Grinnell be responsible for the fire protection on your next installation—whether it requires standard equipment, or special development work. Remember, Grinnell's specialty is fire protection . . . with a background of successful research, engineering, manufacturing and installation for 89 years. Grinnell Company, Providence 1, Rhode Island.

GRINNELL

Research, Engineering, Manufacturing and Installation of Fire Protection Systems since 1870

When man first steps into the vehicle that will carry him into outer space, it will be with complete confidence.

He knows that he can rely on the extensive testing and preparations that have gone before. Flexonics has played a vital part in these preparations—engineering, designing, and manufacturing metal and synthetic components and systems for hydraulic, pneumatic, liquid oxygen, and fuel applications on America's best-proved missiles and aircraft.

You can draw on this unequalled experience, too, by contacting your Flexonics sales engineer.

Thin wall ducting • Flexible hose: metal, synthetic, Flexon-T (Teflon) • Gimbal, pin, and link joints
Metal bellows and expansion joints • Special-formed stainless steel parts

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Industry Countdown

STRUCTURES

Satellite rendezvous . . .

system is being researched by **Norair Division** of **Northrop Corp.** Concept is to permit maneuverable manned satellite to couple in space with life support satellite in permanent orbit. Hook-on would be effected through target satellite controlled approach (TSCA)—space version of aircraft ground controlled approach, or through maneuverable satellite landing system. MSLS would utilize search-and-track radar beacon aboard target satellite with pilot performing terminal phase guidance and coupling through visual observation.

• • •

'Super' *Hawk* . . .

is under research and development by the Army. On the operational **Raytheon**-built *Hawk* low-flying anti-aircraft missile, the Army is planning to spend an additional $127 million in FY 1960. Plans call for 15 *Hawk* battalions—13 operational in mid-1961.

• • •

Reports are current in France . . .

that De Gaulle hopes to get help from **Boeing** in producing a solid-fuel IRBM of his own. Advisors have told him that the cost, plus production of an atomic warhead would be a prohibitive 18 billion francs (about $3½ billion) or more. The French almost-ready atomic bomb is presently uncomfortably large for an aircraft, let alone a missile warhead.

• • •

Government recognition . . .

of the missile industry won't be possible for at least two years. It takes that long to make the change in the Standard Industrial Classification of the Census Bureau. Argument is under way now whether missiles should be classed as ammo/ordnance, lumped together with aircraft or treated separately in the 1958 census of manufacturers listing dollar value of contracts. This will be published in 1960.

• • •

Total of $384 million . . .

so far has been awarded **The Martin Co. Denver Division** for design, fabrication and test of *Titan* ICBM. Recently, ARPA chose modified first stage of *Titan* as second stage of 200-foot, 1.3 million pound thrust *Saturn* space vehicle.

• • •

Timetable for missile cruiser . . .

Long Beach to be ready for action is early 1961. The *Talos*- and advanced *Terrier*-carrying nuclear-powered warship was launched at the **Bethlehem Steel Co.** shipyard in Quincy, Mass., on July 14. Outfitting will take until late next year.

PROPULSION

Dynasoar propulsion . . .

systems proposals are being reviewed by Source Selection Board composed of AMC, ARDC and SAC officials. **Boeing** concept would use *Atlas* or *Titan* to blast off the boost-glide space vehicle, while **Martin-Bell** proposes using *Titan* only.

• • •

Saturn at lift-off . . .

will weigh about 580 tons—500 of it fuel. Booster for the 1.3 million pound thrust vehicle is cluster of eight H-1 **Rocketdyne** engines.

• • •

In pop-up tests . . .

of full-scale mockup *Polaris* at San Clemente Island, Calif., **Lockheed** is using 186-foot barge-mounted crane to catch the instrumented missile in the air. Operation is called "fish-hook."

ELECTRONICS

Western Electric has won . . .

the $25 million-plus NASA contract to construct the Project *Mercury* world-wide tracking range. On the **Western Electric** team are **Bell Telephone Laboratories, International Business Machines, Bendix Aviation Corp.** and **Burns and Roe, Inc.** Formal contract negotiations will begin this week.

• • •

Improved Azusa Mark II . . .

tracking system is being readied by **Convair Astronautics** for installation soon at Cape Canaveral under $1.7 million contract. Azusa circuits presently are aboard *Thor, Jupiter, Polaris, Atlas* and *Titan*. Mark II, which employs continuous microwave signal showing velocity and position, will be installed in second generation missiles and space vehicles.

ASTROPHYSICS

The Czechs are setting up . . .

an astronautics commission in the country's Academy of Sciences. But reports from the Iron Curtain country say the commission will not participate in any satellite or rocket launchings. Activity will be confined to optical, photographic and radio observation of cosmic activity.

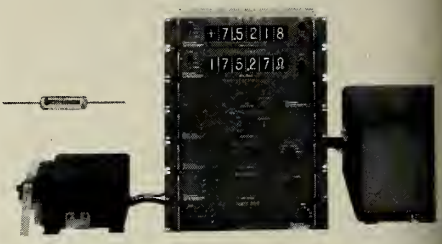
• • •

"Moon garden" of snap beans . . .

carrots and turnips is being grown in pressurized vessels by **Republic Aviation** researchers. Project is aimed at determining the feasibility of growing crops to support a lunar base. Results so far indicate that little germination results in seeds planted in simulated altitude of 46,000 feet.

Low cost, versatile DIGITAL SYSTEMS

for automatic testing of transistors resistors diodes and capacitors



Small E-I automatic digital systems provide many advantages. First, they cost less. This is primarily the result of large-quantity manufacture of modules which make up the E-I system. Cost is almost a linear function of performance capabilities desired in the system.

Second, they are exceptionally versatile. The E-I system can be expanded simply by adding appropriate modules. Typical systems presently in use measure resistance, capacitance, DC and AC voltages, DC/DC ratios, AC/DC ratios, AC/AC ratios and combinations of these. Measurements to four or five digits can be visually displayed and printed out at rates up to five readings per second. Operation can be semi- or totally automatic with go/no go comparison of values and programmed readout at periodic intervals. Scanners can be provided for scanning thousands of single and multi-wire input channels. In brief, the E-I system has an extensive scope of operating capability.

Third, E-I systems provide unmatched reliability. Where practicable, circuits are totally transistorized. The use of etched, plug-in circuit boards, and modular internal construction make maintenance checks and in-plant repairs easy.

Typical E-I system for evaluating components—includes 100 channel input signal scanner. Can digitize DC voltage, resistance, AC voltage and DC/DC voltage ratio analogs. Digital equivalents are recorded on strip printer for "quick look" data and on punch paper tape for additional data reduction by digital computer.

Lower cost, maximum versatility and greater reliability—if you want these advantages in your component test system, contact your nearest E-I representative. He can give you complete information or answer any specific questions you may have.

Electro Instruments, Inc.

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he 28" diameter Scoife missile motor cose shown bove wos laborotory-tested to 230,000 p.s.i. minimum ield without permonent deformotion. Here is another riking example of how Scaife's missile metol ports know-how", combined with the most modern monu-acturing techniques—such as the fomed Reverse-Drow rocess—have advanced missile frontiers over the past decode. Todoy, os higher specific impulse propellants goin wider use, Scoife's progress in developing the right "hordwore" becomes even more important to your R & D ond Production progroms. For full information on what Scoife is doing right now to ochieve even higher yields, and how this importont break-through con benefit you, telephone EMerson 2-2100, or write today.

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RODUCER OF THE GREATEST NUMBER OF HIGH PERFORMANCE* MISSILE MOTOR CASES IN AMERICA

PMR Outlines Plans To Spend $30 Million

by Robert Mount
Special M/R Correspondent

OXNARD, CALIF.—Pacific Missile Range development of downrange and coastal facilities moves into high gear this fiscal year with $30 million in expenditures authorized.

Island facilities at Eniwetok, Wake, Kaneohe Bay, Midway and Kwajalein are under way, and some modification of the tracking station at Ka Lae, South Point, Hawaii, may also be in the cards.

In addition, PMR will develop new instrumentation facilities at Point Montara, near San Francisco; Granite Canyon, on the Monterey Peninsula; Piedras Blancas, west of Paso Robles; Point Pillar, south of Point Montara; and at Laguna Peak, next to Pacific Missile Range Headquarters, Point Mugu.

Expenditures at PMR headquarters itself this year will total about $18 million, with nearly $10 million more earmarked for Point Arguello development. Launching pads for the Air Force project, WS-117L (Project *Sentry*) are under construction at a contract cost of over $5 million at Point Arguello. *Sentry* is the advanced reconnaissance satellite, still listed in Air Force releases under that name. It will utilize **Convair's** *Atlas* for a booster and a **Lockheed**-developed satellite stage.

• **For the islands**—Island development planned this year includes:

• Eniwetok—Communications data link with Wake Island, to handle missile impaction location data, $317,000. SOFAR MILS (Sound Frequency and Ranging/Missile Impact Location System) installation, $435,000. Sounding rocket facility to obtain high-altitude meteorology data, $22,000. Such data are essential for operations involving nose cone re-entry and missile impact data collection.

• Wake Island—Expansion of Federal Aviation Agency transmitter building, $93,000, needed because ICBM target area is near Wake Island and impact data must be transmitted. Wake is one of several PMR stations in what eventually will become Naval Missile Facility Western Pacific. Another $190,000 will be spent here for civilian bachelor quarters this year.

• Midway—SOFAR MILS installation, $435,000.

• Kaneohe Bay—SOFAR MILS installation, $486,000. PMR Hawaiian Islands communications center located at this Marine Corps Air Station will cost another $123,000.

• Ka Lee, South Point, Hawaii—Although no money is explicitly earmarked for this site, recently acquired from the Air Force in a transfer, it has been reported that this deep space tracking station may be modified to increase its ICBM tracking capabilities.

• **On the coast**—Instrumentation along the West Coast budgeted for this year includes:

Instrumentation stations with portable communications and tracking equipment at Point Montara, Granite Canyon and Piedras Blancas, to cost a total of $423,000.

At Point Pillar, the Navy will construct permanent instrumentation facilities costing $545,000, and $63,000 more in photographic and calibration instrumentation for air-to-air and air-to-surface missiles.

A new remote monitoring building atop Laguna Peak, near PMR headquarters at Point Mugu, will extend monitoring coverage to the Los Angeles Basin, presumably to refine current capabilities for frequency screening and interference control.

At Point Mugu, the following major construction is planned:

Roads, $3 million; missile project building, $2.9 million; armament test project building, $2.4 million, which may herald transfer of some armament system studies from Patuxent River, Md., to Mugu; PMR headquarters building, $1.8 million, to house about 600 administrative and operations personnel by 1961; parking facilities and flight aprons, $1.1 million; instrumentation facilities $750,000; frequency control facilities $580,000.

At Point Arguello, planned inter-service and inter-agency launch site for PMR, the following are approved:

Roads and facilities, $5 million; security facilities, $955,000; central launch control building and missile assembly building, each costing $873,000; multipurpose Marine detachment quarters $410,000; range users' engineering building, $400,000; second unit of radio receiver station, $238,000; operational computer center, $233,000; ordnance assembly building, $200,000; public works shop, $150,000; launch site support, $65,000.

Beryllium Heat Sink Is Forged for *Mercury*

CLEVELAND—An 80-inch saucer-shaped beryllium disc has been forged for heat-sink service in the Project *Mercury* space capsule.

A 50,000-ton press at the **Alcoa** plant here squeezed a steel-jacketed beryllium billet into the shape desired at a temperature of 2000° F. **Brush Beryllium Co.** hot-pressed the 62-inch billet by a patented process involving simultaneous application of vacuum, heat and pressure.

After preliminary machining by Brush, Alcoa heated the billet in a special furnace. Then a huge manipulator placed it on a pre-heated die and pressed it to 3 inches thick. The forged part goes back to Brush for precision finish machining, after which Alcoa will perform ultrasonic inspection.

The shield will form part of the outside covering of the capsule, for which **McDonnell Aircraft Corp.** is prime contractor. The shield will be the leading face of the chamber on the return to earth. The piece is one of a series of beryllium forgings Brush and Alcoa will produce for *Mercury*. Beryllium was chosen because it is only a fifth the weight of steel and is an excellent heat absorber.

Only MARMAN makes all four!

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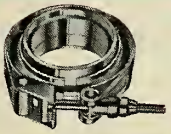

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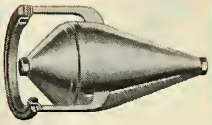

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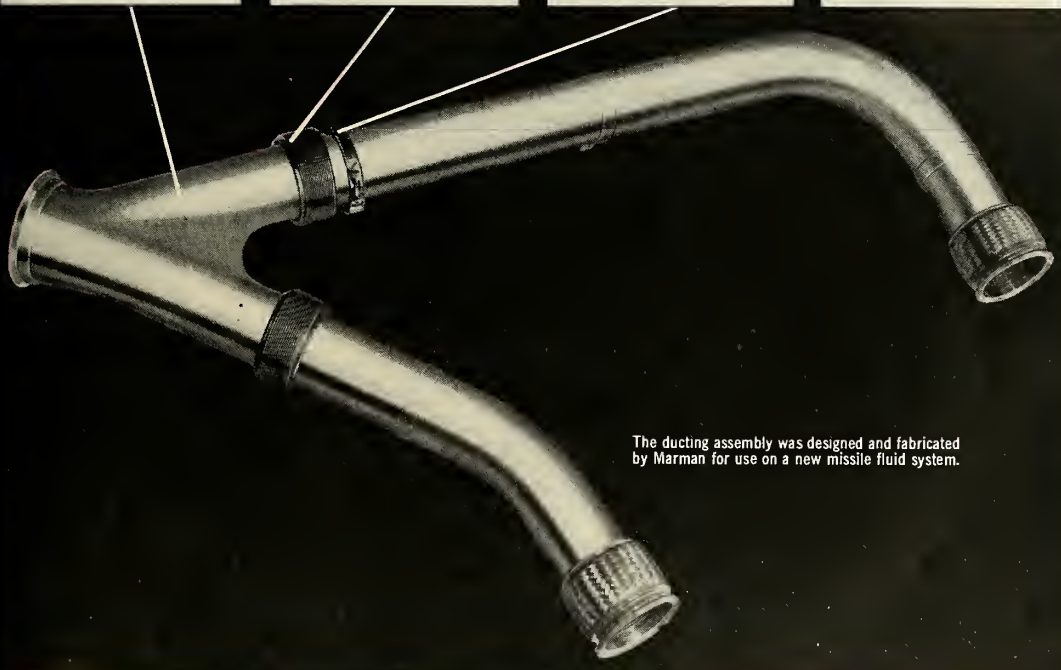

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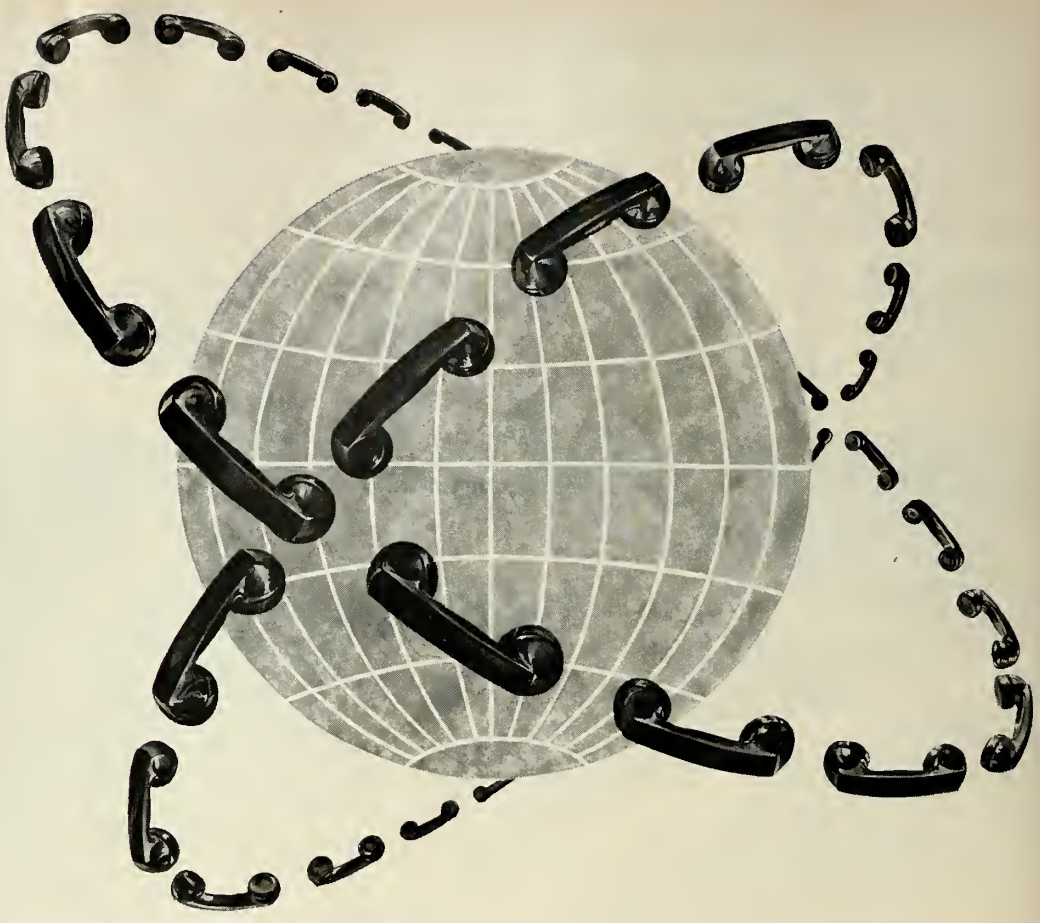

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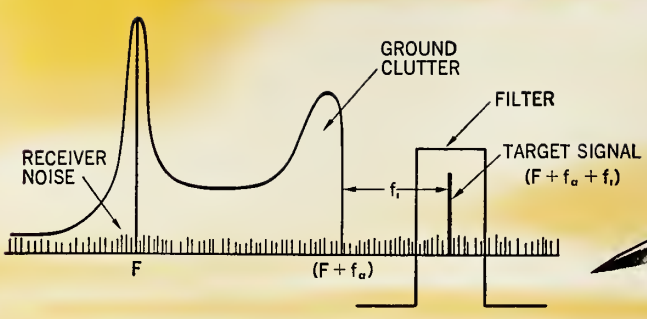

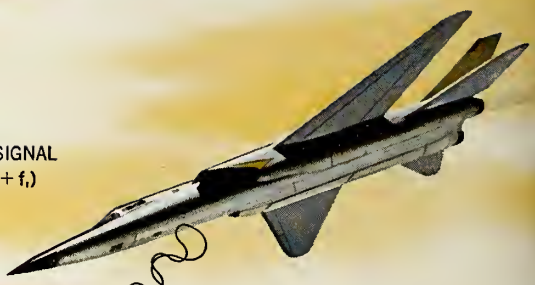

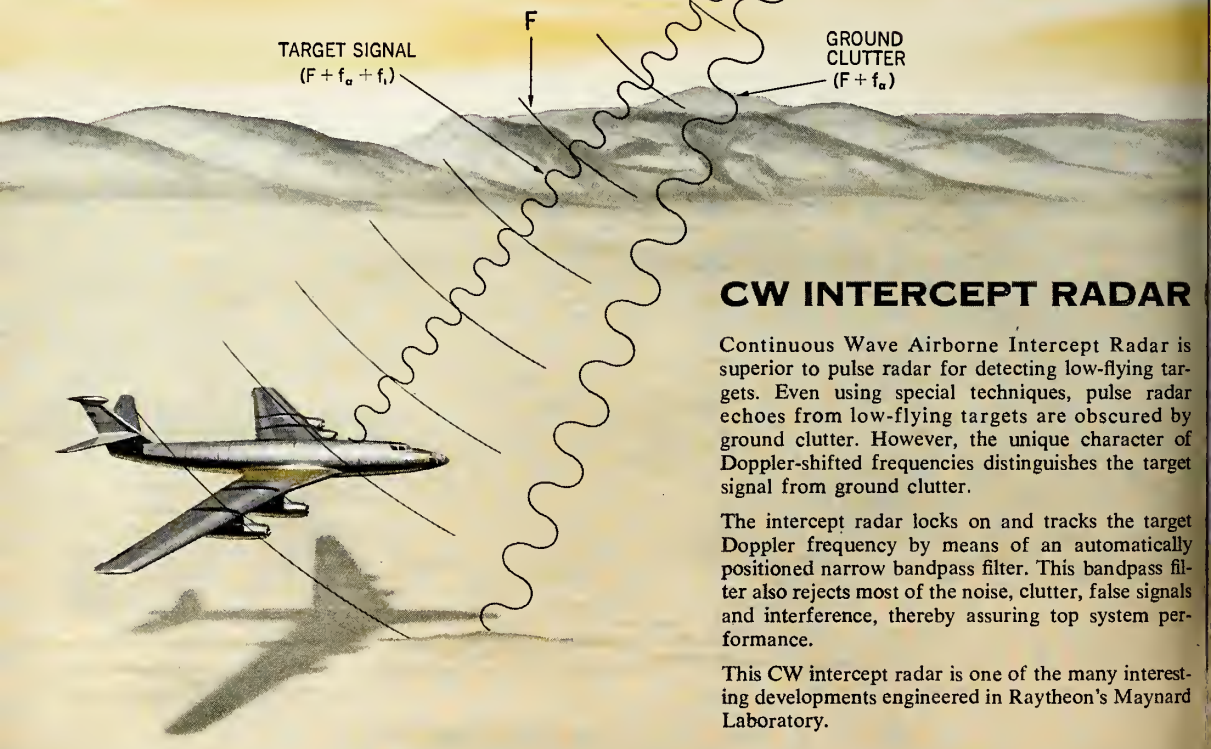

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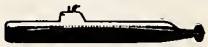


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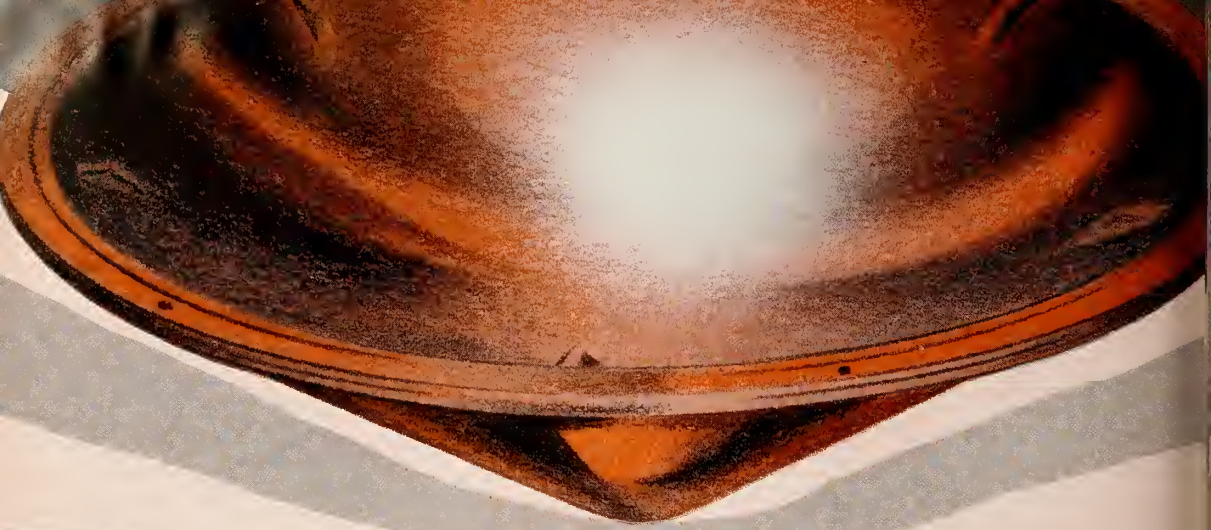

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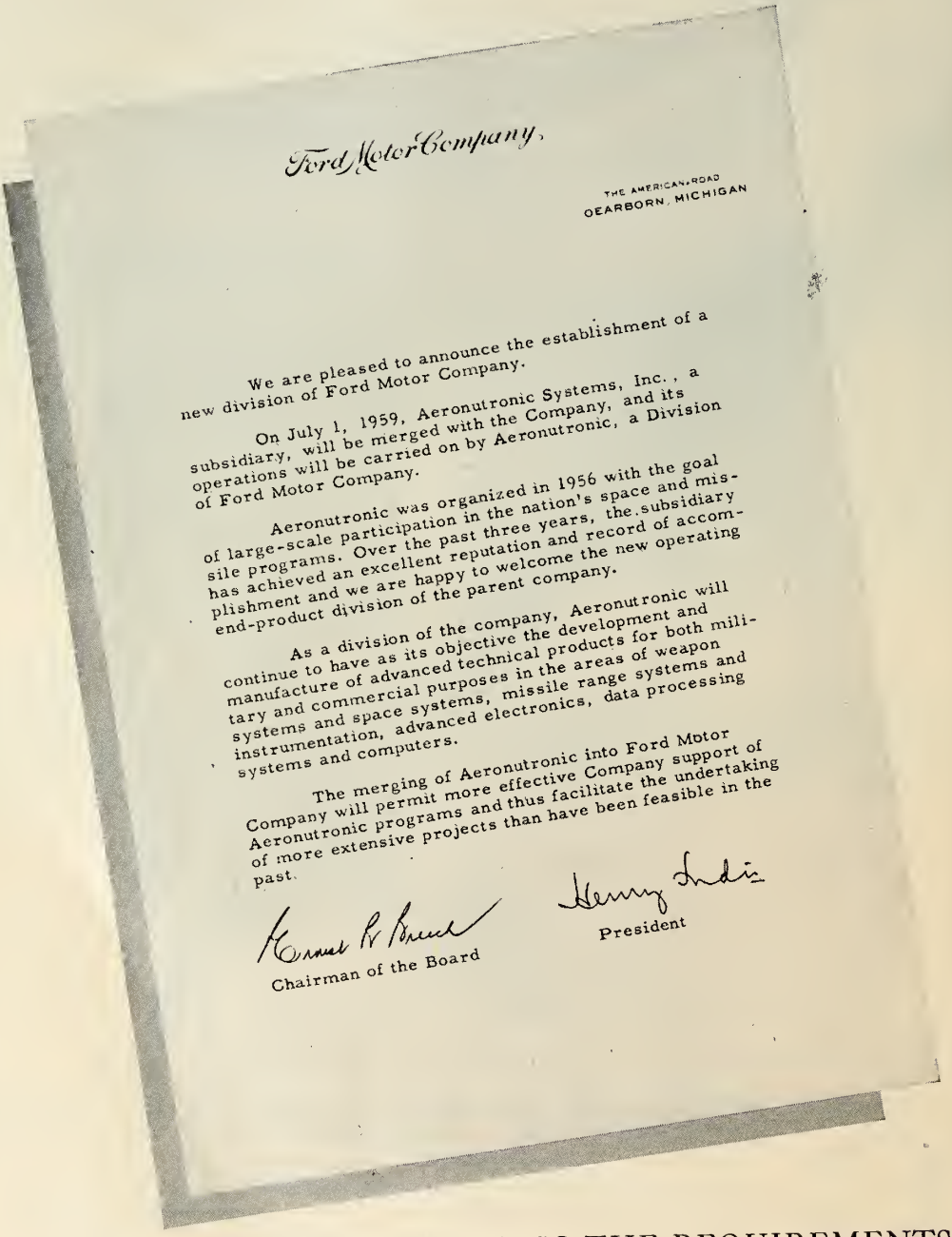

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On July 1, 1959, Aeronutronic Systems, Inc., a subsidiary, will be merged with the Company, and its operations will be carried on by Aeronutronic, a Division of Ford Motor Company.

Aeronutronic was organized in 1956 with the goal of large-scale participation in the nation's space and missile programs. Over the past three years, the subsidiary has achieved an excellent reputation and record of accomplishment and we are happy to welcome the new operating end-product division of the parent company.

As a division of the company, Aeronutronic will continue to have as its objective the development and manufacture of advanced technical products for both military and commercial purposes in the areas of weapon systems and space systems, missile range systems and instrumentation, advanced electronics, data processing systems and computers.

The merging of Aeronutronic into Ford Motor Company will permit more effective Company support of Aeronutronic programs and thus facilitate the undertaking of more extensive projects than have been feasible in the past.

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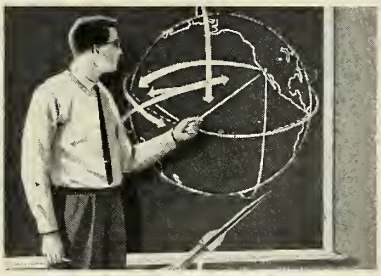

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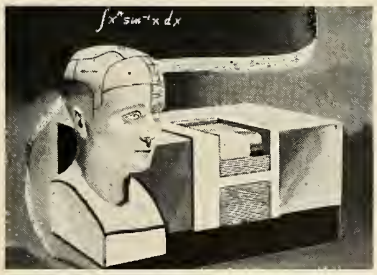

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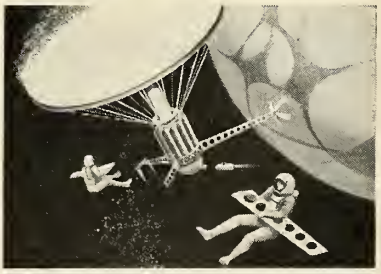

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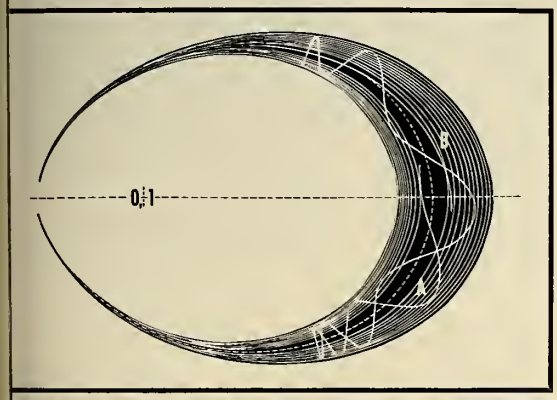
Van Allen Discovery Most Important

U.S. has obtained more fundamental scientific information from its satellites than the USSR from its instruments in heavier payloads



RBITS OF trapped particles, from the paper published by oermer in 1913: Orbit A shows a particle injected into the diation belt at a large angle to direction of the local magtic field; Orbit B, particle injected at small angle. (Fig. 1)

INNER AND outer radiation belts in space. Outer belt penetrates into the atmosphere at the latitudes of the auroral zones. Zones are indicated by light bands across the surface of the earth. (Fig. 2)

by Dr. Robert Jastrow

WASHINGTON—The first step toward e exploration of space occurred apoximately 22 months ago as a part of ie International Geophysical Year. In ie short interval since October, 1957, te new tools of research, the satellite d the space rocket, have produced o unexpected results of fundamental ientific importance.

First, instruments placed in the *Exprer* satellites by James A. Van Allen lve revealed the existence of layers energetic particles in the outer atmosphere. This discovery constitutes the most significant research achievement of the IGY satellite program. The layers may provide the explanation for the aurora and other geophysical phenomena, and they will also influence the design of vehicles for manned space flight, whose occupants must be shielded against their harmful biological effects.

Second, the shape of the earth has been determined very accurately with the aid of data from the first *Vanguard* satellite. As a result of this investigation, we have found that our planet tends toward the shape of a pear, with its stem at the North Pole. This discovery may produce major changes in our ideas on the interior structure of the earth.

Each of these discoveries was made with the aid of a U.S. satellite having a payload with a weight of approximately 10 pounds. It is a remarkable fact, and to the credit of the scientists responsible for the design of these small satellites, that they could be constructed to yield so much information per pound of instruments. It can be reasonably stated that we have obtained more fundamental scientific information from our satellites than the U.S.S.R. from its instruments, and on a per pound basis our yield of information has been amazing.

Of course, this is not to say that we could not have done even more in this first stage of space exploration, if heavier satellites had been available.

In addition to these two results of greatest fundamental importance, both the U.S. and the U.S.S.R. space research programs have also yielded other interesting data on the properties of the ionosphere and on the density and tem-

About the Author

Robert Jastrow, 33-year-old geophysicist and nuclear theorist, is chief of the Theoretical Division and chairman of the Lunar Explorations Working Group of the National Aeronautics and Space Administration.

Jastrow, who was graduated from Columbia College at the age of 18 and won his Ph. D. at 22, has lectured in physics at Columbia, Cooper Union, Leiden (the Netherlands), California, Yale and Maryland universities. He has been a member of the Institute for Advanced Study at Princeton, N.J., and consultant to the U.S. Naval Research Laboory, the Convair Division of General Dynamics, and the Los Alamos Scientific boratory. Jastrow joined NASA in 1958.

what are the particles? . . .

perature of the upper atmosphere.

• **Trapped particles**—The discovery of an intense zone of radiation in the outer atmosphere was first reported by Van Allen and his collaborators at the State University of Iowa on May 1, 1958. at a meeting of the National Academy of Sciences in Washington. Van Allen's results were confirmed by *Sputnik* data released by the U.S.S.R. at the Moscow IGY conference early in August, 1958. The zone discovered by Van Allen is commonly called a radiation belt, but the term is a misnomer because it is really a belt of particles rather than radiation.

We shall begin with a few remarks on the general features of the Van Allen particles. They are known to be electrically charged (probably a mixture of electrons and protons), because their intensity follows precisely the shape of the earth's magnetic field. A magnetic field acts on charged particles, but it does not have an effect on neutral particles and radiation.

Also. we know from a great deal of theoretical research, going back to papers published by the Norwegian physicist Stoermer a half century ago, that charged particles can be trapped in the earth's magnetic field in orbits in which they spiral about the lines of magnetic force, traveling back and forth between the north and south magnetic poles. Fig. 1 shows typical orbits of trapped particles, reproduced from the original paper which Stoermer published in *Videnskapsselkapets Skrifter* in 1913. The particles can stay in these trapped orbits for very long times, perhaps as long as several years if they are at altitudes of one thousand miles or more. The trapped particles are injected into the outer atmosphere at an exceedingly slow rate, but because they stay there so long the *total number* of particles in the atmosphere will still build up to very large values. That is the key to the formation of the Van Allen layer.

The *Pioneer III* space rocket showed that the layer actually consists of two separate zones, as shown in Fig. 2. Each zone contains particles with energies varying from approximately 20,000 to several million volts or more. There may be an appreciable number of particles at still lower energies, but these could not have been detected with the instruments flown thus far.

It is found that the particles only appear in appreciable numbers above 200 miles in the northern latitudes and above 600 miles over the equator, and have a maximum density of about 1 per cubic centimeter. However, the Russians have reported *Sputnik III* results which suggest that in or near the auroral zone, the outer belt may reach a density of 100 particles/cm at an energy of 10,000 volts.

• **Protons or electrons?**—The component at the lower energies probably consists of electrons. The more energetic particles are protons or a mixture of protons and electrons. In the inner zone, the penetrating particles have been definitely identified as protons with energies up to one billion volts, according to the results of an emulsion experiment recently conducted by White and Freden of the Livermore laboratory. The concentration of energetic particles is greatest in the inner zone, but is still only 0.1 per cent of the density of soft electrons in that zone.

The inner zone is peaked at an altitude of 2500 miles. The outer zone has a maximum at an altitude of 10,000 miles, and extends into space to a distance of approximately 35,000 miles from the center of the earth.

Until recently, we did not know the mechanism that produced the two zones. This problem of the origin of the zones was the subject of a very lively debate, marked by high atmospheric temperatures, at a recent conference sponsored by the NASA Theoretical Division. However, it is now believed, on the basis of a preliminary report by Van Allen on the *Pioneer IV* results, that the outer layer is produced by particles coming from the sun. The surface of the sun boils and bubbles in a very active manner, occasionally emitting large gusts of plasma or charged particles into the solar system. The *Pioneer IV* flight came immediately after 5 days of continuous and unusually intense solar activity of this sort, *and showed radiation intensities in the outer zone which were many times greater than those measured in the* Pioneer III *space rocket*. The *Pioneer III* flight had occurred in a time of solar quiet. The difference between the radiation levels measured in the *Pioneer III* and *IV* flights definitely establishes that the outer zone is fed by particles from the sun.

It is not yet precisely clear how the outer zone is built up by the solar streams. It may consist of the actual solar particles which have been trapped near the earth by the geomagnetic field, or it is possible that the sola stream produces the trapped particle indirectly by collisions with air atom The NASA schedule of rocket an satellite launchings includes exper ments which will indicate which c these theories is correct.

• **Cosmic ray reflection?**—The caus of the inner zone has not yet been de termined, but the available theoretic evidence indicates that at least som of the particles in this belt are produce by the beta decay of cosmic ray neu trons, as suggested by Christofilos, b Singer, and by the Soviet physici Vernov. The observations by Frede and White also support the hypothes that the inner belt is produced by co mic rays. The Freden-White data i dicate that the number and energ distribution of the energetic proto are in good agreement with what w expect from the beta decay of fa neutrons.

The presence of a gap between th two zones still presents a serious prol lem. On the hypothesis of beta-deca for the inner zone and a solar orig for the outer zone, we would expe the inner zone to rise smoothly in the outer, and it is difficult to expla the finding of a minimum in radiatic intensity between the two. In this co nection an interesting suggestion w made at the NASA conference by D Dessler of the **Lockheed Missile ar Space Division,** who pointed out th there is an irregularity in the geoma netic field which may be described a hole or depression in the magnet contours. He pointed out, further, th the lines of force passing through th irregularity are located at the positi of the gap between the zones. Wh particles are trapped on these lines force in the magnetic field they desce to lower altitudes than would be t case in a perfect dipole field. At t lower altitudes they pass through denser atmosphere and are rapidly moved from the radiation zone.

• **Geophysical effects**—As Fig. 2 i dicates, the particles in the outer zo are funnelled into the Arctic and A arctic by the concentration of the ma netic field near the north and sou poles. The outer zone dips down ir the atmosphere in these regions a disturbs the normal conditions whi exist at other latitudes. Two examp will indicate the consequences of t interaction between the trapped p ticles and the atmosphere.

First, we are rather certain that t *aurora borealis* and the *aurora aust lis* result from the excitation of t Arctic and Antarctic atmospheres collisions between air atoms and particles trapped in the outer zone.

Second, the trapped particle zo

xplain the recent surprising discovery hat the air at high altitudes is warmer n the arctic than in the temperate ones. This discovery was made by the nalysis of experiments performed in .S. rockets at the White Sands missile nge in Arizona, and at the Fort hurchill range in the Canadian Arc-c. The rocket measurements indicated hat at altitudes above between 90 and 40 miles the air over Fort Churchill as a temperature of approximately 000°F., as compared with a relatively ool 2000°F. over Arizona.

We can understand these tempera-re differences as a result of heating oduced by collisions between the apped particles in the outer zone and e atoms and molecules of the upper mosphere. The Van Allen data, sup-emented by *Sputnik III* results and rocket measurements performed by e Naval Research Laboratory and the ate University of Iowa, provide opportunity to make a quantitative st of this heating mechanism. With e aid of the rocket and satellite data, Harris of the NASA Theoretical Di-sion and the author have carried out lculations that show that collisions th the Van Allen particles must use an increase of several thousand grees in the temperature at the cen-r of the auroral zone, in qualitative reement with the observations.

Thus we see that the trapped par-le layers provide the explanation for a number of geophysical phenomena. is this geophysical significance of the apped particles that makes their dis-very so important to fundamental search.

• **Radiological hazard**—The trapped rticle layer has an additional signifi-nce for space technology in that it ay constitute a serious radiological zard to the personnel of future man-d space flights. In order to determine e biological exposure level produced the layer, we must know the ener-s of the trapped particles, and ether they consist of electrons, pro-ns, or heavier particles. Detailed swers to these questions should be ovided in the future by further ex-riments now in preparation. The ta available at present tell us only t the exposure levels appear to be hin the range from 2 to 50 roent-gs for personnel in a vehicle passing ough the atmosphere to the moon outer space. These levels are far ow the estimated lethal dosage for mans, and they can be further re-ced by body shielding. This problem y not be a major one in comparison h other uncertainties of the first ce flights.

Of course, the exposure can be ch greater for personnel in a man-ned orbiting satellite. It may in fact be necessary for the early manned satellites to remain at low latitudes and relatively low altitudes, below 400 miles, where the intensity of the radiation belt is sharply reduced.

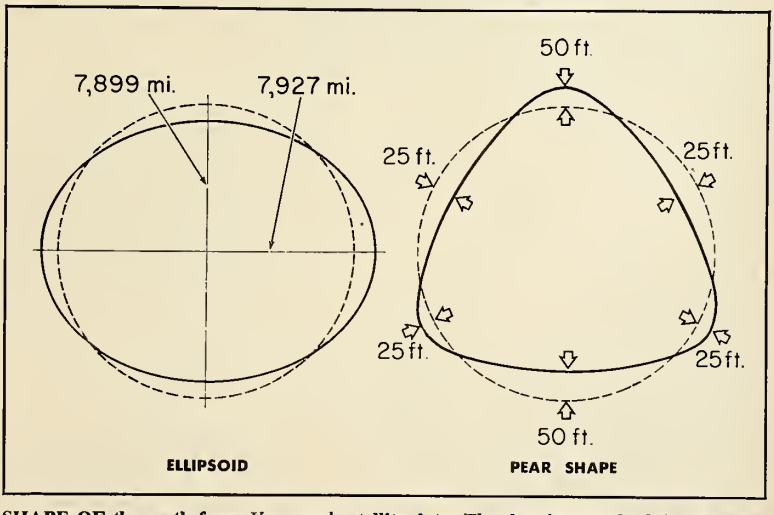
• **Shape of the Earth—1958**—*Beta 2*, the first *Vanguard* satellite, was launched on March 17, 1958. Later in 1958, O'Keefe, Eckels, and Squires, three scientists in the Theoretical Division of the NASA Goddard Space Flight Center, recognized certain changes in the perigee height of the satellite (orbital point closest to the earth) that were contrary to the established theory on the shape of the earth. This theory maintained that the earth had the shape of nearly perfect sphere, flattened somewhat at the poles, and bulging at the equator by about 12 miles as a result of the outward centrifugal force produced by the rotation of the earth. If the "flattened sphere" theory were correct, the force of gravity on the satellite would be the same in the northern and southern hemispheres. Actually, the orbit was found to be different in the northern and southern hemispheres. This indicated that the earth was not symmetrical above and below the equator as previously indicated.

The new findings show that the sea level at the north polar cap is raised by about 50 feet above what has been considered normal. At the solar polar cap there is a depression of 50 feet in the sea level. There are also small changes of the sea level in the temperate zones. The combined effect of these variations is to give the earth a tendency toward the shape of a pear, with the narrow end in the Arctic and the broad base in the Antarctic. A schematic representation of the old and the new shapes is shown below in Fig. 3.

This result is not entirely new. Without indicating his reasons, Columbus stated in the 15th century that the earth must be pear-shaped, as the following quotation proves: ". . . that it is not round in the way they have written, except that it has the shape of a pear that is very round, except where it would have a stem, where it is higher . . . " (Henry Vignaud, *Histoire Critique de la Grande Entreprise de Christophe Colomb*, Paris, H. Welter, 1911.)

A 50-foot variation seems insignificant in comparison with the 4000-mile radius of the earth, or even in comparison with the 12 mile difference between the polar and equatorial radii. However, this change means that there is an excess of matter near the North Pole, or a deficiency at the South Pole, sufficient to draw up the level of the sea by 50 feet *over an area the size of the Atlantic Ocean*. Such variations in the distribution of mass imply very large shearing forces in the interior of the earth.

We may ask what can be the cause of the pear shape. That is not known, but we can make some interesting guesses. For example, we know that the earth is currently growing warmer. It is possible that the Antarctic ice cap has been decreasing in thickness faster



SHAPE OF the earth from *Vanguard* satellite data: The drawing on the left represents the old conception of the spheroidal earth, with a 26 mile difference between the diameters at the pole and the equator. The figure on the left shows, in exaggerated form, the effect of adding a pear-shaped component to the ellipsoid, as required to fit the *Vanguard* data. In both drawings dashed circle represents an equivalent spherical earth with equal volume. (Fig. 3)

shape of geoid established . . .

than the earth beneath can bounce back beneath the reduced load. That would account for the depression at the base of the pear.

The above result indicates that the interior of the earth is not as plastic as originally assumed. NASA scientists have in fact concluded that a mechanical strength at least as great as that of a brick wall is required to support the dome in the north and the variations in the southern hemisphere.

• **Ionosphere properties**—The U.S.S.R. satellites have been the major source of ionospheric information thus far, primarily because these satellites transmit on the relatively low frequencies of 20 and 40 megacycles.

Low frequencies are poor for tracking purposes because the signals are bent by the electrons in the ionosphere during the course of their passage from the satellite to the ground tracking stations, producing an error in the apparent position of the satellite. At 40 megacycles the ionosphere produces an average error of 6 miles in the position of a satellite 600 miles from the observing station.

However, the bending that adversely affects the low-frequency signals for tracking purposes can provide valuable data on the state of the ionosphere, provided the true position of the satellite is known at all times. For example, the difference between the true position and the apparent radio position depends on the number of atmospheric electrons in the path of the signal from the satellite to the observing station. This effect has been used by several scientists to measure the electron density in the ionosphere. The true position can be determined by optical methods if the satellite is sufficiently large. Otherwise it can be done by combining a large number of radio observations for improved accuracy.

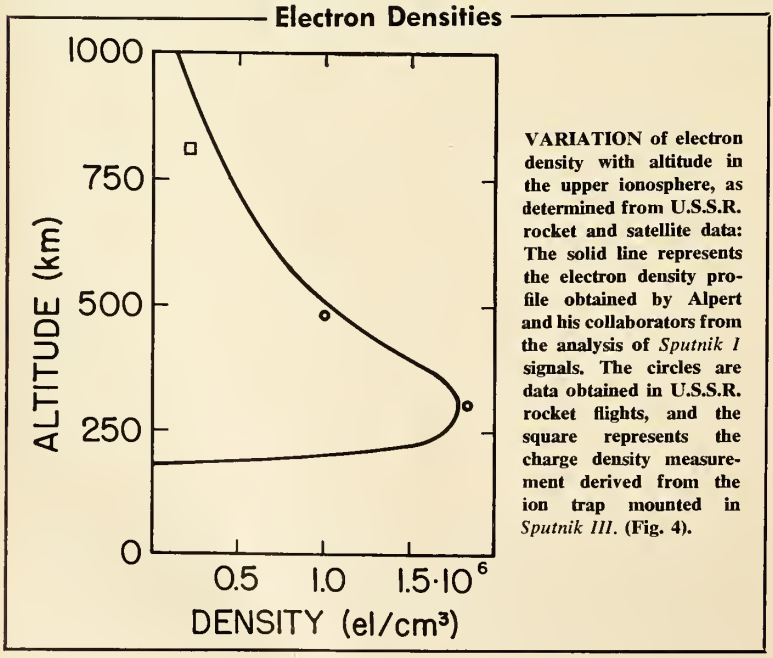
The U.S.S.R. satellite, *Sputnik I*, is a particularly intriguing satellite for ionospheric studies because it transmitted signals on both 20 and 40 megacycles for an extended period. Excellent worldwide recordings were obtained on both frequencies during the radio lifetime of this satellite. The ionosphere physicists must know the true position of *Sputnik I* in order to extract scientific information from these records. Thus far the U.S.S.R. has unfortunately not furnished any detailed information on the orbits of *Sputnik I* or the other Russian satellites, although requests for this information were made in 1958 at the IGY conference in Moscow.

• *Sputnik* **ephemeris**—In the absence of orbit information from the U.S.S.R., the Theoretical Division of NASA has collected all available radio observations and combined them to produce an ephemeris, or table o true positions, for *Sputnik I*. Thi ephemeris has an accuracy of only te kilometers in the position of the satel lite, but it is the best one available t American and European scientists a the present time. The NASA ephemeri for *Sputnik I* is being made available t all scientists in the U.S.A. and in othe countries.

The Moscow IGY conference in cluded a Soviet report on ionospheri investigations, based on undisclose U.S.S.R. orbit data. Prof. Alpert of th University of Moscow gave the result of an analysis of the *Sputnik I* signals which indicated that the upper layer o the ionosphere extends to much highe altitudes than had been anticipated Alpert found the very important resul that the number of electrons above th level of maximum density in the iono sphere is 3.5 times greater than th number below the maximum. The elec tron density profile obtained by Alper is shown in Fig. 4, together wit U.S.S.R. rocket data. The Alpert profil appears to be a reasonable representa tion of ionospheric densities unde average conditions.

The third U.S.S.R. satellite, *Sputni III*, has also yielded interesting iono sphere results obtained from a devic called the "ion trap." The ion trap i a spherical collector approximately 1 inches in diameter, attached to the sur face of the satellite by an extendin rod 30 inches long. A negative voltag is placed on the trap, drawing all near by positive ions to it. The rate at whic the ions are collected is telemetere automatically to the ground, and pro vides a measurement of the number o positive ions in the neighborhood o the satellite.

A few samples of the ion trap dat were presented at the Moscow con ference. They indicated that the io density values are in reasonable agree ment with the electron densities meas ured by Alpert, as shown in Figure 4 As a by-product of the experiment, th ion trap also showed that *Sputnik II* acquired an appreciable negative charg in its passage through the ionosphere corresponding to negative potentials o several volts. An investigation by scien tists in the NASA Theoretical Divisio indicates that a satellite can be charge to still higher potentials, on the orde of thousands of volts, in those parts o its orbit that extend into the region o the great radiation belt. An extensio of the calculations published in 195 by C. A. Pearse and the author show that if the satellite is charged to kilo volt potentials, it will be slowed dow



VARIATION of electron density with altitude in the upper ionosphere, as determined from U.S.S.R. rocket and satellite data: The solid line represents the electron density profile obtained by Alpert and his collaborators from the analysis of *Sputnik I* signals. The circles are data obtained in U.S.S.R. rocket flights, and the square represents the charge density measurement derived from the ion trap mounted in *Sputnik III*. (Fig. 4).

y an electrical drag force which is 10 100 times greater than the ordinary erodynamic drag.

• **Density and temperature**—Direct easurements of the density of the atosphere have been made by installg ionization gauges in rockets. These easurements extend to an altitude of 50 miles. For altitudes above 150 iles the density has been measured inrectly, by analysis of satellite orbits. he indirect measurements depend on e fact that the atmospheric drag rces acting on the satellite are proortional to air density. The drag forces use a decrease in the energy and erefore in the period of revolution of e satellite, which can be easily meased and analyzed to give the average r density in the orbit.

The striking feature of the latest cket measurements of density is their eat variability with time of day, sean and latitude. The data show that an altitude of several hundred kiloeters the upper atmosphere is two hes heavier in the day than at night, d two times heavier in the summer hn in winter. During a summer day arctic latitudes, where the "day" lasts rarly 24 hours, the density is four to ht times greater than the density at e same time in the temperate zones.

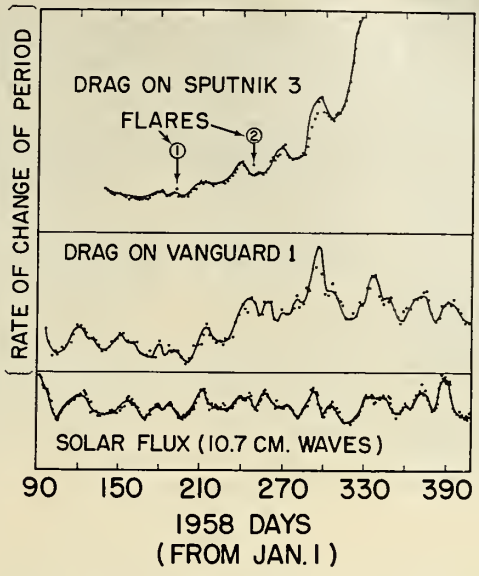
There appears to be a simple exnation for all of these effects, rmely, that prolonged exposure to the sn heats the atmosphere and causes a upward expansion, producing very ge relative increases in the thin air a high altitudes.

• **Satellite drag variations**—The satite density data also show large fluctitions in addition to the systematic riations described above. These fluctitions are probably the result of atospheric heating produced by streams o energetic particles and radiation m the Sun. Dr. Jacchia of the rvard Observatory has in fact discovered that the apparently random fluctuations are actually proportional to the changes in the intensity of the 10-centimeter radiation from the sun, which constitutes an excellent measure of solar surface activity. The correlation between the satellite drag and solar flux is shown in Fig. 5.

Jacchia has been able to eliminate electromagnetic radiation as the source of the drag variations, and has succeeded in identifying the heating effect with the arrival of corpuscular streams in the vicinity of the earth, following major solar flares. The proof of this result is shown in a report recently published by Jacchia in *Nature*. Fig. 6 shows that the drag increases observed after two solar flares did not occur at the time of the flares, but began approximately 1 day later at the same time that the magnetic K index spurted upward. A rise in the K index signifies the onset of a magnetic storm, and therefore the arrival of the relatively slow-moving solar corpuscular stream which accompanies the flare.

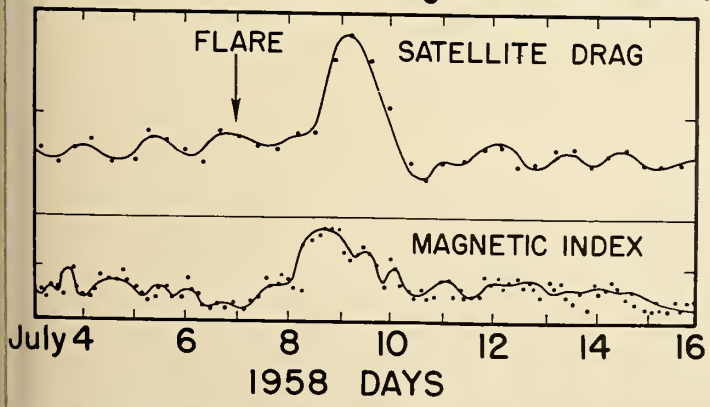
This beautiful demonstration of the relation between upper atmosphere properties and solar corpuscular streams promises to open a new chapter in the study of solar-terrestrial relationships. I believe that in retrospect it will turn out to be one of the most significant results to come from the IGY satellite program.

Solar Effect on Satellite Drag

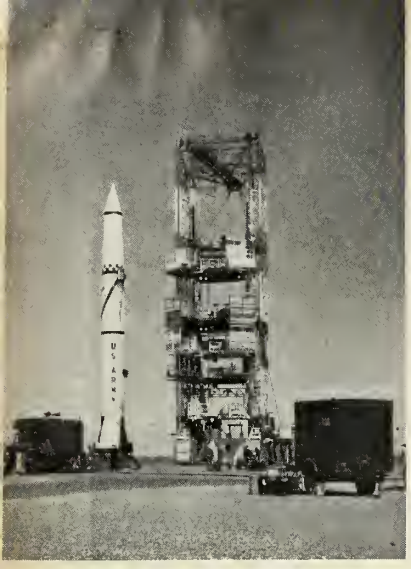


CORRELATION between solar activity and satellite drag. In the graph satellite drag is plotted on the same base with the observed flux of solar radiation in the 10 centimeter region of the spectrum. The 10 centimeter radiation is an accurate measure of solar activity. The figure demonstrates a perfect correlation of maxima and minima in the two curves. (Fig. 5).

Drag Increase with Storms



CORRELATION of drag increases with magnetic storms, following a major solar flare: The time of occurrence of the flare is indicated by an arrow. The onset of the magnetic storm, which signifies the arrival of corpuscular streams from the sun, is marked by the increase in the magnetic index plotted from the lower graph. (Fig. 6).



SERVICE tower for *Redstone* at White Sands.

Missile Support Progress . . .

Bigger Vehicles Will Pose More Baffling Engineering

Solution to missile support problems largely rests with Army's Corp of Engineers which has lion's share of responsibility

WASHINGTON—The art of launching a rocket has reached such refinement that the supporting mechanisms and structures required to get our exotic birds off the ground present the most baffling of engineering problems.

The solution of some of these support problems is a responsibility of the U.S. Army Corps of Engineers, headed by Maj. Gen. E. C. Itschner. As the Chief of Engineers explains it, the Engineers' role in the Government's missile and space program is a multiple one—performing a variety of missions for the Army Missile System; constructing missile bases for the Air Force; and carrying on construction projects for the Advanced Research Projects Agency and the National Aeronautics and Space Administration.

Working closely with the Army Ordnance Missile Command, the Corps of Engineers' support of guided missile and rocket operations includes the provision of Engineer troops; construction of missile sites, test laboratories, training centers and other facilities needed to train men and develop weapons; supply and maintenance of engineer equipment and material; provision of maps and geodetic data; and development by research; often in cooperation with industry, of new engineer equipment for the Army's family of missiles.

• **Keeping abreast**—All of these areas of support are equally important to the Army missile program, Gen. Itschner said, but to those whose interests lie primarily in keeping abreast of new developments in the constantly changing requirements of the program, a review of the research efforts of the Corps is in order. These efforts affect all Army missiles, from the operational *Lacrosse* to the still-to-be tested *Pershing*, successor to the *Redstone* family.

"Nuclear warfare will impose a requirement for great mobility on our ground forces, which must have the capability of hitting the enemy, then dispersing and regrouping again for another strike where it is least expected," Gen. Itschner explained. "We must be able to move our rockets and missiles into the battle area and out again on short notice. Supporting equipment, such as power generators, fuel tanks, fire control vans and radar equipment must also be easily and quickly moved. To attain this mobility, the Corps is developing smaller and lighter equipment which will do the job for which a particular missile has been designed.

"For example, the presently avai able conventional engine generat capable of providing power r quired for guidance of the *Lacros* missile weighs 900 pounds with a cessories. Since it is necessary th this generator be manpacked to t forward observers' position, we a developing a generator of 3 KW ou put, 400 cycle with precise pow regulation capable of being carri by one man, or with a full fu tank, by two men. The **Curtiss-Wrig Corporation, Santa Barbara Divisio** developed and demonstrated enginee ing models in sixteen months. One the unusual engineering characteristi of this generator is the silencing fe ture. Operational noise from this equi ment will not be heard further than few hundred feet.

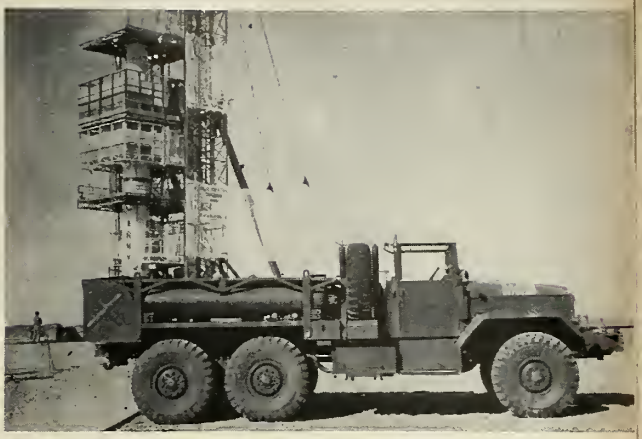
"Also under development is t power pack for the *Pershing* miss system. This pack is a combination utilities ordinarily furnished by t Corps of Engineers as separate piec of equipment. The various units a packaged on one base plate, with lit greater total weight than is norma found in any one of the componen Electric power of three different outp characteristics, high pressure air (30 psi), and conditioned air all generat from one gas turbine drive, are cluded for a total weight of abo 2600 pounds. This unit will be tra ported on a vehicle weighing 95 pounds which also mounts a fire co trol hut. The standard air compress of the size needed, three generato and an air-conditioning plant heati unit, with four vehicles previously quired to transport them, would wei upwards of 28,000 pounds."

• **Interservice cooperation**—Of vi

About the Army Engineer Chief

Maj. Gen. Itschner has charge of the booming missile construction program for both the Army and Air Force. In addition, he is responsible for the Corps' nationwide civil functions. A graduate of West Point (1924) and Cornell, the General has served in Army construction projects all over the world—Europe in WWII, the Philippines, and Korea. Known as a "man in a hurry," his major responsibility now is directing construction of the new Air Force ICBM bases along with a whole range of missile research and development, testing, and launching facilities, including the Army's Nike bases.

IYDROGEN peroxide service truck is part of support equip-ıent for *Redstone*.



BIG TASKS are performed by vehicles in missile support. Representative is this 5000-lb compressed air storage tank.

enefit to the Army in speeding the evelopment of the *Pershing* system is ıe precedent established by having one chnical service participating directly ı the program of another, the Chief f Engineers said. Specifically, the ower pack is being developed by the **Martin Company,** contractor for de-elopment of the missile system for the rdnance Corps, Army Ballistic Mis-le Agency, and the Engineer Research nd Development Laboratories (ERDL) ho serve as technical supervisor of the ack development for the ABMA, op-rating within the framework of the rime contract.

"Again, in the high power acqui-tion radar (HIPAR) building for the nproved *Nike-Hercules*, as in the *ershing* power pack, we have an in-grated Engineer-Ordnance working elationship," Gen. Itschner pointed ut. "ERDL is the technical super-isor for the Army Rocket and Guided lissile Agency for the development f a pre-fabricated building to house new radar. It is evident that the rmy will gain from this joint opera-on in both the development and logis-cs stages. Experience gained by the orps of Engineers from participation development will enhance our capa-lity for providing spare parts and aintenance support of the resulting roduction item."

In the HIPAR building, where mo-lity and weight are of prime im-ortance, the unique engineering prob-m is in retaining the necessary air-ght panel seal despite repeated as-mbly and disassembly of the build-g, a problem not heretofore involved prefabricated building. Inflated seals e being used at all joints, and it ppears possible that a technical break-through in this particular problem area may result, the General disclosed.

Another development item with a requirement for high performance and low weight is the air-conditioner—heater plant for an Army field missile. This plant, a unit weighing 350 pounds, provides 38,000 BTU of air-conditioning and approximately 35,000 BTU heating per hour. It will be used in a van or a shelter of a field battery control center. Two difficult engineering problems—vibration and noise level—were encountered due to the high rotating speeds of the motors and compressors. Both are being solved through unique packaging and insulating methods. Because of an immediate requirement for this unit, a six month development time was imposed. Production models are scheduled with an initial delivery time of nine months.

• **Skyscraper on wheels**—Recently, the design was completed for a 305-foot missile service tower to be built at Cape Canaveral for the Advanced Research Projects Agency space vehicle, the *Saturn*. (MISSILES AND ROCKETS, June 8, 1959.) The tower, as tall as a 28-story building, will be on wheels.

Another ARPA project at Redstone Arsenal, is a static test tower being modified for use with the *Saturn*. This is the Army Ballistic Missile Agency's 140-foot tower previously used to test missiles up to the size of the *Jupiter*. Upon completion of the work, the tower will be capable of statically testing missiles having up to 1,500,000 pounds of thrust.

The work consists of driving approximately 6000 lineal feet of steel piling, constructing two reinforced concrete underground anchors 61 feet below bedrock and erecting approximately 470 tons of structural steel to be used for mounting the hold-down devices for the missile test. A cantilevered 100-ton bridge crane and hoist will be erected atop the modified structure for lifting the missiles and equipment into test positions.

Another missile service tower, fabricated by the **Noble Co.,** Oakland, Calif., is under contract with ERDL and scheduled for erection at Cape Canaveral in July. It is a mobile structure 150.25 feet tall, composed of twin towers mounted on a rubber tired trailer 42½ feet long. The tower has a traveling crane on top and is designed to handle *Jupiter* and *Redstone* type missiles. When servicing of the missile is completed, the tower moves away on its own trailer.

As missiles become more sophisticated, the demand for purer fuel becomes more urgent, Gen. Itschner said. The Ordnance Corps has determined the maximum allowable hydrocarbon count as .03 parts per million in the liquid oxygen as it is pumped into a missile such as the *Redstone*, largest field operational weapon of the Army. There must, therefore, be frequent purity checks by the soldier missilemen of the Engineer unit charged with supplying the fuel. To meet this requirement, ERDL is pursuing a project for developing a test instrument that can be easily used by the engineer soldier for checking the purity of LOX with a maximum of accuracy and a minimum of danger. Another field instrument under development by ERDL is for checking the dew point moisture content of compressed air at temperatures as low as –85 Fahrenheit.

• **Storage problems**—Loss of liquid

oxygen through evaporation during storage and transfer to the missile is another problem which plagues the Engineers. This loss, which now varies from 50 to 75 percent, is being reduced by improved equipment, especially fittings. ERDL is also developing a new type of storage container with unusual types of insulation. Inasmuch as LOX must be hauled from our mobile field generating plants to the launching sites in nine-ton tank trucks, the handling problem is a major one. Even though the Engineers have developed LOX plants with capacities of up to twenty tons per day, fantastic amounts are required to fuel a 70-foot missile. Heavy losses, particularly in the event of an actual combat situation, might cripple operations.

The Corps of Engineers' research and development work for the Army missile systems presently constitutes at least 25% of the research and development effort at ERDL. This work is being carried on both by ERDL personnel and by contract. It includes dozens of projects not heretofore mentioned, such as special air-transportable and mobile cranes, safety shower bath units to decontaminate personnel and clothing worn around toxic fuels, night vision equipment and special tools such as a welding machine for use on thin gauge materials. ERDL is even developing an unusually effective vacuum cleaner for cleaning the electronic and other delicate equipment used in the control vans.

Recently, the Corps completed an engineering analysis of the power requirements for the *Nike-Zeus,* including consideration of the remote stations where commercial power is not available. Transportation of fuel is a costly and often hazardous logistical effort. It has been determined that nuclear power plants can be designed to meet the stringent specifications required in operation of *Nike-Zeus* radar and electronic equipment. **Alco Products, Inc.,** which built the first Army power reactor plant at Fort Belvoir, Virginia, has completed a preliminary design and has been selected by the Army to complete the final plans of the proposed plant.

Missiles, regardless of whether they are Army surface-to-surface weapons or the Air Force's intercontinental ballistic missile, must be aimed at the target before they can be fired, Gen. Itschner noted. To attain the degree of accuracy needed to make missile warfare pay off in victory, the man aiming the weapon must know two things. First, he must know precisely where the missile is located at the time of launching, and second, he must know precisely where the target is in relation to the missile.

The task of locating targets and the guiding of the missiles to them is a complicated one requiring close coordination of the efforts of many men. Basically, it is a mapping job. The Engineers are responsible for providing the interconnected grids and earth measuring information necessary to direct longer range strategic missiles.

Said Gen. Itschner, "With the Air Force, we are working on the use of high altitude electronically controlled aerial photography to speed the compilation of maps, and we are using helicopters and geodimeters to accelerate field surveys. By using electronic digital computers, the time required for geodetic control adjustment has been reduced by years.

• **Where we are**—"Engineer teams on Pacific islands, using tracking devices, are obtaining valuable data from the *Vanguard* satellite as to precise island locations, which heretofore have been mistakenly located on maps from hundreds of meters to miles from their actual positions. This activity is helping us to get the answer to the question, 'Where in the world are we?'

"To help perfect methods of rapidly and accurately locating targets within a tactical area, which might be 200 miles deep on an atomic age battlefield, the Corps of Engineers is evaluating various target location systems. These involve the use of day and night aerial photography, radarscope photography to map the ground through clouds and darkness, and electronic systems to locate the photographic aircraft with respect to known ground stations."

A large part of the Engineers' efforts in construction are being directed toward the Army and Air Force missile programs. Construction of missile support facilities involves types and methods of building undreamed of a few years ago. Specifications now require construction tolerances which were possible before only as laboratory experiments.

"The *Zeus,* third generation of the *Nike* family, will create greater problems," Gen. Itschner predicted. This weapon is the Army's anti-missile missile designed to intercept enemy ICBM's in flight. The *Nike-Zeus* is a highly complicated system that brings the scientist, manufacturer and construction man together. Missile, test, and launching facilities are designed, developed, and built simultaneously. Flexibility will be the watchword at all times for those connected with the development of this missile. Constructors, designers and manufacturers will have to adapt themselves to the demands imposed by the rapidly widening knowledge being acquired by missile experts, for whom there seemingly are no limits except the horizons of their imaginations.

"Where these scientists and missile experts will take us in the space age is difficult to foresee at this point. The Army's Corps of Engineers, however, is preparing for whatever problems present themselves, whether they be on the moon or some fantastic reconnaissance space station on the route to Mars. Our Engineer research and development experts are conducting studies on space construction problems in sanitation, water supply, thermodynamics, electric power and advanced methods of prefabricated shelter construction. One of the programs considered important to the future involves a look into new sources of energy such as thermoelectric and thermionic generators and solar energy.

"The by-products of the research which our space program has brought about are leading us to portals of knowledge which are only now beginning to open for the benefit of mankind."

TWO IMPORTANT items for *Jupiter:* 100 KW power generator and vertical check-out shelter.

Fertile Field for New Applications

Microminiaturization, solid-state physics and communications technology are promising areas

by Robert J. Jeffries

DANBURY, CONN.—Whenever a new ientific fact is discovered, or when a w technology gains momentum, there a great tendency for authors and blishers to rush into print with a ultitude of predictions and projec- ns as to what the future will bring. areas already established there are e traditional articles on the "state the art" which appear periodically.

Both categories of exposition— e projections and implications of new chniques, and the periodic review established technologies—fill impor- nt functions. In general, they serve e needs of the "lay" public, as a basic ucational tool, and the practitioner the field, possibly as a stimulant, and rtainly, in the minimum, as a con- nient tabulation of the art, by means which he can mentally check his n progress and understanding.

Progress in Space Instrumentation ses a particularly difficult subject on ich to write an article for the read- of MISSILES AND ROCKETS Magazine. be correct, the author must define at he means by "Instrumentation"; must also define what he means by pace"; the meaning of "Progress" may take as self-evident. Also it obvious that the audience is not a y" audience in the sense of being technically unsophisticated in the subject, and lastly, for reasons of security, it is impossible to present an up-to-date review of the state-of-the-art in any detail.

What objective and means is there left then which justifies an article at all? The answer lies in perspective. If an article can present a situation in perspective in such a manner as to aid the reader in a better comprehension of his own role and problems, if it can stimulate the reader to a more creative synthesis of solutions to his problems, if it can direct attention to critical areas in need of attention and potentialities as yet unexploited, then it serves a useful purpose. In a modest way these shall be the objectives of this article.

• **What is instrumentation?**—Literally hundreds of efforts have been made over several years to define instrumentation. A synthesis of these several efforts, which in the least serves to define the scope of interests of this article is as follows:

"Equipment and techniques associated with and essential to the detection, measurement, transmission, translation and display of information, and including possible associated computation and utilization of the information for control purposes."

• **What is space?**—For purposes of this discussion, space may be defined as the volume around us excluding the earth, the oceans, and the atmosphere. Unfortunately, this definition tells us little, really, in that it assumes a precise definition of "atmosphere." One can define "atmosphere" as one chooses. For immediate purposes, let us assume as a purely arbitrary decision, that the atmosphere extends from the surface of the earth and its oceans to a height of 100 miles. Space then becomes the volume around the planet Earth, but external to a spherical shell 100 miles thick, surrounding the Earth. Obviously this definition is unique to the understanding and use of an earth-oriented creature.

• **What is space instrumentation?**—From the definitions above, it is apparent that Space Instrumentation embraces all the instruments that guide and control space vehicles, measure characteristics and performance of space vehicles and operate on and digest, display, and automatically react to the resultant information. It also includes the hardware and techniques of measurement of space and its contents. This is to say that Space Instrumentation embraces virtually every technique and piece of hardware designed to gather data in space or related to the gathering of that data. Space instrumentation is not generally understood to include considerations of propellants, propulsion or structures. But what of a nose cone? In some instances, a nose cone becomes, in itself, an instrument—detecting, and measuring directly and indirectly, meteoric dust, temperature, etc. All the above considerations demonstrate the necessity for an arbitrary agreement as to what shall be embraced by the term space instrumentation. For purposes of this discussion, space instrumentation is defined to include the following:

About the Author

Robert J. Jeffries is president of Data-Control Systems Inc., Danbury, Conn. A former assistant to the president of Daystrom Inc., Dr. Jeffries was president of the Instrument Society of America in 1957-58.

He has taught engineering at various universities and has been a consultant to all three military services, the National Bureau of Standards and numerous commercial firms. Jeffries is a founder and trustee of the Foundation for Instrumentation Education and Research.

small business to benefit . . .

• Instrumentation for measuring characteristics of space vehicles,

• Instrumentation for measuring characteristics of space and its contents,

• Instrumentation for communicating and displaying space data.

Measurements of temperature, acceleration, position, flow, stress, vibration, noise, etc. are commonly made today by means of a host of different transducers. These measurements will continue to be made in the years to come. This past year has seen a continuation of the long-term trend, in which transducers are becoming smaller, lighter, of higher frequency response and greater output. There is evidence of a renewed interest in variable-reluctance phenomena in transducers. Most transducers in use today yield analog output signals. There are coming to the fore an ever-increasing number of techniques, combined with conventional transducer principles, which yield digital output signals. The number of measurements which can be made with sufficient accuracy to justify the resolution of digital representation is still small. The advantages of reduced susceptibility to degradation of data in subsequent handling is currently the most important influence in the stimulation of digital techniques.

• **Terse messages**—Space engineers are employing techniques of predigestion of data in flight, with subsequent transmission of derived and statistical characterizations of phenomena. Probably the greatest incentive and utility of such techniques lie not in the inherent data analysis that occurs but in a reduction of the total information to be relayed to a remote point or points.

Solutions to several of today's problems will undoubtedly become operational in the next few years. For example, with the advent of transistor circuitry we can anticipate that transducer outputs will ultimately be adapted to current-input circuits, rather than voltage-inputs. In the near future, however, and before the above can come to pass, the present 0-5 volt input levels will begin to lose popularity. Signal-conditioners, that is amplifiers, and signal translators for modifying available transducer signals to adapt them to conventional standardized telemetry equipments will increase in number and complexity. Finally, the technology is forced to an entirely new approach based on the characteristics of solid-state circuitry. Low-level, solid-state computers will replace electromechanical devices and multi-channel amplifiers. Some prototypes of this type already exist.

A prime objective will continue to be the reduction in size of all equipment. Many components, such as voltage-controlled oscillators, are already approaching a situation wherein the connectors and junction boxes are as large as the components themselves. Further reduction in actual size of individual components does not appear to offer as much margin for improvement as do several other avenues. In the near future, one can expect high-speed, low-level commutation to reduce the space requirements of multi-channel systems. New multiplexing concepts will permit more efficient utilization of available power, thus reducing space requirements for RF components and space and weight in the energy source. For sustained flights, power "captured" in flight is already being used to reduce overall weight requirements. The present enthusiasm for digitized data, while justified in many instances, must be tempered with the sobering fact that in most applications digitization of data increases the space and weight requirements of the instrumentation equipment required for a given information capability.

The most important and exciting promise of the future for all types of flight instrumentation lies in the evolving techniques of microminiaturization. There can be no doubt that these techniques have the potential to reduce the size and weight of all flight instrumentation circuitry. Some equipment of this type is now in use. However, several fundamental facts stand out at this time: (1) Microminiaturization techniques, being relatively new, have not yet progressed to a stage, at which it is possible to achieve accuracies and stabilities comparable to conventional circuit techniques in reproducible units. (2) Microminiaturized circuits are essentially custom-made, with a high rate of failures, with complicated fabrication problems and large capital equipment requirements.

The manufacturers of space instrumentation hardware are, in the main, small businesses. This is so because of the rate of technological advance, the relatively small production runs involved, and the high premium on individual initiative and adaptability. As small businesses they are not able to undertake the basic research inherent to microminiaturized circuit development. For these reasons it is not to b anticipated that conventional *miniatur ized* standard flight instrumentation wil be replaced in the near future, for th bulk of space vehicle instrumentation with *microminiaturized circuitry*.

• **Measuring characteristics of spac** —The obvious questions asked first b any explorer of a new world are "What is present?", and "How much i there?" As we initiate our manned ex plorations of space we begin with thes elementary questions. It is almost cor rect to say we are in the Stone Age o space knowledge; we must first find ou whether the environment of this nev "space world" is hostile to our being We must first detect and measure, an later evaluate, the effects of such thing as radiation, meteorites, weightlessness etc. The fundamental problem is to de cide what we should be looking for Once the variables to be detected an measured are defined, then the appro priate hardware can be developed.

While we progress toward manne exploration of space, we learn muc from unmanned observation station Missiles in trajectory, satellites in or bit and balloon-borne stations affor us effective vantage points for view ing space from a new angle an without the distractions and interfer ences associated with an earth-boun observatory. Obviously, most of th measurements made on far-space fron any vehicle located in near-space mus be based on electromagnetic phenom ena—received, reflected, refracted, o absorbed. The sciences and techno ogies of astronomy, optics, chemic analysis and photometry, working wit the instrument technologists are no evolving the transducer hardware adapted to the near-space environmen Balloon-borne telescopes, spectometer star trackers, etc. are now familia items for work in near-space.

• **Instrumentation for communicat ing**—Telemetry is the all-inclusive wor used to embrace the concepts and hard wares involved in remote measure ments. In practice, one usually differ entiates among transducer, telemetry and display equipment. Telemetr equipment provides the communicatio links between the measuring tran ducers and the display equipment.

The prime objectives of currer telemetry development are improve accuracy, reliability, space and weig reduction. Improved resolution is po sible through pulse code technique (However, improved resolution do not necessarily mean improved accu acy.) Pulse-coded data can be relaye from point-to-point either by radio o wire with no theoretical degradatio of quality. This represents a distin advantage over transmission of data i