SEPTEMBER 14, 1959

EACEFUL USES FOR COLD WAR SCIENCE
ROM MISSILE OPTICS—BETTER EYESIGHT

missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS

AN AMERICAN AVIATION PUBLICATION

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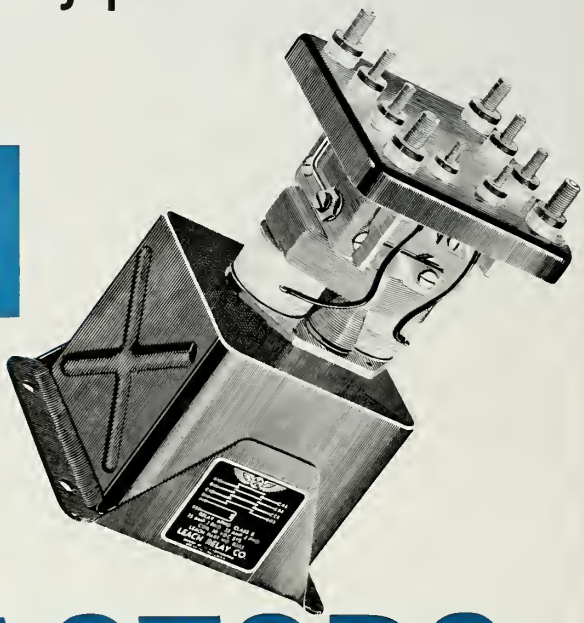

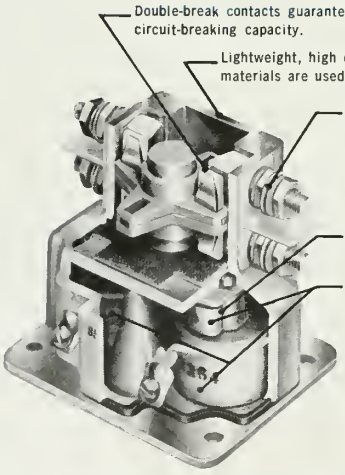

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DISTRICT OFFICES AND FIELD REPRESENTATIVES IN PRINCIPAL CITIES OF U. S. AND CANADA • EXPORT: LEACH CORP., INTERNATIONAL DIVISION

GENERAL ELECTRIC

ANNOUNCES

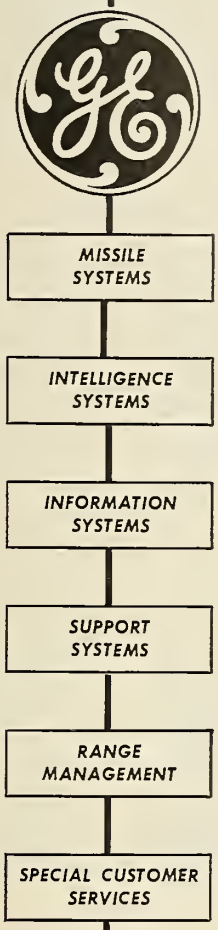
the establishment of the

Special Programs Section

of the

DEFENSE SYSTEMS DEPARTMENT

(A Department of the Defense Electronics Division)



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Missiles and Rockets Volume 5 Number 38

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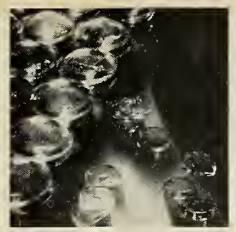
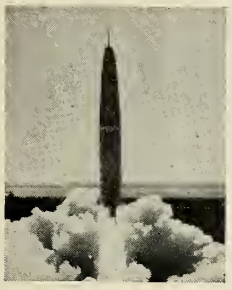


COVER: Mass production of optical glass, developed for military by Corning Glass, provides high-quality, low-cost spectacles for millions. Survey of non-war uses of R&D starts on p. 13.

OPERATING micro-module made by RCA under contract for the Army. Nearly 100 companies so far have taken part in the R&D of micro miniaturization. A progress report starts on p. 18.



RELIABLE *Thor* rises from Cape Canaveral. The urgent need for better reliability of components and the steps that are being taken to achieve it are reported in story beginning on p. 28.

OXIDIZER is reduced to size in this grinder and gyratory sifting machine at Thiokol Chemical Corp.'s Utah Division, Brigham City, Utah. For a picture report on work at the new division, see pp. 32 & 33.

missiles and rockets ®

MAGAZINE OF WORLD ASTRONAUTICS

SEPTEMBER 14 HEADLINES

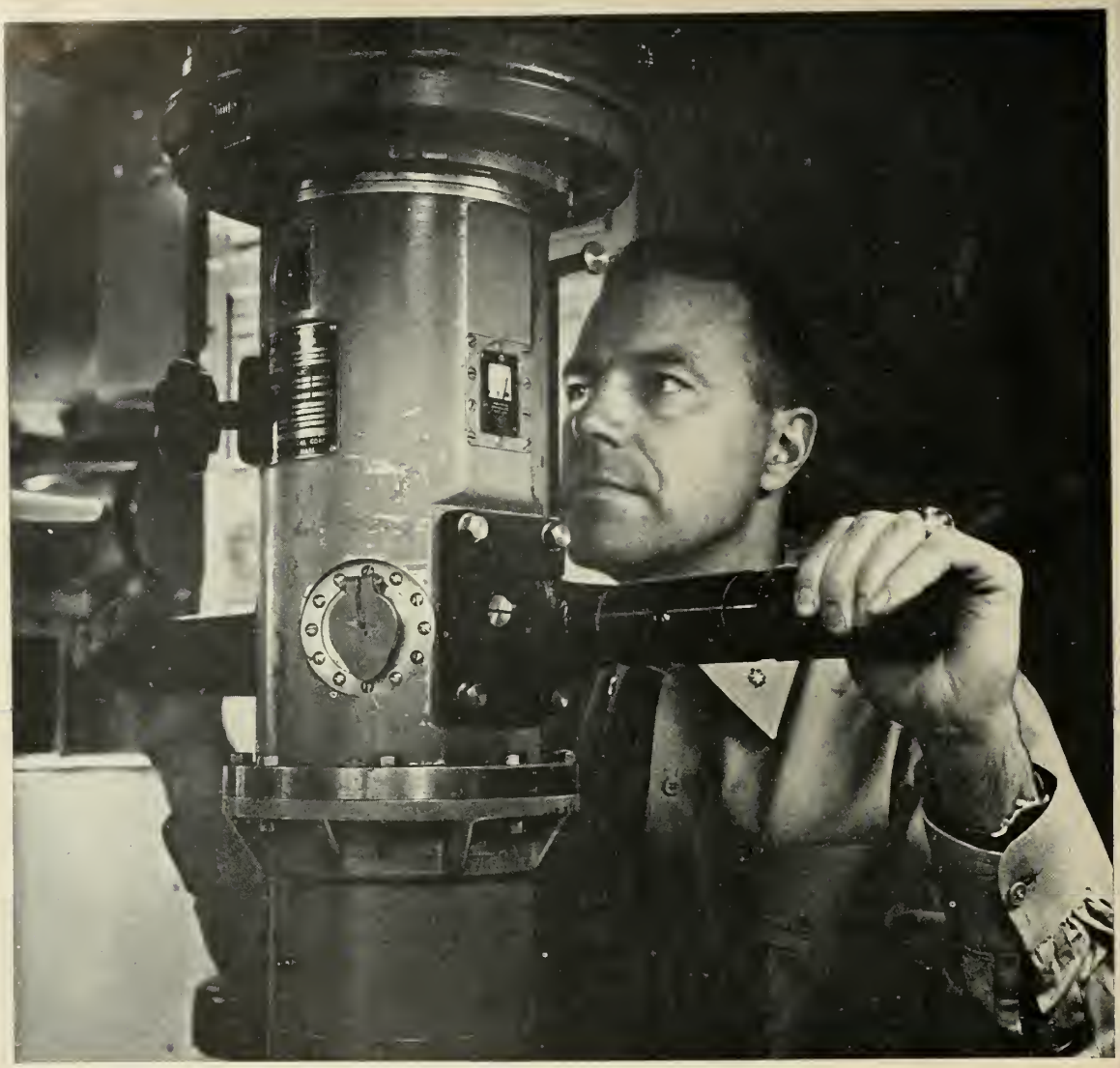
ASTRIONICS

MISSILE SUPPORT
U. S. Reg. Pdg.

ASTRONAUTICS ENGINEERING
U.S. Reg. Pdg.

THE MISSILE WEEK
U.S. Reg. Pdg.

DEPARTMENTS



COUNTDOWN...at full fathom five

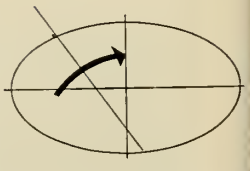
One day, a new fleet weapon system will be *on-station* beneath the ocean surface—ready to hurl retaliatory missiles toward strategic inland targets with pinpoint accuracy. This new weapon system will be part of the Navy's Polaris Fleet Ballistic Missile Program.

Though new in concept, the Polaris program makes full use of the precision Shipboard Inertial Navigation Systems (SINS) developed and produced by Autonetics for the United States Navy.

System design and components of earlier autonavigators have proved reliable in an Air Force supersonic missile, aboard the Navy's surface ship *USS Compass Island*, and on the *USS Nautilus* and *Skate*.

Advanced Autonetics' Shipboard Inertial Navigation Systems—like those to be used by the *USS George Washington*, the first Polaris-carrying submarine—will provide the critical missile alignment data to insure effective missile launching. SINS emits no tell-tale signals ... requires no receipt of external transmission at any time.

DID YOU KNOW?



The flattening of the earth at the poles can result in a navigational error of almost eleven nautical miles if not taken into account.

Inertial navigation by Autonetics

A DIVISION OF NORTH AMERICAN AVIATION, INC., DOWNEY, CALIFORNIA • REGIONAL OFFICES: WASHINGTON, D.C. AND DAYTON, OHIO
INERTIAL NAVIGATION/ARMAMENT CONTROL/FLIGHT CONTROL/COMPUTERS AND DATA PROCESSING

Washington Countdown

IN THE PENTAGON

Transit will go . . .

into orbit within the very near future if the present ARPA-Navy schedule is followed. Plans call for launching the first U.S. navigational satellite with a **Douglas** *Thor* booster.

• • •

Minuteman would roll . . .

over the nation's western wastelands under Air Force plans now being considered. The **Boeing** solid ICBM's would be mounted on big trucks which would roam empty Federal-owned lands, preventing Russia from zeroing in its missiles on them. The *Minuteman* could be fired from the trucks.

• • •

The price of survival . . .

according to Gen. Thomas Power, SAC commander: Dispersion and hardening of missile and bomber bases, secure communications, a constantly ready alert system and defense against sabotage.

• • •

The threat of sabotage . . .

incidentally, is putting many a gray hair on the heads of SAC security officers as ICBM bases become a reality. The big ICBM's are particularly vulnerable to simple methods of sabotage. One shot from a .22 calibre rifle, for instance.

• • •

Music to launch by . . .

is considered "a must" for hardened ICBM bases. Air Force psychologists say music should be piped into underground missile sites to prevent missile "molemen" from losing their efficiency because of monotony.

• • •

A new secrecy gimmick . . .

for withholding information in the Pentagon is said to be tripping up missile industry officials. It's reported that unclassified material is being withheld by labeling it "not releasable."

• • •

The battle of the B-70 . . .

is looming. Air Force commanders are braced for an all-out fight to save the **North American** Mach 3 bomber and its fighter companion—the F-108—from the budget ax. The B-70 would carry the **Douglas** *ALBM*. The F-108 would be used to defend the United States against the Soviet counterparts of the futuristic bomber and missile.

ON CAPITOL HILL

Anti-influence legislation . . .

will accompany the report of the Hébert Subcommittee on its lengthy investigation of the so-called munitions lobby. The subcommittee plans to meet in late November to write its recommendations. The report and legislation will follow—probably just before Christmas.

• • •

A few more hearings . . .

by the Hébert subcommittee will be held during the fall to take care of some loose ends. But for the most part the public hearings are ended. This is a switch from previous subcommittee plans to hold some finger-pointing hearings in early December.

AT NASA

Equatorial launching range . . .

plans have reached the stage where NASA is expected soon to ask for bids for construction of tracking and launching facilities. The proposal is expected to place the launching site at Manus Island in the western Pacific (M/R, May 18). The contract probably will be let next spring.

• • •

Silent sound sickness . . .

is a new perile of the Missile Age. Scientists have found that "silent" high-frequency sounds given off by large rocket space vehicle boosters may injure the health of launching crews. The sounds have been found to cause stomach ulcers and reproductive disorders in animals. NASA is trying to come up with effective mufflers for the big rockets.

AROUND TOWN

A Nipponese missile navy . . .

may be in the offing in the Far East. The Japanese are reported to be planning to begin it with construction of a missile destroyer. It would be armed with surface-to-air missiles—maybe **Convair** *Terriers*.

• • •

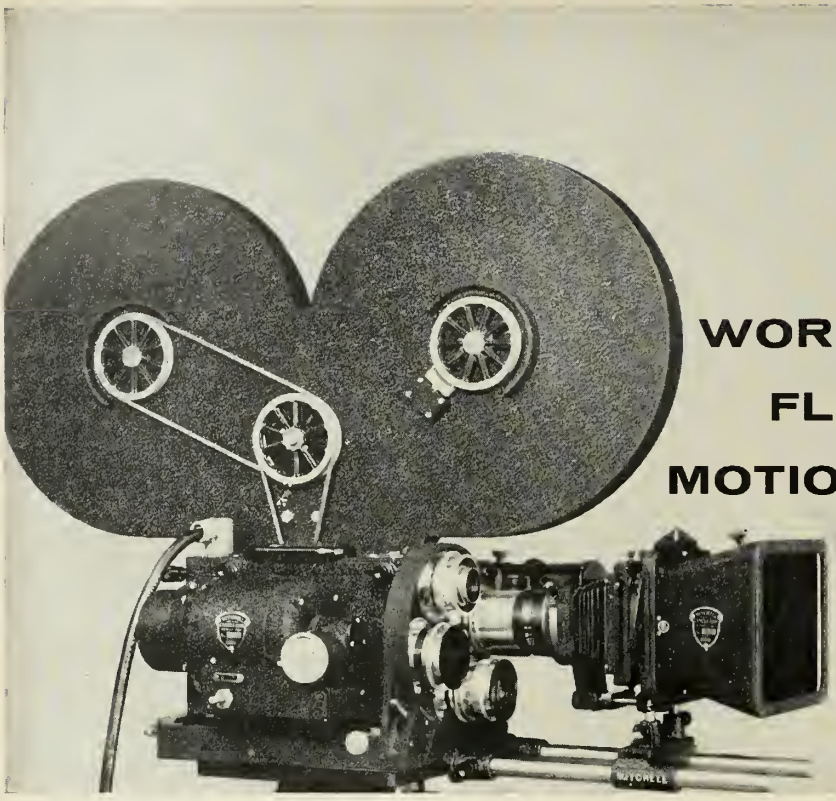
Some other reports . . .

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

. . . Defense Secretary Neil H. McElroy is planning to resign by Jan. 1, at the latest.

. . . NASA Chief T. Keith Glennan will stick out the Eisenhower Administration in his post despite rumors that he also will resign soon.

. . . Western Europe wants to confine its space programs at least for the present to R&D.



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Mitchell camera shown with 1200' magazine.

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No other motion picture camera is today used for such a broad range of exacting film making as is the Mitchell. The versatile speed of the camera, ranging from 1 to 128 frames per second, plus 14 exclusive features equip the Mitchell for an impressively broad range of cinematography. A single Mitchell can meet the requirements for finest quality TV commercials, feature productions, public relations, sales and training films, progress and report films, plus critical research and development data and record photography.

Mitchell cameras include: 35mm and 16mm cameras; 70mm 2¼ x 2¼ high speed cameras; and 70mm, 65mm and standard aperture cameras.

For information, write on your letterhead—please indicate which model camera your request concerns.

GENERAL ELECTRIC uses Mitchell for wide range of work, including slide films.

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Mitchell Camera Corporation, 666 West Harvard Street, Glendale 4, California

Industry Countdown

MANUFACTURING

Competitor to NASA's *Scout* . . .
space vehicle is being pushed by **Grand Central Rocket Co.** The all-solid three-stage GCR *Envoy* would cost $300,000 per flight vs. $500,000 for *Scout*. *Envoy* would be 37.8 feet high, weigh 17,000 pounds and be capable of sending a 50-pound payload to the moon or orbiting 230 pounds at 300 miles . . . GCR also is developing a high mass ratio solid motor for NASA called "Wolf" which the company expects will "revolutionize the satellite launching technology." Object: cheaper upper stage rockets.

• • •

Inside AF pressure . . .
for more spending on the **North American** air-to-surface *Hound Dog* is being stepped up. This bird may be the mainstay of AF "missile mobility" until it gets the long-range **Douglas** ALBM.

• • •

Dyna-Soar contract decision . . .
is still four or five weeks away while ARDC takes more "long looks" at booster designs of competing **Boeing** and **Martin-Bell** teams. Summer-long delay in making the R&D award also is attributable in part to forthcoming ARDC reorganization and possible policy change wherein AF procurement officers would have greater in-house management capability and responsibility.

• • •

Women's underwear mesh . . .
nylon closure may be the answer to weightless walking. USAF space medicine chief Col. John T. Stapp told M/R at London IAF Congress his team is testing out "Velcro" as substitute for suction cups or magnets. The material consists of thousands of small nylon fishhooks which interlock as strong as a zipper when pushed together, and are easily disengaged. The idea is to line the interior of a space ship with the material and also the soles of the spaceman's shoes so he can obtain traction.

PROPULSION

New high-thrust fuel . . .
has been patented by **Dow Chemical.** It's a mixture of an oxidizer and 2-propynyl hydrazine. The compounds 1,1-bis (2-propynyl) hydrazine, 1 methyl-(2-propynyl) hydrazine, 1-ethyl 1 (2-propynyl) amine, dimethyl (2-propynyl) amine, and allyl (2-propynyl) amine are also claimed as alternatives within the invention.

Big boost for composites . . .
is seen in 15% price slash on ammonium perchlorate—most widely used solid rocket oxidizer. **American Potash and Chemical Corp.,** principal AP producer, last week cut its quotation from 34 to 29 cents per pound FOB Henderson, Nev. Missile programs will use between 9000 and 15,000 tons of AP this year; thus the price cut may mean a saving of about $1 million.

ASTRIONICS

High-density pulse-packing . . .
techniques in a lightweight magnetic tape recorder are reported successful in a new system devised by **Consolidated Electrodynamics** and **Douglas Aircraft.** The 100-pound digital recorder handles 1500 bits/in. on each of 16 tracks. With 1-inch tape this provides total capacity of 2.4 x 10^9 bits.

• • •

System can sample . . .
100 primary channels each at a frequency response of 100 cps for a one-hour test. It is designed for PCM/FM telemetry compatibility.

SPACE MEDICINE

Men garbed in coveralls . . .
have survived five minutes in an oven with the air temperature at 300°F and the walls at 500°F in new tests of human endurance. Tests now also show the body can withstand 16.1 g's for 15 seconds during 4-minute run-up and back with the subject supine and without a water jacket.

WE HEAR THAT—

AC Sparkplug is readying . . .
a major plant expansion at Milwaukee and Flint. The company will add nearly a quarter-million square feet to consolidate its defense engineering facilities under one roof at Milwaukee . . . **Space Technology Laboratories** is officially denying rumors that it is about to be bought by **Ford Motor Co.** . . . However, it is known **Twin Coach's Aircraft-Missiles Division** is in the market for acquisitions and mergers . . . Anticipating a big increase in space/missile beryllium usage, **Beryllium Corp.** is expanding its Hazleton, Pa., facility to install three vacuum hot press furnaces to produce billets from 6 to 45 inches in diameter and up to 60 inches long.

More About the Missile Week on Page 44

HOW BLOODHOUND

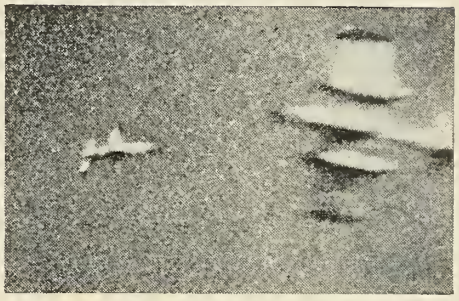
FOR

WEAPON DESIGN AND CONSTRUCTION BY BRISTOL · GUIDANCE AND CONTROL BY FERRAN

PROVIDES

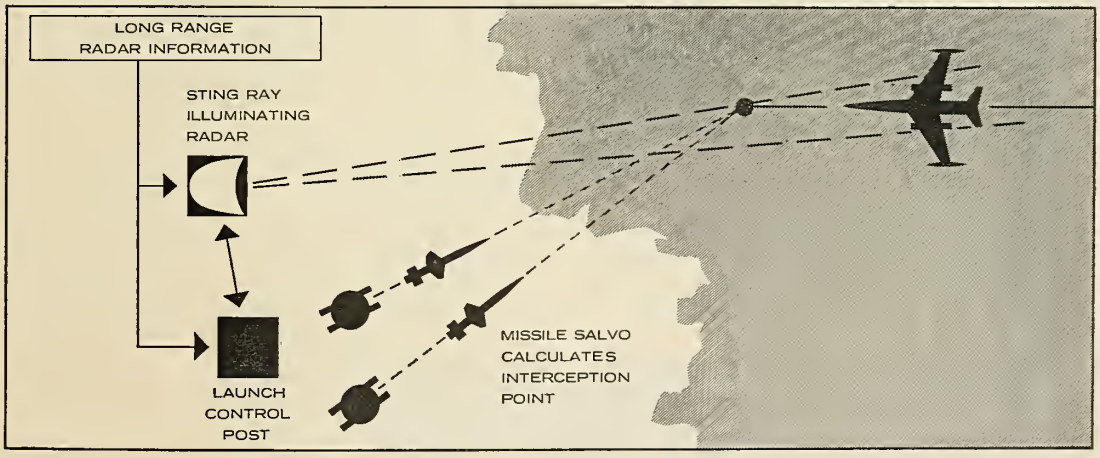
DEFENCE

Surface-to-air guided missiles represent the most important advance in defence against air attack since aerial aggression began. These unmanned interceptors are not committed to a predetermined course, but, even after launching, take corrective action against target aircraft evasion.



READY NOW

The World's most effective surface-to-air guided missile system is Bloodhound. Already in operational service with the RAF and adopted by non-NATO Sweden. Bloodhound is now to be further developed for the RAF. Bloodhound has been proved in many hundreds of test firings. It exists for defence—*now*.



WHAT BLOODHOUND PROVIDES

By using radar intelligence, enemy aircraft may be allocated for interception either to Bloodhound missiles or to manned fighters.

Essentially a deterrent designed to frustrate not to initiate aggression, Bloodhound contributes to air defence the advantages of very effective high fire power which is always available for action at a moment's notice. And the development of Bloodhound is still in its infancy.

Now—and for many years to come—Bloodhound provides the world with its most impregnable defence system.

BRISTOL/FERRANTI

Bloodhound

GUIDED WEAPON SYSTEM

RGET ILLUMINATING RADAR BY BTH · SYSTEM SALES ORGANISATION BY BRISTOL AIRCRAFT LIMITED

MOVING AHEAD----

"TO PROVIDE FOR THE COMMON DEFENSE"

Only by conceiving today the weapons which will be needed tomorrow; can the free world continue to preserve the peace—or successfully meet an attack.

TIME IS OF THE ESSENCE!

ANOTHER STEP FORWARD

To cope successfully with this urgent and continuing problem, RCA recently extended to a corporate-wide basis the techniques which had been proven successful within its various departments, by creating an *Advanced Military Systems* organization at Princeton, New Jersey. There, in an atmosphere of intellectual freedom, a group of mature scientists and engineers are engaged in the analysis and study of our national defenses—present and future—and how they can be made most effective to meet any future enemy capability.

These studies are conducted at the frontiers of knowledge and encompass such areas as the physical and engineering sciences, military science, economics, and geophysics. Studies have, as an end result, the creation of military systems which will satisfy projected military requirements.

A SPECIAL KIND OF MAN

Members of the technical staff are at the highest creative and intellectual level. They have a degree of maturity which comes only with many years of experience. They generally have held responsible positions in research, advanced development, or systems planning. Most of them have an extensive background in the broad fields of electronics, vehicle dynamics, physics (astro, nuclear, or plasma), or military science (operations research). All are temperamentally suited for performing highly sophisticated, comprehensive analysis and planning of a detailed nature. They are men who enjoy seeing the fruits of their work turn into realities that have an extensive effect on the defenses of the country.

A SPECIAL KIND OF CLIMATE

Each member of the technical staff operates either independently or in a loosely organized group, and is generally free to select his own area of work. The only condition: results must have a direct application to problems of national defense. He has no responsibility for administrative details, although he must be ready to give guidance to program implementation. He can call in any specialists he may need. He has full access to all available information—military, academic and industrial. Specialized research projects and laboratory work can be carried out at his request by other departments of RCA. In a word, he is provided with every opportunity and facility to use his creative and analytical skills to maximum advantage and at the highest level.

A SPECIAL KIND OF ENVIRONMENT

Princeton offers unique civic, cultural and educational advantages along with the convenience of its proximity to New York City. In this pleasant environment, Advanced Military Systems occupies a new, air-conditioned building on the quiet, spacious grounds of RCA's David Sarnoff Research Center. Working in individual, well-furnished offices, staff members find their total environment highly conducive to creative activity.

INQUIRIES ARE INVITED

If you are interested in learning more about this far-reaching program, write:

Dr. N. I. Korman, Director,
Advanced Military Systems, Dept. AM-11
RADIO CORPORATION OF AMERICA,
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EQUAL JOB OPPORTUNITY For All Qualified Applicants

RCA

RADIO CORPORATION of AMERICA

How Missile/Space Spending Enriches the Peacetime Economy

Survey shows that the nation is already benefitting greatly in new goods, techniques and industries

Finding that little or no research material on the subject was available, Missiles & Rockets last spring sent questionnaires to several hundred companies in the missile and space fields, asking which of their products developed during defense or space research had resulted in products or techniques for peacetime usage. The survey resulted in the story which follows. We realize that the survey is far from complete and would welcome further information; the field—now and potentially—is almost limitless.—Editor.

by Edward J. Michelson*

WASHINGTON—Vast U.S. government spending during the past Cold War decade for missile and space research, technological military development, testing and space exploration activities is beginning to yield tremendous dividends in terms of American economic growth.

The nation has spent billions for research and development in these fields. The current R&D budgets alone for the Department of Defense and the National Aeronautics and Space Administration total more than $4.2 billion. Of this more than $2.4 billion is for missiles and space activities.

From this Cold War research, quantities of new consumer goods, services and industrial processes are now appearing on the American scene. Even new industries have appeared as the results of inventions, techniques and knowledge gained since the dawn of the Space Age.

One of these is the computer industry. Computers were developed as a result of military demands for faster figuring and the industry itself has developed as a result of the even greater demands imposed by missile and space operations.

Companies of virtually every size and description participating in missile and space programs today are alert to the opportunities for new industrial, commercial and consumer ventures growing out of their work.

The firms surveyed by M/R range in size from **General Motors** to small electronics companies founded in the first half of the now-ending 1950's. In numerous cases, newcomers in nucleonics, avionics, metallurgy, "hardware" production and plastics are planning to promote goods and services for industrial and consumer use even though the enterprises don't have sales promotion or marketing staffs. Their sole customer until now has been Uncle Sam.

One Space Age supplier, **North American Aviation, Inc.**, has gone to the length of establishing a subsidiary, **Navan Products, Inc.**, for the specific purpose of marketing its own and others' inventions.

Evidence that military-supported scientific and technological advances have already resulted in new goods now under development abounds. **Westinghouse Electric Corp.** is actually showing three prototype appliances in television commercials—thermoelectric devices for cooling and heating. Thermoelectric research has been a company interest sporadically since 1937, but it was Navy and Air Force requirements for highly efficient, lightweight prime energy sources for space vehicles that spurred this development.

Corning Glass Works cites an impressive array of products ranging from Pyroceram skillets and pans to silicone rubber interlayer material, making possible "windows" capable of resisting Mach 2 temperatures (approaching 500°F). Emphasis is on improved glass-making technology and higher quality materials for myriad uses including nuclear food preservation and power reactors.

• **Born of WW II**—Corning developed a mass-production process for the manufacture of optical glass to meet military needs during World War II. The company's scientists developed platinum-clad melting chambers and blending machines that made possible an unprecedented production rate of 50 pounds of optical glass per hour.

In the ensuing years, the process was adapted to production of optical blanks of all sizes—for use in lenses for bombsights, periscopes, aerial cameras, wind tunnel windows and missile-tracking optics. (See cover picture.)

The production technique allowed Corning to go into peacetime production of low-priced, high-quality lenses for spectacles, telescopes and cameras.

The chief accent of management men responding to a survey questionnaire is on development of better, more durable materials, more reliable manufacturing techniques and increased product reliability. This reaction is inevitable; American businessmen have traditionally excelled in developing engineering ideas aimed at offering end products of higher quality, greater utility and minimum unit manufacturing cost.

In the missile and space field, gains

MATERIAL developed for radomes was made into a tough line of kitchenware by Corning Glass Works.

**Edward J. Michelson is Washington correspondent of Forbes and Printer's Ink magazines and a contributor to other general and business publications. He has been a national capital press corps member since 1946.*

have been made in such areas as materials, electronics, equipments, medicine, propulsion, communications, aeronautics, air traffic control and navigation, and knowledge of human psychology and physiology.

• **Competitors reluctant**—For obvious competitive reasons, some firms are none too communicative. This is especially true of the motor car manufacturers. **Chrysler Corp.** acknowledges that its propulsion work for satellite vehicles is bound to generate scientific and engineering suggestions to be considered ultimately for application to its

'SWORDS INTO PLOWSHARES'—SOME EXAMPLES

COMPANY	MILITARY USE	CIVILIAN USE
Stalker Corp., Essexville, Mich.	Jet Engines (for GE)	Jet engines
Rahm Instruments, Westbury, N. Y.	Pressure transducer for Vanguard	Commercial pressure measurement systems
RCA, Los Angeles	AF and Navy weather radar, including Loran; Navy beacons	Commercial Airlines
	Ground weather radar for AF	Weather Bureau, radio-TV stations
	Micro-miniature Army transmitters and receivers	Police and Doctors
McCormick Selph Assoc., Hollister, Calif.	Explosives	Several products applicable, but no action so far in exploiting commercial market.
Summers Gyroscope, Co., Santa Monica, Calif.	Target Drone Autopilot	Inexpensive pilot assist and safety device for private aircraft.
Allegany Instrument Co., Cumberland, Md.	Electronic integrators and amplifiers; equipment for measuring low-level electrical signals from thermocouples, load cells, and pressure cells used to evaluate performance of solid fuel rockets at static test facilities.	Medical research to measure body temperature and blood flow.
Stavid Engineering, Inc., Plainfield, N. J.	AN/FMS-3 designed to receive, locate and plot lightning flashes, over a 2,000-mile radius. Six satellite receivers take in and simultaneously transmit data by telephone wires to central receiving and plotting station where lightning flashes are plotted on a cathode ray tube. Overlays are marked by a monitor to show movement and location of fronts.	For Weather Bureaus. The system is being installed in the Tornado Belt to detect severe atmospheric disturbances.
General Precision Laboratory, Inc., Pleasantville, N.Y.	Radan (radar doppler automatic navigator) for military aircraft	Radan 500 for business and commercial aircraft
ECO Engineering Co., Newark, N.J.	Inert thread sealing compound, developed for Redstone Arsenal.	T-Film thread sealing and anti-seize compounds for pump manufacturers serving process industries.
Miskella Infra-Red Co., Cleveland, Ohio	Atlas Satellite	New Infrared appliances, i.e., lamps, hot dog roasters, switches, ovens.
Fairfield Engineering Co., Marion, Ohio	Automatic control components	Proximity switches, plugs, valves, cylinders, and other components already are an integral part of industrial conveyor systems.
Filtors, Inc., Port Washington, N.Y.	High environmental reliability	Improved commercial airliner equipment, for high reliability of operations.
AVCO Lycoming Div., Stratford, Conn.	T-53 and T-55 Gas Turbines for Army and Air Force	Engines for helicopter field. Marine and industrial versions.
Frank R. Cook Co., Denver	Silver-zinc batteries developed for guided missile power	Ideal for portable and airborne applications requiring small size and light weight.
Rosemont Engineering Co., Minneapolis	Variety of precision platinum resistance temperature sensors developed for missiles	Any industrial or commercial applications in which higher accuracy and stability is needed for temperature measurements.
B&F Instruments, Inc., Philadelphia	Accelerometers for aircraft and missile flight tests; torquemeters to test missile components; strain gauge control equipment for aircraft and missile structural testing.	Univ. of California auto crash tests use these accelerometers; other instruments are in use in motor testing, shipbuilding and bridge construction.
Fairchild Engine and Airplane Corp., Hagerstown, Md.	Armalite C-82 Radar	Armalite principle in civilian guns. Cargo carrier in South America. Proximity warning device for aircraft.
Miles Reproducer, Inc., New York, N.Y.	Recording equipment	Automatic voice recorded started and stopped by sound of voice; "Walkie-Recordall"—miniature conference recorder-transcriber.
Edgerton, Germeshausen and Grier, Boston	Milli-mike traveling wave oscilloscope for Atomic Energy Commission.	Now available for laboratory purposes, to measure high-speed electrical phenomena occurring in less than one millimicrosecond.
Southwestern Industrial Electronics, Houston	Miniatured electronics and bearings (a Division of Dresser Industries)	For portable radio and TV; microminiature roller, needle, and ball bearings for such equipment as compressed air-turbine dental drills.
Marblette Corp.	Epoxy Resin #617—missile application Epoxy Resin #341 in atomic submarine construction	For plastic tooling, metal bonding adhesive plus casting and laminating applications; #341's primary distinction is protection against radiation.
B. F. Goodrich Aviation Products, Akron, O.	New fabric-laminated tire treads	
Nacimac Products San Diego, Calif.	Film resistance thermometers	For animal and human temperature measurements.
AMP, Inc., Harrisburg, Pa.	Solderless wiring connectors	
Don-Lan Electronics, Inc. Santa Monica, Calif.	Coaxial switches, waveguide switches, antennas	Most microwave components
General R. F. Fitting, Inc., Boston	R F coaxial connections	
G. B. Electronics, Inc., Valley Stream, L.I., N.Y.	Tracking antenna systems, SVE arrays, infrared devices	Scatter communications systems for networks; infrared detection systems for aircraft and other testing.
Corning Glass Works, Corning, N.Y.	Silicones for electric motor insulation, subzero lubricants, water-repellent and weather-	Better glassmaking technology for myriad products.

commercial product lines.

General Electric also is reluctant to speak in general terms of the potentialities of its space work assignments for other manufacturing divisions. GE regards space travel as an extension of terrestrial travel. GE also points to benefits in the development of materials—metallic and otherwise—which make possible recoverable nose cones capable of withstanding the stresses and strains of re-entry.

• **Sizing up markets**—Volume procurement of lithium has brought down the price, sparking producers' thinking

COMPANY	MILITARY USE	CIVILIAN USE
Corning Glass Works, Corning, N.Y. (Cont.)	resisting coatings; resilient rubberlike plastic	
	Fused silica in radar delay lines	Wind tunnel windows, crucibles and laboratory instruments.
	Optical blanks for aerial camera lenses and wind tunnel windows	Radiation shielding windows
	Ribbon glass for capacitors	For electronics capacitors now in use.
	Radar bulbs	Air traffic control equipment.
	Dosimeter lockets	For nuclear food preservation.
	Ceramic reactor fuels	Power reactors.
	Pyroceram—in missile radomes	For skillets, pans and other utensils.
Nortronics, Inc., Hawthorne, Calif.	Voice interruption priority system	Process control warnings; verbal assembly line production control
William Brand & Co., Willimantic, Conn.	Turbo Ribbon cable for missiles	For communications systems and electronic components generally
Fairchild Camera and Instrument Corp., Syosett, N.Y.	Airborne radio compass Automatic gun cameras	Commercial aircraft Surveillance cameras in banks, toll booths, etc.
	T-11 Cartographic Aerial Mapping Camera	Commercial mapping firms
	35mm and 16mm mini-rapid film processor	For television newsfilms and commercials, industrial films
SKF Industries, Philadelphia	Quiet running bearings for underwater craft	For electric motors; all precision, special tolerance and unique design bearings originally made for military are now in industrial use.
Douglas Aircraft, Santa Monica, Calif.	Data reduction techniques, camera equipment and films, miniaturization of electronic components.	
Essex Mfg. Co., St. Louis	Cryogenic disconnects, pressure switches, check valves, pyrotechnic components; Liquid nitrogen missile disconnects; liquid propane refrigerant disconnects.	All are in industrial use
Aeroquip Corp., Jackson, Mich.	Hoses of Teflon for jet aircraft, missiles and launchers.	Extensive industrial steam-carrying and chemical uses.
Chemalloy Electronics Corp., Santee, Calif.	Fluxless aluminum soldering	For kitchen utensiles repair, gutters, flashings, TV antennas, electrical joints, auto repairs, fencing, milk cans, silos.
American Brake Shoe Co., New York, N.Y.	Machinable manganese steel for use as fittings in minesweepers	For structural components for electric power equipment and heavy electronic gear.
	Ultra-high strength steel castings for missiles and airframes	For lightweight, complex shapes in structural components requiring High dimensional accuracy, exceptional strength and complete reliability.
American Brake Shoe Co., New York, N.Y. (Cont.)	Lightweight hydraulic pumps for missiles and aircraft	Industrial hydraulics, automated machinery, electro-hydraulic and hydraulic-pneumatic control systems.
Cannon Electric Co., Los Angeles	Solenoid-actuated lock mechanism on Atlas, Thor (as umbilical disconnect)	In wing flap brake mechanism of Lockheed Electra
Sanders Associates, Inc., Nashua, N.H.	Flexible printed circuitry	
DeHavilland Aircraft of Canada, Downsview, Ontario	Transistor inverter electrical power supply	Instrument inverters, power inverters, de-icers for windshields.
	Infrared devices	Cell coolers, detecting devices, tracking devices.
	Turbo-alternator electrical power supplies	Standby units for emergency air and ground electrical power
Hart Mfg. Co., Hartford, Conn.	Sensitive relays and small switches for high shock and temperature applications	Computors and sensitive industrial instruments and controls.
Rocketdyne Div., North American Aviation, Canoga Park, Calif.	Hydrazine liquid storable propellant	Drugs based on hydrazine derivatives for mental illness, tuberculosis
Propellex Chemical Div., Chromaloy Corp., Edwardsville, Ill.	Landing gear actuator for aircraft cartridge-actuated emergency truck brake Technique of explosive or blast forming of difficult-to-mold metals into intricate shapes.	
Westinghouse Electric, East Pittsburgh, Pa.	Thermoelectric power generators	Thermoelectric appliances
General Electric Co., Philadelphia	Improved materials, propulsion for space travel	
Curtiss-Wright Corp., Woodridge, N.J.	Control concepts and other research for advanced air vehicles	Various applications in industry
Raytheon Mfg. Co., Boston	Microwave systems, radar equipments	Market planning for industrial and commercial sales.
Chrysler Corp., Detroit, Mich.	Propulsion for space vehicles	Possible application in automotive industry.
Navan Products, Inc., Los Angeles	Subsidiary of North American Aviation, newly established for marketing parent company's (aircraft, missile, nuclear, rocket engine and electronic designs) and other inventions commercially.	Specializing in marketing, financing, and manufacturing of inventions, with emphasis on national sales.
Food Machinery & Chemical Corp., San Jose, Calif.	Techniques for m/r space and allied fields by company's ordnance division.	New technique for continuous welding process on aluminum.
Convair Div., General Dynamics, Pomona, Calif.	Hyge machines for shock test facilities of Lockheed, Martin, Avco, Minneapolis-Honeywell, Sandia Corp., and other firms.	Actuator for shock-testing, simulates shock for precision test needs of large and small industries.

about commercial markets. The sole commercial use that immediately comes to mind is in nickel-oxide storage batteries. **Firestone** and **Shell Chemical** are reported to be employing a lithium catalyst in synthetic rubber production. **Frank R. Cook Co.,** Denver, suppliers of silver-zinc batteries for guided missile power, look to civilian customers in need of lightweight and small (one-sixth to one-fourth the dimensions of conventional batteries) for portable and airborne applications.

Rosemont Engineering Co., Minneapolis, has only begun exploiting the market for a variety of precision platinum resistance temperature sensors developed for missiles. The company stresses the high accuracy and stability of its product for temperature measurements, in selling for all industrial or commercial applications.

• **Cases in point—Raytheon Manufacturing Co.** uses the term "fallout" for products originally designed for military needs. In World War II, Raytheon supplied three of four Allied warships with surface search radars. Today Raytheon claims to be the largest single producer of such equipment for the world's merchant shipping and passenger liners.

In little more than three years, Raytheon's payroll has increased from 18,000 to 39,000. Where its ratio of government to non-governmental activity was 60-40% in 1956, company responsibilities for the *Falcon* and *Sparrow III,* among other systems, have increased the ratio to 85-15%.

With an eye to the future, Raytheon's market planners are concentrating on resources which, combined with capabilities of companies Raytheon has been acquiring, will make the company name as familiar in commercial marts as it was before its radio-TV operations were sold to **Admiral Corp.**

A major rubber company, whose identity is withheld by request, reports that a high-speed, fabric-laminated tread tire used on recoverable test missiles is also being sold now for commercial jet aircraft. **Marblette Corp.,** producer of resins for missile and rocket applications and atomic submarine construction, cites civilian uses for each type. One is already popular in plastic tooling, metal-bonding, adhesive and casting, and laminating operations; the other, in high-density casting compounds. The latter type resin is lead-filled for barriers against radiation.

SKF Industries is now producing for non-Government users all precision, special tolerance bearings for electric motors, including those of unique design, that the military had to have. Both Air Force and Navy needs have contributed greatly to such advances. A major Air Force contribution in recent years was the technique for plating nickel and tin-indium without electrical current to prolong the life of friction bearings and similar parts.

• **Peace-to-war-to-peace**—The interrelationship of peaceful industrial research and that for defense is graphically illustrated in the case of Westinghouse Electric's interest in thermoelectrical developments.

The company began to study the possibility of converting electricity directly to heat in 1937. By 1939, the Westinghouse Exhibit at the New York World's Fair was showing thermocouples demonstrating this principle.

Early in the 1950's, management's imagination was fired by the possibility of thermoelectric household appliances which would be highly efficient, have no turning parts, nothing to wear out. The intensive laboratory activity for the next three years centered on a small but highly dependable prime source of electricity, a generator that would be gas-fueled at first but eventually nuclear-fueled.

The Navy happened to be in the market for such a power generator. Since Westinghouse had acquired considerable experience and knowledge in this field, the company was put to work. The objective: to build a lightweight, highly efficient generator capable of performing the selective cooling required for electronic gear in aircraft and in equipments such as those used in the Arctic for communications networks.

The advent of the Space Age heightened the need for power generators for satellite vehicles. Westinghouse is subcontractor in this connection for projects on which **The Martin Co.** and **Minnesota Mining and Manufacturing** have prime responsibility. Westinghouse also has an Air Force order for a TAP-100 (Terrestrial Auxiliary Power —100 watts) generator for remote locations such as the Arctic. Ultimately, such equipment, relying on nuclear fuel, can power relay stations for round-the-world communications.

A Navy contract calls for a 500-watt generator and a thermoelectric air conditioner for shipboard use, with a capacity of one ton. This unit is a parallel development of the baby bottle warmer-cooler, dehumidifier, and refrigerator prototypes already being pictured in ad copy as part of Westinghouse's projected line of thermoelectric home appliances.

• **Improbable diversification**—Most Americans are not only startled by the fact that billions in Government scientific and engineering research and technological development pay off in terms of new jobs, new products, new industries and the resulting increase in economic wealth; they are also surprised to see that companies engaged in one line of manufacturing diversify into remote fields as a result of their defense activities.

The public thinks of **Food Machinery and Chemical Corp.** as a packaging business, with some ordnance work. Not generally realized is the new technique Food Machinery has for continuous welding of various types of aluminum, including those of considerable thickness.

Another example is the case of **Rocketdyne Division** of **North American Aviation,** a division created because of the Space Age. Rocketdyne produces hydrazine liquid storable propellants. Rocketdyne officials say drugs based on hydrazine derivatives have been tested in terms of treatment for mental illnesses and tuberculosis. The company gives no indication that it contemplates entering the pharmaceutical industry. But it is significant that most of the 10,000 compounds that have been introduced in medical practice since 1939—the outbreak of World War II—were available much sooner than might otherwise be the case because of mobilization requirements and wartime demands.

General Bronze Corp., a leading manufacturer of metal windows and other construction items, is preparing to spill over into the industrial and commercial electronics fields. A subsidiary devoted to space science and engineering requirements, **G.B. Electronics, Inc.,** was established less than two years ago, to develop tracking antenna systems for missile support equipment supplied by prime contractors. The company has now gone in for infrared research, with prospects of turning out highly sensitive devices for such industrial uses as the detection of flaws in the welding of aircraft.

• **Moving into aeronautics**—The aeronautics industry is eyed by numerous companies—even though some of the best-known aircraft manufacturers, such as **Douglas** and **Northrop,** are turning to such fields as data processing and reduction techniques, and systems for production control in highly automated plants, respectively.

Summers Gyroscope's inexpensive autopilot for target drones has applicability in light aircraft as a cheap pilot assist/safety device. **Avco's** Lycoming Division anticipates that within a year

it will be selling commercial versions of its T-53 and T-55 gas turbines for helicopters. Marine and industrial versions also will be offered. **General Precision Laboratory,** prime contractor for the Federal Aviation Agency's semi-automatic traffic control system, cites its radar doppler automatic navigator (RADAN 500), for sale to business and commercial aircraft. **The Stalker Corp.,** Essexville, Mich., mentions jet engines it builds for the military under GE subcontract as a line for other buyers.

RCA is optimistic as to the civilian usefulness of its radar equipment for Air Force and Navy weather studies. **Stavid Engineering, Inc.,** Plainfield, N.J., has elaborate apparatus for locating lightning flashes over a 2000-mile radius and for instantaneous transmission, monitoring and plotting of weather front locations and movements.

• **Peaceful electronics**—A vast array of precision instruments, refinements and improvements on automatic production control components, photographic equipment, and infrared appliances will go into industrial and consumer marts. **Miskella Infra-Red Co.,** Cleveland, is transferring capabilities and know-how that go into its tasks for the *Atlas* satellite to new types of electronic lamps, hot dog roasters, switches and ovens. **ECO Engineering Co.,** a Newark, N.J., supplier of Redstone Arsenal, had to develop an inert thread sealing compound for that key customer. Now ECO counts on such sealing and anti-seize compounds to appeal to pump manufacturers in the process industries.

The tremendous impetus which defense research gave to the miniaturization of electronic components continues. Dresser Industries' **Southwestern Industrial Electronic Co.,** Houston, is "transistorizing and minifying" for portable radio and television sets. In addition, Southwestern makes micro-miniature roller, needle and ball bearings for compressed air-turbine dental drills. Another missile electronics supplier, **Miles Reproducer, Inc.,** New York City, is promoting an automatic voice recorder which starts and stops at the sound of a voice, and a "Walkie-Recordall" which is a miniature conference recorder-transcriber.

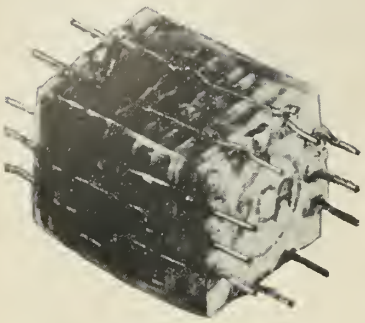
• **Long-range jobs**—An eloquent indication of the benefits to industry of current programs is the spate of large Engineers Wanted ads in metropolitan Sunday newspapers; most of the advertisers are Space Age research and development organizations.

In the hectic competition for the most desirable mechanical and electronic engineers, companies emphasize the long-range attractions of careers in their laboratories. The Propeller Division of **Curtiss-Wright Corp.,** for example, specifically mentions that the design, development and testing work available on "advanced air vehicles" and the control concepts under development have "application in industry as well as many other areas yet to be fully explored."

A few winters back, after the Soviets had orbited their second satellite, a group of U.S. Congressmen landed in Sydney, Australia, on a transpolar Antarctic flight. One of them, Rep. Torbert H. Macdonald of Boston, was properly respectful in reading of the accomplishment in a Down Under newspaper. The hotel elevator operator was reassuring and consoling. "You Yanks needn't worry," he said. "You'll do all right. And when you get your satellites going round the earth, they'll be much better. They'll be air-conditioned!"

The lawmaker from an area abounding in electronics production and research activities for the Space Agency and ARPA thinks this point was well taken. Experience has proven that every military undertaking in nuclear fission and fusion, astronautics, electronic computation and new aerodynamic and hydrodynamic R&D is from the outset destined to pay off in new skills, technologies, industries and related forms of economic wealth.

LEFT: Premier Khrushchev on his visit here may follow the same path as his deputy, Frol Koslov, shown here visiting Westinghouse's peaceful atomic power plant at Shippingport, Pa. With Koslov at the main control console is Vice Admiral H. G. Rickover, father of the atomic sub. RIGHT: This the world's first industrial atom smasher at Shippingport, a direct industrial outgrowth of the atom bomb.



Microminiaturization— A Revolution Under Way

M/R reports on a fast-developing concept that will save millions and boost reliability

by Charles D. LaFond and James Baar

WASHINGTON—Yellowish smoke rolls across the meadow and shrouds the *Lacrosse* fire direction truck.

Inside the truck the red fire button on the console flashes. The sergeant moves his hand to push it. Then he stops. The light has gone out. In its place, a trouble indicator light is flashing: A bank of binary flip-flops in the guidance computer has failed.

A private quickly removes the micro-modular bank, throws it away and inserts another. The fire button flashes again. The sergeant pushes it. Only seconds have been lost . . .

This is the micro-module concept in action.

Microminiaturization—The manufacture of highly reliable and highly standardized electronic equipment one-tenth the size of existing miniaturized equipment—is a billion-dollar technical revolution that already is beginning to sweep the electronics industry.

It is not something that is coming in the next 10 or 20 years. It will be here in full force about two years from now.

It means:

- Swift, simple "throw-away" maintenance of military electronic equipment both in combat and behind the lines.
- Saving of millions of dollars a year in military maintenance costs.
- The cramming of a maximum of 600,000 components per cubic foot into a missile, space vehicle or computer, instead of the present maximum of 50,000 or 60,000.
- Improvement of reliability by up to 50%.

The effect of this on the development of missiles and space vehicles as well as all other military and commercial equipment employing electronic components is obviously going to be tremendous.

Moreover, the effect on the multi-billion-dollar electronics industry will obviously be equally great. Nearly 100 firms have taken part in the R&D program. Nearly all others have watched it closely.

The dramatic story of how this revolution has come about starts only about 18 months ago in the laboratories of the U.S. Army Signal R&D lab at Ft. Monmouth and **Radio Corporation of America** at Camden, N.J.

The Signal Corps and RCA set out to radically improve the present level of miniaturization using only proven components available today.

They wanted components that are smaller, cheaper, standardized and easier to maintain. At the same time, they wanted a design so flexible that radically new components now under development could be absorbed into the system in the future.

The result was the micro-module concept.

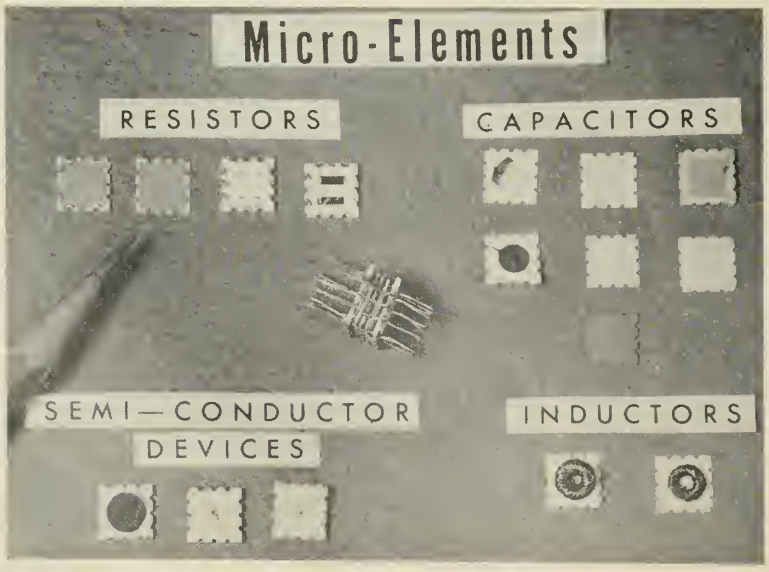
- **Program grows**—RCA began the initial design program April 1, 1958, after receiving a two-year, $5-million contract from the Signal Corps. The contract recently was increased by $2.4 million and extended another year.

The total program probably will run to about $15 million in Federal money—a bargain basement figure made possible by sizeable industry contributions.

However, a fourth year and more funds may be added to the program depending on how quickly industry assimilates the program's results.

The first year was directed to the development of the basic module-element configuration and the prototype production of various components. This year more prototype elements are being developed.

Approximately half of the total number of different micro-elements to be built are already available and are undergoing comprehensive performance tests and evaluations. In all, the program calls for nearly 5 x 10^6 unit hours of life testing.



But if you want to try, do this:

- Spend 20 years applying advanced metallurgy to production.
- Shake down 35 high-temperature alloys in the laboratory.
- Fabricate these super-alloys into critical hot-part components for prototype power plants.
- Swing into volume production of proved designs.
- Prove, over and over again, that you know what you're doing—with jet, propjet and piston engine components and afterburners, ramjets and rocket motors.
- Make your name a byword for high-temperature research and development... for precision-made components and complete power packages.

Better still—take a 20-year stride by putting Ryan to work on your heat problems.

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solid propellant motor ever test-fired in the free world . . . unleashes more than 400,000 lbs. of thrust in static firing!

400,000 pounds of thrust—power enough to deliver the instant reach of high altitudes needed for effective defense.

While the Zeus booster stands as the most powerful solid propellant motor now on record, it in no way represents the ultimate capability of present THIOKOL facilities. Current capacity includes motors still larger—of ICBM and even satellite size.

Under Army direction, and in cooperation with Douglas Aircraft, THIOKOL development in the Nike program has advanced the science of rocket propulsion.

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DIMAZINE is stable and non-corrosive during storage . . . is not shock sensitive . . . has high thermal stability, low freezing point, minimum susceptibility to contamination and high compatibility with most metals and appropriate sealing materials.

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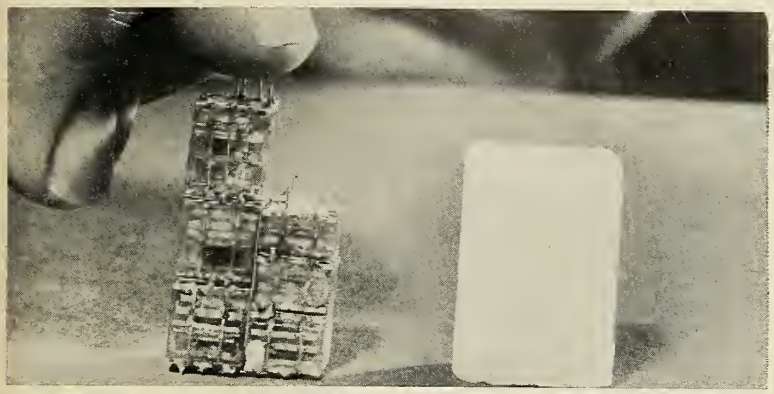
industrial sources are established . . .



COMPRESSED into size no larger than a sugar lump, this military radio illustrates the progress achieved in the Army micro-module program. Receiver is made of micro-modules, circuit building blocks 1/3″ square promising reduction of at least 10:1.

Beginning this year and through the third year of the developmental program, somewhat more than $3 million also will be required for construction of two equipments employing micromodules. Finally, in the third year, a mechanization phase will be entered during which approximately $5 million will be needed to develop pilot production. This includes necessary equipment for automation and the overall evaluation of the completed modules and the two equipments.

• **The concept**—Essentially, the micromodule system is based on the use of very thin wafers connected in a building-block fashion to make miniature cubes of functional circuits.

To lend itself to automatic manufacture, a notched wafer design employing round riser wires was first selected. Internal wafers were specified to be 0.310″ x 0.310″ x 0.010″. End wafers were limited to 0.350″ x 0.350″ x 0.020″. Riser wires were set at 0.013″ diameter and when coated with solder were limited to a maximum overall diameter of 0.014″.

In the assembly of micro-elements to form a micro-module, a 0.01″ space is allowed between each element to provide electrical decoupling. This also provides an allowance for joints and tolerances.

Two types of micro-wafers currently are being evaluated. The original notched design and a notchless design connected by means of flat ribbon conductors.

The micro-elements made from the wafers may be single- or double-sided and other variations provide for adaptability of all the basic components to the micro-element form.

In all, 14 elements have been completed so far. Seventeen types will be made available during the latter half of this year.

After assembling the micro-elements and after completing all of the internal interconnections, modules are then sealed by molding or encapsulating to form a solid body. Encapsulation provides standardization, structural strength, easy handling and environmental protection.

STYCAST 2651 epoxy resin is used as the encapsulant. **Dow Corning** 271 element silicone adhesive resin is used as the inter-face coating. The uniform shape which results from this type of assembly provides a unique standardization.

• **Future assured**—Circuit areas in which microminiaturization capability has been proved include RF, IF, audio and digital. But most important of all, microminiaturization as a concept is an integration vehicle no matter what new components evolve in the future.

Service test models of the first microminiaturized equipments should be completed by April, 1962. One will be a typical tactical radio communication set; the other, a typical tactical computer.

Semi-conductor devices were selected for the active circuit elements in all of the micro-modules. The inherent small size of transistors and other semi-conductor devices lends itself well to the microminiaturization program and a great majority of all electronic circuits employed today are capable of being transistorized.

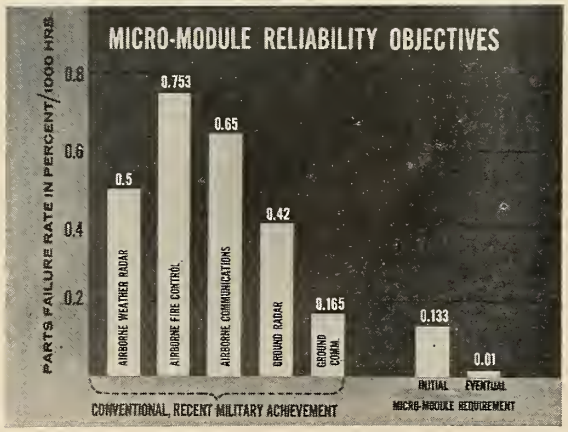
In the future, it is possible that almost all circuits operating at low and at medium power levels will employ transistors and other semi-conductor devices. Of course, the reduced power consumption also makes semi-conductors well suited for micro-module applications.

A great deal of progress has been made in the fabrication of the micro-elements themselves and, in line with this, industrial sources for these elements have been established.

• **Setting sights**—With transistors and semi-conductor diodes certain limits necessarily had to be established. For

ACCEPTANCE TESTING SUMMARY

TEST	SUBASSEMBLIES	MODULES (Total)	ELEMENTS (Total)
LIFE (2000 HRS.)	20	405	6176
SHOCK (50G) VIBRATION (55 CPS) SALT ATMOSPHERE	12	40	457
TEMPERATURE CYCLING MOISTURE RESISTANCE	12	40	457
ALTITUDE (150,000 FT.) VIBRATION (2000 CPS)	12	40	464
SHOCK (15,000 G) SPIN	12	32	442
STORAGE (2000 HRS. MIN.)	--	32	354
TOTAL	68	589	8350



instance, in the preliminary module design work, four equivalent type transistors were designated. Semi-conductor diodes were limited to three types.

As indicated earlier, the primary consideration in the development of micro-modules has been a vastly improved reliability. The initial goal was to achieve an average part failure rate of 0.1% per thousand hours of operation. Another goal was the establishment of a 50-part complexity level capable of operating in a temperature range of from –55°C to +85°C for more than 15,000 hours. It is believed with the goals established for micro-module reliability an increase of at least 50% will be obtained over the best equipments now in use.

• **Varied benefits**—The future of microminiaturization both militarily and commercially is as broad as the field of electronics.

Army experts feel that wherever size is a factor, micro-modules will be used. Moreover, there are the large economies possible through the cutting of maintenance costs and the possibility of large-scale production.

Space exploration will be one of the first areas to benefit from microminiaturization. Ten times as much electronic equipment will be jammed in satellites of the near future. U.S. astronauts will go into orbit with far more electronic equipment including much larger computers than were previously possible.

The "throw-away" maintenance provided by microminiaturization is precisely what is needed for Missile Age nuclear battlefields.

The rapid massing and dispersal of troops called for by the tactics of nuclear warfare eliminate any possibility of lengthy maintenance work on equipment. The chances of operating large maintenance depots behind the lines are non-existent.

As for other applications, the Army already is reviewing all future equipment designs for possible use of micro-modules. Industry is certain to do the same thing for many commercial items such as radios and TV sets.

Meantime, the Air Force and Navy are kept informed of developments in the micro-module program and can be expected to adapt the results to their uses.

• **Ultimate** uses—The great promise of the microminiaturization concept beyond the immediate future is its expected ability to encompass many of the revolutionary developments seen on the horizon.

Ultimately, active and passive circuit elements probably will lose their identities completely. It is believed that they will be replaced by active volume elements—those emitting an energy flux at a desired frequency—and by passive volume elements—those storing or dissipating such energy.

In the interim period, functional design modules will be categorized by performance, but identity as distinct circuit elements, no matter how complex, will be retained.

As parts densities and functions increase per unit volume, new nomenclature may evolve. It has been suggested that the next step will probably be tagged with the unwieldy "milli-micro-miniaturization." Finally, "Angstronics" may be the most descriptive word for more advanced programs.

We are now feeling our way toward an outer understanding of the solid-state era into which we have gained entry. So-called molecular electronics has provided a whole new concept in utilizing semiconductors.

New components employing equivalent or functional circuits are being born daily:

• Silicon Trigistors, by **Solid State Products, Inc.**, has a triggered bistable transistor with characteristics comparable to a flip-flop or bistable multivibrator.

• **Texas Instruments** with its Semiconductor Solid Circuits has developed single-crystal functional circuits providing equivalent components densities of more than 3×10^7/cu. ft.

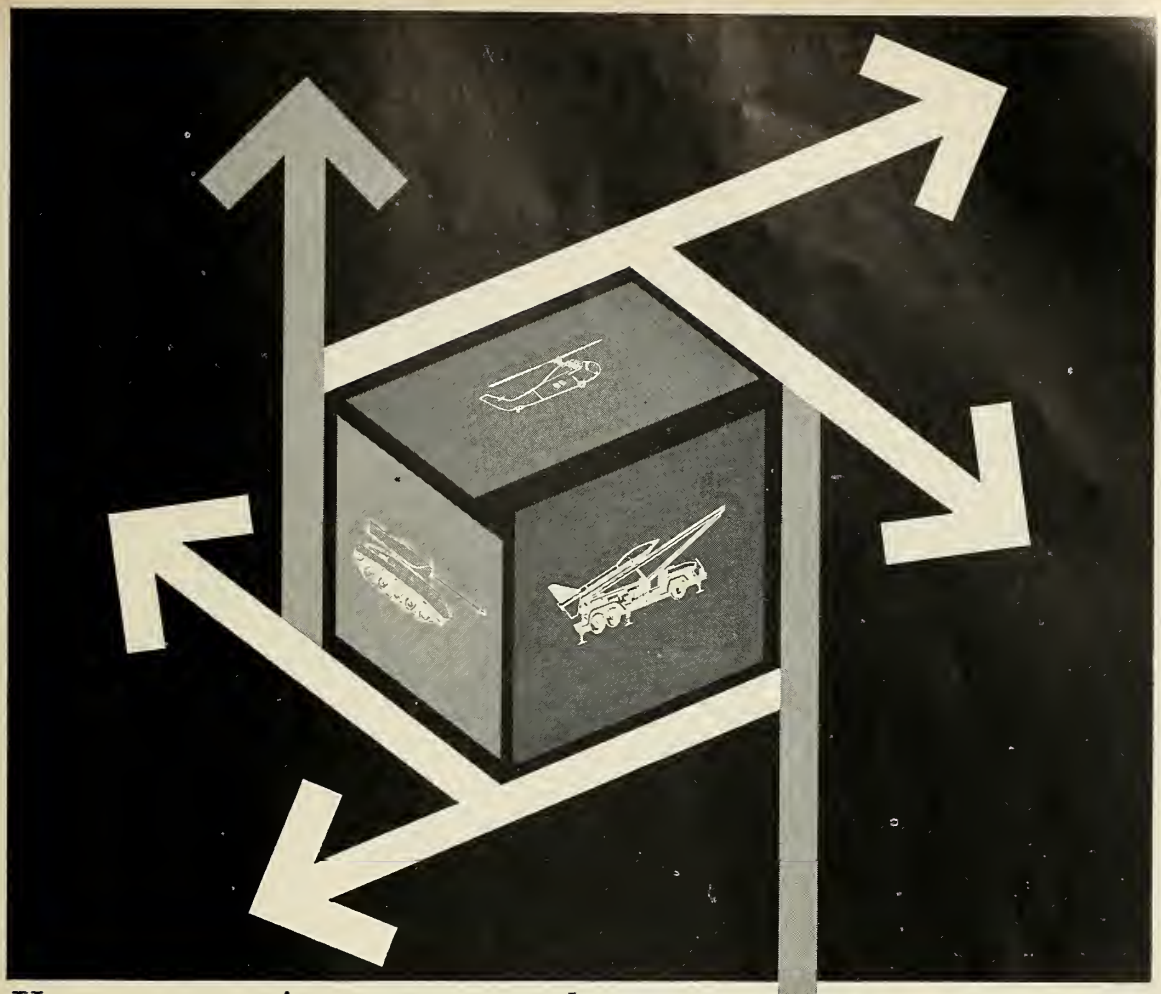
• **Westinghouse,** with its Moletronics, is achieving similar results by controlling crystalline structural arrangements in "growing" solid state ribbons. Many complex circuits have evolved. Currently it is applying Peltier-effect techniques for heat stabilization in more advanced circuits.

• **General Electric's** tunnel diode shows great promise for the future.

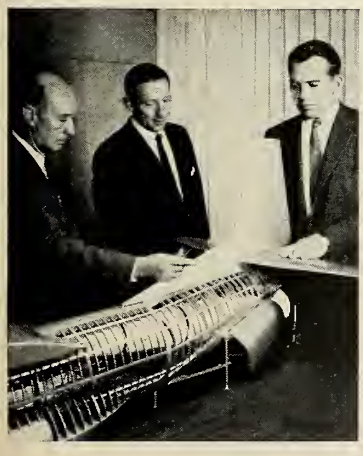
These are but a few of the future "components." In time, all can be utilized in microminiaturized equipments without changing today's concepts of the program.

Micro-Module Program
RCA, prime contractor

COMPONENTS	PRINCIPAL SUBCONTRACTORS
Resistors	Weston Instrument Div., Daystrom Inc.
Capacitors	Sprague Electric Co. P. R. Mallory & Co., Inc.
Transistors	Philco Corp., Lansdale Tube Co. Div.
Semiconductor Diodes	Pacific Semiconductors Inc. General Instrument Corp.
Quartz Crystals	Midland Manufacturing Co.
Substrates	American Lava Co. Coors Porcelain Co.



How to put wings on a warehouse



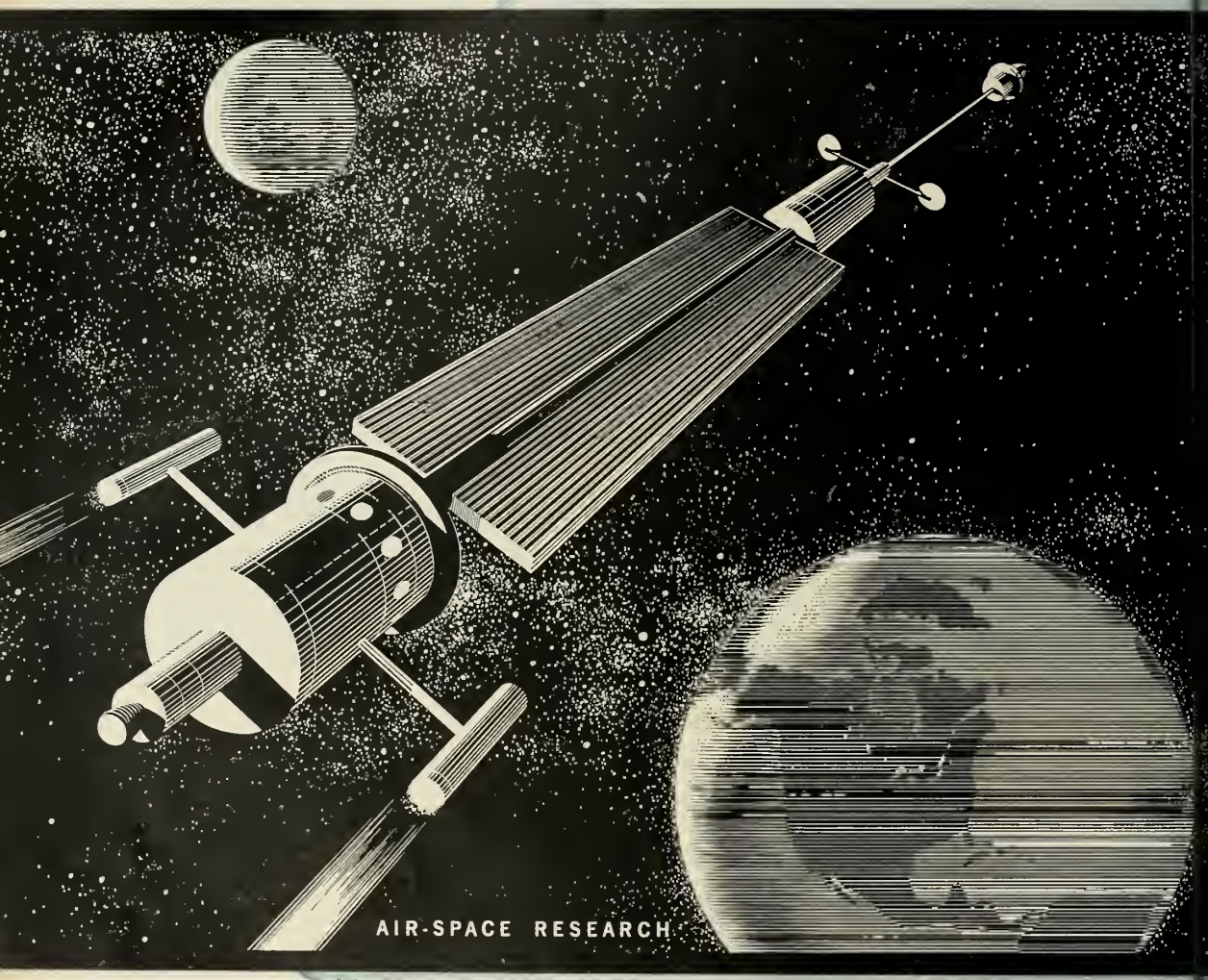
Giving overseas air bases what amounts to local warehouse service on important parts is an Air Force objective. Its present system has slashed delivery schedules up to *20 times*...saved taxpayers several *billion* dollars over the past decade. To improve it further, Douglas has been selected to develop specifications for a comprehensive Material Handling Support System involving better communications, control, cargo handling and loading, packaging and air terminal design. Douglas is well qualified for this program by its more than 20 years in all phases of cargo transport. Air logistics is only one area of extensive Douglas operations in aircraft, missile and space fields in which outstanding openings exist for qualified scientists and engineers. Some are listed on the facing page.

Schuyler Kleinhans and Charles Glasgow, Chief Engineers of the Santa Monica and Long Beach Divisions, go over air transport needs relating to advanced cargo loading techniques with Donald W. Douglas, Jr., President of DOUGLAS

'ETLINERS ■ MILITARY AIRCRAFT ■ CARGO TRANSPORTS ■ MISSILE SYSTEMS ■ SPACE SYSTEMS ■ AIRCOMB ■ GROUND-HANDLING EQUIPMENT

New Concepts for the Space Age
Mark 15 Years of Progress by MARQUARDT

When founded in 1944, Marquardt was an organization devoted exclusively to research and development of the ramjet propulsion principle. Today, in its fifteenth year, the Corporation employs more than 5,000 in the creation and exploration of new concepts for the space age. Marquardt is now diversified, operating in five basic areas—all primarily related to the search for earlier and ever more effective solutions to space-age problems.



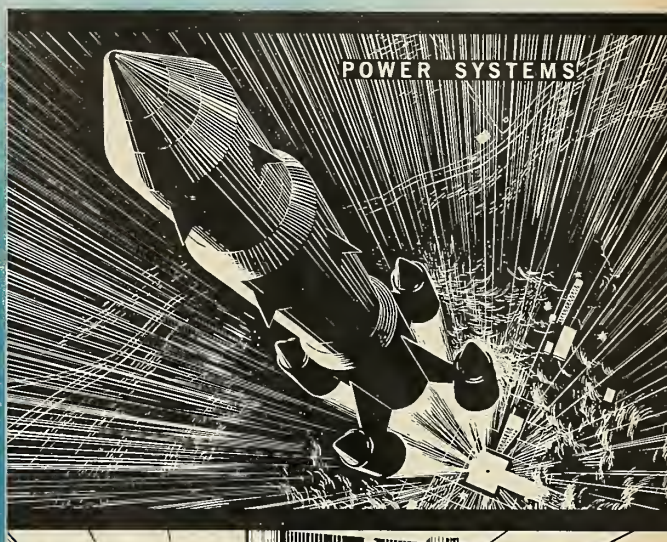
NEW CONCEPTS IN AIR-SPACE RESEARCH spring from ASTRO—Marquardt's Air-Space Travel Research Organization—where studies of an ionic rocket capable of powering future space vehicles are in progress. Other imaginative ASTRO studies span a broad spectrum including high-energy fuels, exotic materials, nuclear powerplants, advanced optics, cryogenics, space medicine, communications and guidance.

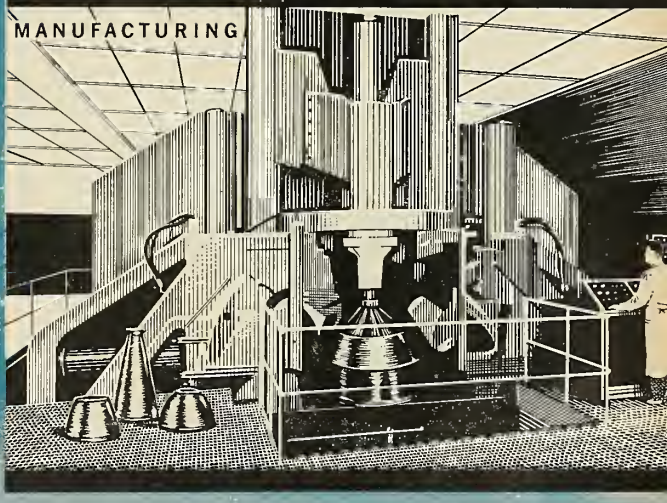
NEW CONCEPTS IN POWER SYSTEMS are in the making at Marquardt's Power Systems Group. Within the Group, Propulsion Division is engaged in continuing studies of a Hyperjet (rocket-ramjet) configuration capable of lifting future satellites from launch pad to upper atmosphere. Controls and Accessories Division is currently developing attitude controls for reconnaissance satellites, while Test Division is capable of ground-testing space-age hardware.

NEW CONCEPTS IN MANUFACTURING are typified by the first-of-its-kind Hufford Spin-Forge at Marquardt's Ogden Division. This 250-ton machine will contribute advances in space-age metal working state-of-the-art, while augmenting the Division's production of supersonic ramjet engines for the Boeing Bomarc IM-99.

NEW CONCEPTS IN SPACE-AGE TRAINING are an important product of Marquardt's Pomona Division—creators of a unique system which realistically simulates a 4,000 mile mission on an 8-foot map. The system will ground-train air and spacemen without risk and at great savings in cost.

NEW CONCEPTS IN RESEARCH ROCKETRY and instrumentation come from Cooper Development Corporation, a Marquardt subsidiary. Cooper has contributed to programs including Explorer and Sunflare projects, and Falling Sphere—is now at work on Project Mercury.





Engineers and scientists capable of making contributions in these and related areas are invited to write The Marquardt Corporation, Corporate Offices, 16555 Saticoy Street, Van Nuys, California; or

THE Marquardt CORPORATION

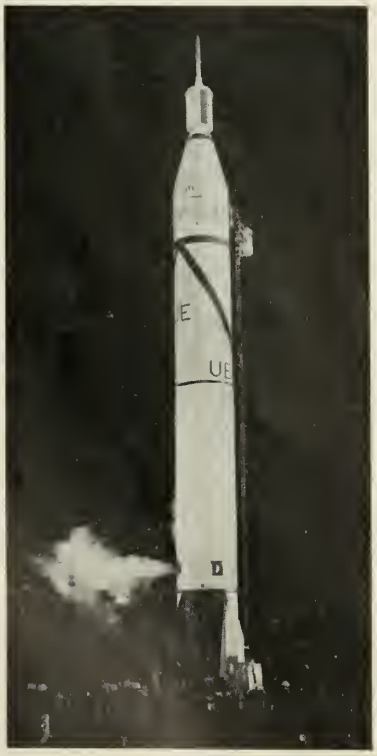
POWER SYSTEMS GROUP AND ASTRO
16555 Saticoy Street, Van Nuys, California
POMONA DIVISION
2709 North Garey Avenue, Pomona, California
OGDEN DIVISION
1000 West 33rd Street, Ogden, Utah
SUBSIDIARY: COOPER DEVELOPMENT CORPORATION
2626 South Peck Road, Monrovia, California

Rocket Reliability Drive Gains Fresh Momentum

Services plan to increase use of off-shelf components; NASA stretches out firing schedules

RELIABLE ROCKETS: Air Force *Thor*, above, lifts off from Cape Canaveral.

Below, modified Army *Redstone* awaits launch of *Explorer I*.



For want of a nail, the shoe is lost;
For want of a shoe, the horse is lost;
For want of a horse, the rider is lost;
For want of a rider, the battle is lost;
For want of the battle, the kingdom is lost—
And all for the want of a horseshoe nail.
—Old Saw

by Jay Holmes

WASHINGTON—Last June 23, a three-stage *Vanguard* rocket blasted off from Cape Canaveral. The first stage operated well. But in the second stage a small valve for regulating helium pressure failed to operate on radio command.

The vehicle came apart, and plunged into the Atlantic. For want of a $150 pressure regulator, a $3-million satellite was lost.

Failures in *Vanguard* launchings are merely the most publicized feature of a problem that strikes at every side of our space program: how do we make our rockets more reliable?

There is no reason to believe the problem is confined to this side of the Iron Curtain. The Soviets announce only successes. They haven't announced many recently. It is only logical to reason that there must have been failures.

Simple arithmetic sets out the situation. If a missile has 1000 parts and it must operate for an hour without failure, the probability of failure for each part operating an hour must be less than 1 in 1000. Each part must be good for 1000 hours.

Thousand-hour performance, standard for many aircraft parts and components, is not too difficult to achieve. But as the missile and space vehicle systems grew more complex, the number of parts increased. A navigation system alone can have 10,000 critical components. An advanced vehicle may carry a small computer—whose parts number hundreds of thousands.

• **Cost prohibitive**—Testing for this kind of reliability is out of the question. No one is willing to spend the time and money involved in testing a part for 10,000 hours or more. And even if we do this, what assurance is there that the part will not fail in the first second of use after the test?

The predicament is even more serious when we begin designing vehicles for lengthy voyages in space. J. M. Wuerth, chief reliability adviser to **Autonetics Division, North American Aviation,** points out that if we want to keep failures on a Mars trip below 1 in 1000, each item in a 10,000-part system must be designed to last 7,000,000 years.

Will such reliability ever be achieved? Certainly not in the foreseeable future. Other approaches must be taken if space travel is to be anything but a very dangerous business.

Is there another approach? Some industry spokesmen have suggested reliability might be improved if each part and component is designed specifically for its task in space.

Spokesmen for the military services and the National Aeronautics and Space Administration are cold to this idea.

"Don't design a new part unless you have to," says R. W. Cuthill, reliability engineer for the Army Ordnance Missile Command, Redstone Arsenal, Ala.

"If an off-the-shelf item will do the job, we use it," says an Air Force materiel officer. "However, if there is a reasonable doubt the item will perform, then we must design something new."

"We are now in a state of transition," reports Dr. Homer J. Stewart, director of NASA's office of program planning and evaluation. "Ten years ago, almost no components were taken off the shelf except vacuum tubes and

transistors. Now we have experience and can use components in existence or modifications of them."

E. F. Sweetser, director of the Defense Department's Office of Guided Missiles, recalls that there used to be criticism of the military for having too much special designing of parts. The complaint hasn't been heard very much recently, he added.

• **Exchanging data**—The services are moving in a direction opposite from that suggested by industry sources. Army, Navy, and Air Force are establishing a data-exchange system aimed at promoting even greater use of off-the-shelf parts and components in the major missile systems.

Here is how it will work: Each service will code the results of its tests of components on punched cards. Data not subject to coding—such as performance graphs—will be microfilmed and slipped into envelopes in the cards. Cards will be made in triplicate. Central files will be kept for the Army at Huntsville, for the Navy at the Pomona, Calif., Ordnance Laboratory, and for the Air Force at Ballistic Missile Division, Los Angeles.

The files will enable each service to pick the part most suited to any given need. They will cut down on costly, lengthy searches—which sometimes have to be cut short and produce a second-best selection. Civilian contractors and NASA officials with "need to know" will, of course, have access to the data.

Although they'll be an improvement over present practices, these files won't provide the final answer to centralizing reliability information. They will merely report test results in the ballistic missile systems. No information will be included on reliability of parts in use, or on parts tested for other satellite and space vehicle programs.

• **Parts that fail**—Some service organizations have information at lower levels on failures in use. The Army has failed-parts data centrally filed at program levels—such as for *Redstone, Jupiter* and *Pershing*. The next logical step, Cuthill said, would be to set up a central file for all the services on failures in use.

Still another approach to reliability was suggested by a House Appropriations Committee study last spring—write reliability specifications into vendor's contracts. At about the same time, the Air Force directed commands to review weapon systems on contract and determine whether their reliability systems were adequate. Although contracts may not mention reliability, Lt. Gen. C. S. Irvine, then a deputy chief of the Air Staff, declared that contractors nevertheless have an obligation to build adequate reliability into weapon systems.

Navy spokesmen say reliability is implied in their contracts, too. George S. Peratino, reliability engineer in the Bureau of Weapons, says reliability requirements are a part of weapon system specifications, which become a part of the contract even though the requirements are not written into the actual documents.

The Army has tried to establish reliability as a separate effort, Cuthill says. The reliability organization asks contractors to say in advance what tests they will run. Huntsville now is reviewing a three-year *Pershing* test program submitted by **The Martin Co.**

"We try to have reliability people looking over the shoulder of the design engineer," Cuthill said. "Some designers don't like it. They think they know how to do it all themselves. They're right. But we're all human."

• **In-house or out?**—Cuthill's comment points up fundamental differences in the ways the services build missiles. The Army prefers to have in-house experts who can supervise contractors in great detail. Cuthill contends this supervision makes Army weapons more re-

liable than otherwise.

The Air Force has delegated many of its supervisory functions to **Space Technology Laboratories** and prime system contractors. "You don't have to be a qualified pilot to run an airline, or a bus driver to run a bus system," an AF spokesman said.

The Navy steers a middle course. Some Navy missiles are manufactured at service arsenals; other by civilian contractors.

The Defense Department considers reliability primarily a question of education. "We must impress on all echelons—the services and industry—the consequences of poor reliability," Sweetser declared. "Like advertising, it's valuable only if you pound the point home."

Both the military and industry are working on schemes to improve reliability. Next winter, the services will sponsor a joint military-industry symposium on reliability. The Army called all its contractors to Huntsville for a day-long briefing last December.

Engineering organizations are busy too. Four leading groups—the Institute of Radio Engineers, the American Society for Quality Control, the Electronic Industries Assn. and the American Institute of Electrical Engineers—will hold a national symposium on reliability and quality control in Washington next January.

• **Corrective action—Douglas Aircraft Co.,** prime Air Force Contractor for the *Thor* IRBM, invited 150 representatives of sub-contractors to its El Segundo, Calif., plant for a seminar on reliability. One announcement: reports on all rejected parts will be made on punched cards. Monthly cumulative reports by part and vendor will provide a basis for corrective action in cases of excessive repetitive rejections.

This type of approach—standard industrial quality control—will eliminate the worst offenders. Random inspection of one or two parts in every batch will give an indication of reliability. More thorough testing of larger parts and components will help, too.

"But you can't inspect reliability into an item," says Louis Schlesinger, Navy components engineer. "You can't make an unreliable item reliable. Inspection will prevent the use of defective items, not unreliable."

The stickiest question in developing reliability is the conflict with performance. If we design a rocket case so that 99 of every 100 will withstand a pressure of 1235 pounds per square inch, we may need to use twice as much metal for a case good to 1500 psi. This reduces either the payload or the range of the missile.

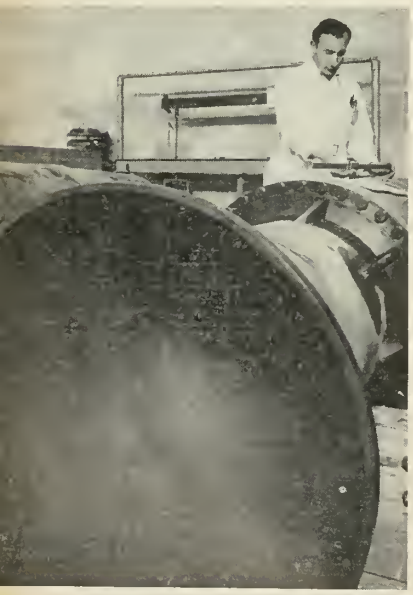
(continued on page 34)

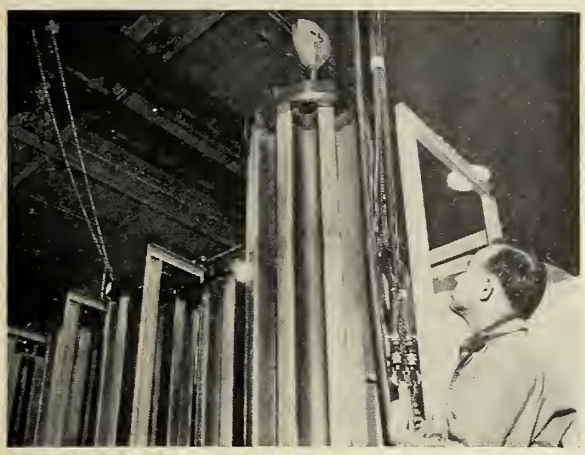
Thiokol Expands in Utah

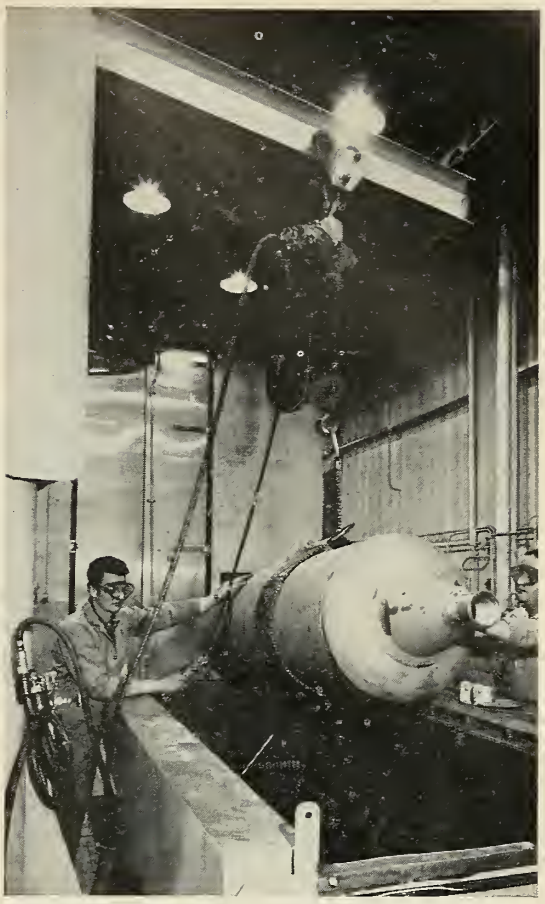
BRIGHAM CITY, UTAH—Less than two years old, Utah Division of **Thiokol Chemical Corp.** now has 2500 employes working in 85 buildings on a site that spreads over 11,000 square miles.

The solid-propellant plant, valued at $16 million, is owned 60% by Thiokol and 40% by the Air Force. Its features include a mile-long monorail system to facilitate assembly of the largest rocket motors and thrust stands capable of measuring up to 2 million pounds.

RIGHT: Thiokol workers man grinder and gyratory sifting machine, which reduce oxidizer to size before JATO propellant is mixed for *Matador* fuel grain. BELOW: Engine case is checked before it is loaded with cast propellant.







TOP LEFT: Cables hoist metal mandrils used in production of *Matador* booster motor. These are put into the mold until the grain solidifies.
TOP RIGHT: The *Matador* motor case is lowered into a degreaser, which removes rust preventive, luhricants and cutting oils. Now the propellant grain may he slipped into position.
BOTTOM LEFT: Besides the *Matador*, many smaller rockets are produced at Thiokol's Utah Division. Inspectors here check on an 8″ case.
BOTTOM RIGHT: *Matador* booster motor moves along a monorail connecting manufacturing and propellant curing huild-ing. The motor has heen loaded and the propellant has been cured. It will undergo conditioning hefore going to static area for firing.

RELIABILITY

(continued from page 31)

Which way do we go? A missile is not designed like a bridge. Twice as much steel framework as necessary may be put into the bridge or a building structure for safety. On this type of structure, you can't afford to take even minimal chances. But a missile is built for performance. Reliability requirements may be less than 90%—something that wouldn't be tolerated where human safety is involved.

The Air Force had to sacrifice reliability for performance in early *Atlas* designs. The nation wanted an ICBM right away. As testing progressed, the missile became more reliable. Now it is an operational weapon.

• **Speed sacrifice**—Peratino reports the Navy was able to take another tack in one weapon system (identity classified). "We found we could increase reliability if we sacrificed speed and range," he said. "We did so because the weapon carries an atomic warhead. The decision, incidentally, also led to the elimination of several parts and the saving of a half-million dollars."

Stewart said the reliability difficulties of the *Vanguard* satellite program stemmed at least in part from the rigid time schedule set by the International Geophysical Year. Programs under less priority pressure, he said, have developed higher degrees of reliability. As an example, he mentioned the Army's solid-propelled *Sergeant*.

"But it isn't necessarily true that all solid-propelled rockets are more reliable," he declared. "First, some solid fuels are unreliable. Second, the only reason some solids are reliable is that they have gone through development testing to make them reliable. The important question is not whether the fuel is liquid or solid but whether the system has had development testing."

In future NASA programs, Stewart said, there will be more on-the-ground development testing and fewer test firings in an effort to improve the reliability score on the shots we take.

We are going to make haste a little more slowly in our space program. American leaders have quietly dropped the talk about immediate trips to Mars and Venus. The major concern of our space program in the near future will be the moon—near misses, moon orbits and hard and soft landings of rocket payloads on the earth's nearest neighbor. NASA Administrator T. Keith Glennan outlined the policy change in a recent Los Angeles speech. He added:

"Some of the firing schedules we developed nine months ago lacked . . . realism."

IAF Papers Cover Space Field

Here are abstracts from some of the most significant documents offered at the recent London Congress by delegates from many nations

by Donald E. Perry and Anthony Vandyk

LONDON—Space medicine and magnetohydrodynamics dominated the technical sessions of the Tenth Annual Congress of the International Astronautical Federation which convened here recently.

But the Congress was by no means limited to these subjects; papers were delivered on practically every field of astronautics interest. As a service to readers, M/R has prepared brief technical abstracts (readers wanting more information may contact the author or the editorial office of MISSILES AND ROCKETS):

Accuracy Limits in Electronic Tracking of Space Vehicles, Paul F. von Handel and Fritz Hoehndorf, AFMDC of ARDC, Holloman AFB, N.W.

The authors predicted that the general trend of further developments in tracking space vehicles will shift toward electronic procedures which promise to achieve the same accuracy without restrictions on weather conditions and time of the day.

Pointing out that electronic tracking of objects moving in the atmosphere is limited by propagation anomalies—limiting use of high precision systems—they recommended frequencies in the kilo megacycle range.

The Technical Realization of Subgravity and Weightlessness, O. Wolczek, Institute for Nuclear Research of the Polish Academy of Science, Warsaw.

The author suggests that an effective way of obtaining smaller gravitation and weightlessness on earth for hours and more could be by centrifuges or devices operating on the same basis. Such devices would be stationed in a vertical position so that their axis of rotation would be paralleled to the earth's surface. Equipment would first serve to investigate force effects on small objects—construction materials, miniaturized measuring apparatus and smaller experimental animals such as mice.

Interplanetary Homing, E. V. Stearns, Lockheed Missiles and Space Division, Sunnyvale, Calif.

A closed loop system of instrumentation was proposed for control of vehicle trajectory in order to give necessary thrust control to place space vehicles in a suitable orbit for final approach. Midcourse trajectory based on knowledge of probable guidance and control accuracies—will have a probable error of about 100,000 miles. As such it must be brought into a landing corridor that is about 10 miles wide at periapsis. Taking into account the strong influence of the destination planet's gravity field. An interplanetary sextant was proposed for the homing task.

Prediction of Man's Performance in Space Using Flight Simulators and Balloonborne Systems, J. Gordon Vaeth, Technical Staff Member for Man-in-Space, Advanced Research Projects Agency, Washington, D.C.

Vaeth proposed development of advanced forms of ground-based flight simulators and use of long-endurance high-altitude manned balloon flights to determine capability of men to perform in space. By comparing measurements with corresponding data on the ability of automatic equipment to do the same, he said it would be possible to specify and predict those tasks which can be achieved better by manned than unmanned space systems.

'Green' Areas of Mars and Color Vision, Ingeborg Schmidt, Division of Optometry, Indiana University, Bloomington, Ind.

To determine whether the dark areas on the planet are real or not, production of contrasts was studied experimentally by using colored papers simulating the bright and dark areas. It is deduced that a contrast induction is possible on the surface of Mars, depending on hue, brightness and saturation of contrast inducing and contrasting area. He recommended an insulation observation of dark areas as a means which may be helpful in deciding about the real nature of the "green" areas of the planet.

Results of Experiments on the Biological Effects of Cosmic Radiation on Seeds of Hordeum (Gold Barley) Bonns 01518/B19 (Gustafsson), with Special Consideration of Heavy Primaries Effects, J. Eugster, University of Zurich, Switzerland, and Lt. Col. David G. Simons, USAF, Holloman AFB, New Mexico.

Of special interest, is that offspring of three seeds which suffered central hits by heavy primaries (F III/1, F IV/6 and G III/2, exposed in the summer of 1955 at Sault Ste. Marie, developed a color mutation. Grains derived from F IV/6 and G III/2 show a dark brown-dark grey. Those derived from F III/1 have a strikingly light yellow color.

Magnetohydrodynamics and its Application to Propulsion and Re-entry, Rudolf X. Meyer, Space Technology Laboratories, Inc., Los Angeles.

First part of this paper is largely a review of some of the basic concepts of magnetohydrodynamics in continuum fluid mechanics. The theory of the Newtonian approximation to flow is developed, however, in the second part of the paper. Results are presented concerning flow in the shock layer of a re-entry body, and a similarity solution of equations is given for a circular cone in the case of finite and variable electric conductivity.

Re-entry Paths for Manned Satellites, Dr. W. F. Hilton, Hawker Siddeley Aviation Advanced Projects Group, Great Britain.

Of interest is that the author considers that "high drag plus high lift" vehicles will be used for manned re-entry, and that "high drag with zero lift" will be reserved for simple unmanned re-entry, or very early manned flights.

A design study is being carried out at Sir W. G. Armstrong Whitworth Aircraft Ltd. (part of Hawker Siddeley) for a complete project to put two men into orbit (apogee 680 miles, perigee, 80 miles) and for them to land safely back on earth. Calculations were made on the most economical method of achieving a given change of orbit. A report showed by accelerating towards the earth at perigee does not bring the satellite any nearer to the earth, but results in rotation of the axis of the ellipse. It was determined that a small rocket producing lg for 1 second at apogee will lower perigee height by about 20 miles.

Rocket Postal Service, Glauco Partel, Missile Systems Consulting Co., Rome, Italy, and Antonio Angeloni, SISPRE, Rome.

Without entering details about vehicles, propulsion units, auxiliary equipment, the authors discuss dimension, weights, energies required and the magnitude of relative costs of international rocket mail service. Postage for a letter mailed to the U.S. from Europe in 2 hours and 40 minutes would not—if a certain number of daily flights and letters were shipped—exceed $2 per letter.

Motion of An Orbiting Vehicle Subject to Continuous Radial Thrust, Including a Study of Planetary Encounters, Bernard Paiewonsky, Department of Aeronautical Engineering, Princeton University.

Use of such thrust for braking spaceships in planetary encounters is investigated, using one-dimensional potentials. It is pointed out that use of radial braking will produce an increase in the perigee altitude compared with the perigee of the coasting path, a generally desired result. However, due to the extreme sensitivity of predicted perigee distance in close approaches to planets, en route measurements of the navigation and guidance equipment for both a radial braking system and the impulsive thrust correction system, will require the same high degree of accuracy. It is concluded that one system does not seem to have any overwhelming advantage over the other.

Some New Methods of Satellite Orbit Calculations and Stability Problems, Herbert Knothe, AFMDC, Holloman AFB, N.M.

Equations of motion for a satellite in a rotationally symmetric gravity field are reduced to systems of ordinary first order differential equations. A rapidly convergent process of iteration for solving these equations is explained and examples are given. The author supplies a differential geometrical approach giving formulae for the calculation of regression.

Design Study of An Earth Satellite Evolving from a Four-Step Solid Propellant Rocket Vehicle, S. K. Kumar and B. R. Rau, Indian Astronautical Society, Mysore, India.

The authors point out that countries like India cannot afford large scale liquid propellant rocket research and any progress or contributions from such countries in space exploration will have to be through solid propellant rockets. But this isn't keeping the nation from a novel space exploration approach.

While planning for launching a 50 Kg satellite, they also want to place a solid propellant rocket on top of the satellite section which would be intended to escape the earth after the satellite has gone into orbit. The experiment would show the possibility of orbital launching.

Launching Conditions and the Geometry of Orbits in a Central Gravity Field, Fang-Toh Sun, Taiwan Provincial Cheng Kung University, Tainan, Taiwan.

Formulas relating the principal geometrical parameters of the orbit to the launching parameters at final burnout are developed. Treatment is given to the elliptic, the parabolic and the hyperbolic types of unperturbed orbit. Problem of burnout precision is briefly discussed, and an energy-momentum diagram shows the essential geometrical aspects of possible orbits in a single chart.

Theory of the N-Step Relativistic Rocket, M. Subotowicz, Polish Astronautical Society, Warsaw.

This gives the theory of the relativistic multistage rocket necessary for the far future flights to the stars. A differential equation describing mass and velocity changes is defined along with its optimization possibilities. The author accepts that all stages would be analogous and all engines would use the same jet mass. Such a stage rocket would have only one reaction chamber, used in turn by all steps.

Problems of Magnetic Propulsion of Plasma, Ralph W. Waniek, Giannini Plasmadyne Corp., Santa Ana, Calif.

The paper deals with theoretical problems and experimental results obtained during a study aimed at accelerating ionized gases by strong transient magnetic fields. Techniques of these fields are discussed with their possible application to high field plasma thrustors. The author shows special air-core magnet configurations and outlines their characteristics as intermittent plasma propulsors. He contends that such thrusts might likely have a useful place in future space vehicles.

Application of Solid Propellants to Space Flight Vehicles, H. L. Thackwell, Jr., Grand Central Rocket Co., Redlands, Calif.

The author gives preliminary design calculations for a three-stage, all propellant vehicle called the *Envoy* which, when ground-launched, could send a 50-pound payload to the moon or place a 230-pound payload into a 300-mile high orbit. The vehicle would weigh 17,000 pounds and would be 37.8 feet in height. He anticipates that *Envoy* would cost considerably less than the $500,000 figure for the *Scout* or $1 million for a single *Thor* liquid booster.

Minimum Energy Requirements for Space Travel, Harry O. Ruppe, ABMA, Huntsville, Ala.

By calculating minimum energy requirements for many space missions and expressing them as velocity requirements of a rocket vehicle, the author comes up with a preliminary outline of an optimum vehicle, or for approximation of the payload capability of a given vehicle.

Measurement of *Jupiter* Re-entry Radiation, David D. Woodbridge, and Warren N. Arnquist, ABMA, Huntsville, Ala.

This is a detailed report on the Army's Operation Gaslight, the name given to the re-entry radiation measurement program of ABMA. Through industry participation, preliminary radiometric and photographic measurements have been made from the PbS infrared limit to the near ultraviolet. Extensions to cover the 3-5 micron band are in progress. Re-entry velocities begin at about Mach 14, which corresponds to an adiabatic shock front temperature of nearly 4000°K. Difficulties of operations are mentioned and the coordination of instruments at several locations with timing circuits is described.

Unsteady Compressible Magnetic Laminar Boundary Layers in Hypersonic Flow, Paul S. Lykoudis and John P. Schmidtt, Allison Division, General Motors Corp., Indianapolis, Ind.

This considers the unsteady hypersonic flow of a compressible, viscous, thermally and electrically conducting fluid in the presence of a magnetic field. The authors show that under reasonable restrictions the equations of conservation of total mass, energy, and momentum may be brought into similar form.

Determination of Air Density and the Earth's Gravitation Field from the Orbits of Artificial Satellites, D. G. King-Hele, Royal Aircraft Establishment, Farnborough, England.

Taking into account the oblateness of the earth and atmosphere, the tumbling of satellites and rotation of the atmosphere, the author gives methods for evaluating density at heights between 200 and 400 Km. Variation of density is traced with time.

On the Apparent Motion of An Earth's Artificial Satellite, J. J. de Orus, Fabra Observatory, Barcelona, Spain.

The author points out that a primary problem in radio observations of an artificial satellite of determining the time when the satellite is at its minimum distance from a determined earth station. He points out that this time calculation is simplified owing to the feeble flattening of the terrestrial globe and the little relation between the periods of revolution of the satellite and the earth's rotation.

Nuclear Rocket Missions and Associated Powerplants, John J. Newgard and Myron M. Levoy, Reaction Motors Division, Thiokol Chemical Corp., Denville, N.J.

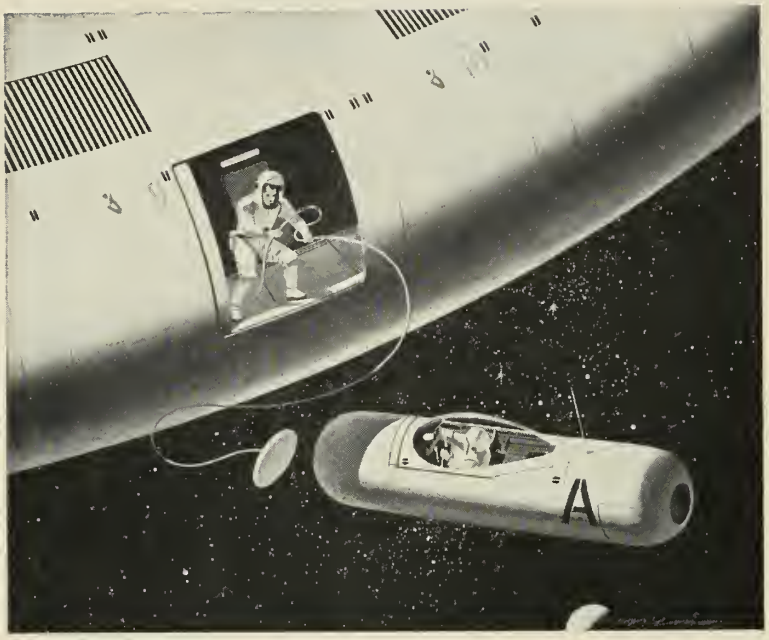
Requirements of open cycle nuclear power plants for a number of terrestrial escape to orbit and space missions are given. Missions analyzed include single-stage, large payload, nuclear boosted escape vehicles; chemically boosted second-stage nuclear rockets escaping with large pay-

STILL A PILOT'S AIR FORCE

His plane looks like a missile. It carries missiles. It is an automatic machine itself — almost to the point of push-button control. But the Air Force pilot gives his aircraft *discretionary* guidance — a generalship that pilotless weapons can't match. Along sensitive borders today, we depend on pilot judgment and reason to keep our guard up without overstepping. The pilot's combat reliability is the foundation of our "mixed forces" concept of deterrent strength through missiles and manned weapons. And getting this keen observer out into space is the immediate goal of U. S. space-science efforts.

COUNT DOWN

for the conquest of space



WHAT KIND OF ENGINE FOR A SPACE-TAXI?

It takes a unique engine to jockey a space-taxi in for a landing on an orbiting space station—one that will give a space pilot instant control and precise maneuverability.

Such an engine is the fully controllable rocket engine—ideal for space travel yet as easy to operate as an automobile engine.

The rocket engines are ready now

Although the space-taxi is still a gleam in an engineer's eye, the controllable rocket engine is available now...and has immediate application for existing aircraft. The pilot of a plane with auxiliary rocket power can switch it on for sudden, swift acceleration at high altitudes . . . the aircraft's air-breathing turbojets supplying power for ordinary flight operations. This is the mixed-power theory. Since World War II several mixed-power concepts have been developed in foreign countries, including Russia, France and England.

Extra power for today's aircraft

Rocketdyne already has designed, tested, and manufactured rocket engines for mixed power applications. The AR-1 rocket engine is a liquid-propellant system, as are the large power plants for the Atlas, Thor, Jupiter, and Redstone ballistic missiles. The AR-1 passed stringent flight tests as a supplementary power plant on modern jet aircraft. Substantial improvements over normal near-sonic speed and 50,000-foot altitude capabilities were demonstrated in more than 100 test flights.

The AR-2, second in a series of four rocket-engine models developed by Rocketdyne, is a fully-throttleable engine that provides varied thrust. Using fuel from the airplane's tanks—which automatically ignites with hydrogen peroxide—these engines have full stop and restart capability.

More value for taxpayers' money

The auxiliary rocket engine gives present aircraft superperformance capabilities at a relatively low cost. It provides the increased speed and maneuverability that could spell the difference between the success or failure of an intercept mission. Almost any existing jet aircraft, as well as those now on the drawing board, can be adapted readily for AR engines.

Looking forward to tomorrow

Beyond a doubt, rocket power has a leading role in the Free World's future. Rocket-propelled airplanes, such as the X-15, will pave the way for man's entry into Outer Space. The multi-million-pound-thrust systems that are now under development at Rocketdyne will be man's means to explore interplanetary Space. But meanwhile, these rapid advances in rocketry can add great strength to America's present deterrent arsenal.

THE MEASURE OF ROCKET POWER

The liquid-propellant AR rocket engines are "static tested" at Rocketdyne's field laboratory to measure thrust and performance.

FIRST WITH POWER FOR OUTER SPACE

ROCKETDYNE

A DIVISION OF NORTH AMERICAN AVIATION, INC.

oads, and terrestrial orbiting nuclear vehicles capable of moving into far space. Important is the analyzation of a "family" of hydrogen cooled, solid-fuel graphic element, graphite core moderated, BeO reflector moderated reactor power plants.

A Practical Investigation of Spaceship Control Problems, C. A. Cross, 284 London Road, Northwich, Cheshire, United Kingdom.

The author describes equipment that has been used to investigate manned spaceflight techniques. The spaceship flight simulator consists of a control panel, an electro-mechanical computer, and a planetarium type projector. A pen in the computer duplicates the motion of the spaceship on a scale of one inch to 70 miles. The pen controls a reference sphere projector which simultaneously plots the position on a chart 10 inches square. The ship can be turned at rates of up to 2 RPM by firing torque jets, and aiming trials have shown that the standard deviation of the main propulsion rocket motor is 1.65°. Some 20 flights have been made to determine a pilot's ability to carry out a simple circumnavigation of a luminous reference sphere 22 miles in diameter in the middle of a 700 mile square navigable area. Trials show that the ship cannot be flown successfully by direct instinctive interpretation of the projected display and it must be navigated from start to finishing by deducing its position in space from the observations, plotting this on a chart, and taking the control action needed.

The Biological Satellite, R. P. Haviland, General Electric Co., Philadelphia.

This is a proposal for a biological satellite to investigate problems of weightlessness and radiation exposure. The author gives conceptions of three different vehicles and outlines the experiments possible. Specific research areas would include adaption to zero-G; learning of locomotion under zero-G condition; free maneuvering in space; effect of exposure to energetic particles, and effect of photon radiation. Three classes of living subjects would be utilized: fruit fly (long term exposure to radiation); mice and rats (radition effects on the organisms and future generations); tailless type primates (probably Rhesus monkey and Chimpanzee) radiation effects but mostly adaptability to zero-G).

A Rocket for Manned Lunar Exploration, M. W. Rosen and F. C. Schwenk, NASA, Washington, D.C.

The authors recommend that a "bold" approach be taken to lunar exploration by utilizing the capabilities of man in the *Nova* vehicle and keeping instrumentation at a minimum. (See M/R *Aug. 31, p. 24*).

Lunar Exploration by Photography from Space Vehicle, Merton E. Davies, RAND Corp., Santa Monica, Calif.

A panoramic camera which should get pictures superior to those obtained by telescope or TV, is advocated. The camera would utilize the lunar vehicle's spin stabilization to perform scanning. However, the vehicle would have to sense its spin rate and the approximate direction of the ground.

Laboratory Experimental Studies in Re-entry Aerothermodynamics, Walter R. Warren, General Electric Co., Philadelphia, Pa.

A criticism of the capability of present laboratory test facilities to undertake future investigations of re-entry problems is made. He postulates that the arc-heated wind tunnel, because of desirable characteristics, will have a higher potential than other facilities in the study of re-entry aerothermodynamics.

Space Power, William W. T. Crane, Martin Co., Baltimore, Md.

Safety packaged isotopic power supplies can be built—the author maintains—during the next few years to produce eight watts per pound and at significantly higher efficiencies than 5 or 6%. The author contends that only four isotopes—Curium-242, Polonium-210, Curium-244 and Plutonium-238 have merit as heat sources.

Sterilization of Space Vehicles to Prevent Extraterrestrial Biological Contamination, Richard W. Davies, Marcus G. Comuntzis, Jet Propulsion Laboratory, CalTech, Pasadena, Calif.

The authors maintain the introduction of terrestrial organisms and contaminants might so distort the biology of plants as to constitute a scientific catastrophe. They believe it is feasible to sterilize probes so that loss of information to future investigators is minimized. Recommended methods are use of ethylene oxide, heat and radiation, accompanied by the sterile assembly of special components. They recommend that pollution tolerance be kept to 10^{-3} dead bacteria per missile, and that infection tolerance be less than 10^{-6} per missile for the planets and 10^{-1} for the moon.

Differential Expressions for Low-Eccentricity Geocentric Orbits, Samuel Herrick, L. G. Walters and C. Geoffrey Hilton, Aeronutronic Systems, Inc., Glendale, Calif.

The authors derive differential expressions that are applicable to correction of low-eccentricity orbits and the evaluation of uncertainty in the knowledge of the orbits.

Some Remarks on the Optimum Operation of a Nuclear Rocket, G. Leitmann, University of California, Berkeley, Calif.

Nuclear rockets in which energy source and working fluid are separated come in for modification by the author. He includes the constraint arising from their energy-limited nature and derives an exhaust speed program which is shown to be independent of mass flow rate. He finds that the characteristic speed corresponding to the optimum exhaust is a function of total working fluid mass only and that it increases as the working fluid mass increases.

Secular Variation in the Inclination of the Orbit of Earth Satellites (1957) and Air Drag, L. N. Rowell and M. C. Smith, RAND Corp., Santa Monica, Calif.

A plausible explanation of this phenomenon, according to the authors, is the component of drag acceleration normal to the orbital plane arising from the rotation of the earth's atmosphere in the same sense as the satellite. This component causes the inclination of the orbital plane to decrease. Rate is found by equations.

Effects of a Meteoroid Impact on Steel and Aluminum in Space, R. L. Bjork, RAND Corp., Santa Monica, Calif.

This paper is largely confined to estimating the effects of a collision between an individual meteoroid and some component of the vehicle. He attempts to calculate the phenomenology of an impact of meteoric velocities from fundamental principles and makes only simple assumptions which may be justified.

Impulsive Midcourse Correction of an Interplanetary Transfer, R. J. Gunkel, D. N. Lascody and D. S. Merrilees, Douglas Aircraft Co., Inc., Santa Monica, Calif.

By surveying possible ballistic trajectories from earth to another planet and paying attention to sensitivity to initial condition errors, the authors indicate that initial condition tolerances can be maximized by careful choice of trajectory. They consider the possibility of midcourse correction to compensate, and give the relationship between correction impulse requirements and sensitivity to initial conditions. They conclude that approximate methods can be suitable for determining basic trends but there is a necessity for using more accurate solutions for design purposes.

Ionospheric Scintillations of Satellite Signals, H. P. Hutchinson and P. R. Arendt, U.S. Army Signal Research & Development Laboratory, Fort Monmouth, N.J.

Techniques using doppler shift and direction-finding may prove to be most useful tools in further studies in the ionosphere and space, the authors believe. They point out that short-time variations of satellite-emitted radio signals can give a good measure of the roughness or inhomogenity of the ionosphere. Variations are more noticeable, they point out, at the low frequencies—20 and 40 mc's than at the higher ones, but the scintillations are not negligible at 10 mc's, the frequency most commonly used for determining position of previous U.S. satellites.

On the Corridor and Associated Trajectory Accuracy for Entry of Manned Spacecraft Into Planetary Atmospheres, Dean R. Chapman, NASA, Moffett Field, Calif.

An analysis is developed that determines the corridor through which manned spacecraft must be guided in order to avoid excessive deceleration for human occupants and yet to encounter sufficient deceleration for completing entry. Introduced is a dimensionless parameter coupling the aerodynamic characteristics of the vehicle with certain planetary characteristics evaluated at the perigee altitude corresponding to the approach conic trajectory.

Methods of Analyzing Observations on Satellites, G. V. Groves and M. J. Davies, Department of Physics, University College, London.

The authors develop a theory for the precise determination of the elements of a satellite orbit from observational data. Account is taken of the effects of atmospheric refraction, aberration, the finite speed of light and the difference between geocentric and geographic latitude.

The Three-body Problem, Earth, Moon, Spaceship, W. Grobner and F. Cap, Innsbruck University, Austria.

The solution of the astronomical n-body problem using Lie series is discussed and the known algebraic integrals—conservation of momentum, angular momentum and energy—are reproduced. There is a thorough discussion of the initial data, the closed solution of the three-body problem is given, and two different methods for numerical computation are furnished.

On the Flight Path of a Hypervelocity Glider Booster by Rockets, Angelo Miele, Purdue University, Lafayette, Ind.

This article investigates the flight of a vehicle operating along an equilibrium trajectory—where weight is balanced by lift plus the centrifugal force due to the earth's curvature. It is shown that the path which maximizes the range includes: an initial sub-arc in which all the propellant mass is expended at the engine's maximum burning rate, and a final sub-arc in which the glider coasts at variable altitude in such a way that aerodynamic drag is a minimum.

Tracking Objects Within tbe Solar System Using Only Doppler Measurements, Robert R. Newton, Applied Physics Laboratory, Silver Spring, Md.

It is assumed that an artificial planetoid emits radiation of reasonably stable frequency which can be received by an earth tracking station. He finds that without using any information except the time dependence of the Doppler shift, that orbital elements can be completely determined with a precision of about five significant figures, during one-half day's tracking from one station. He believes that the effective range for Doppler tracking should be at least 50 million kilometers.

Recent Developments and Designs of the Ion Rocket Engine, R. H. Boden, Rocketdyne, Canoga Park, Calif.

The author reveals that an ion thrust device directed toward a prototype engine configuration has been in operation at his company for several months, producing quantitative measurements of thrust. He believes a flyable ion engine, delivering less than one pound of thrust, could be available in five years, utilizing a propellant such as cesium.

Personnel Selection and Training for Space Flight, Brig. Gen. Don Flickinger, ARDC, Andrews AFB, Washington, D.C.

The author discusses recruitment and training of crews for manned orbital flight, pointing out that the determination of an individual's psycho-physiologic fitness comprises a major task for the behaviorists, the physiologist and the flight surgeon. Medical evaluation, stress tolerance testing and indoctrination would require 18 months for a candidate.

Sedov Elected as IAF Head

by an M/R Correspondent

LONDON—The United States, which dominated the International Astronautical Federation for 10 years, has lost all but two of the principal offices of the organization—probably on purpose in a bid to encourage world astronautics cooperation.

At the closing sessions of the IAF Congress here, Soviet Academician Leonid Sedov was elected president of the federation. He is the first Russian to win that honor.

Sedov, who headed the U.S.S.R. delegation to the Congress, is the son of a mining engineer. After becoming a theoretical mathematician, he won the Stalin Prize in 1952. He is also president of the Interplanetary Commission of the Soviet Academy of Sciences.

Elected as IAF vice presidents were Medicin-General J. P. Bergeron of France, Dr. Leslie Shepherd of Britain, Col. John Stapp of the United States, Eugen Sanger of Germany, and A. M. Hjertstrand of Sweden.

Andrew Haley of the United States was selected as chairman of the group's new General Council.

Dr. Theodore von Karman was chosen chairman of the committee to form the first IAF International Academy of Astronautics, which will have about nine members. Among those mentioned for early election to the academy were Dr. Wernher von Braun, Dr. James Van Allen and Dr. Hubertus Strughold.

The next meeting will be held in Stockholm, and the following one in Denver. Buenos Aires was suggested for the 1962 meeting.

At Farnborough

U. K. Reported Testing AAM Similar to *Eagle*

by an M/R Correspondent

FARNBOROUGH, ENGLAND—Britain is flight testing an air-to-air missile which should provide valuable information for the U.S. Navy's **Bendix** *Eagle* program, U.S. sources disclosed here during the twentieth annual Farnborough air show.

De Havilland Propellers is reportedly doing the development on the AAM, which carries the code name "Red Top." It is said to have infrared guidance, using a cooled lead telluride cell receiving in a 4 to 5 micro range; the U.S. Navy's *Sidewinder*, by comparison, uses lead sulphide with a 2 to 4 micro range.

According to reports, the bird carries a 68-pound non-nuclear warhead, has a 14,000-yard range, and is designed to be carried aboard the de Havilland Sea Vixen. It probably is an advanced version of the *Firestreak*.

American military observers said technological exchange resulting from the tests should lead to earlier availability of the *Eagle*. De Havilland would not comment.

Neither would **English Electric** comment on a report that it was working on an all-solid, surface-to-surface, fully transistorized tactical Army missile in range between the *Lacrosse* and the *Sergeant*.

This year's Farnborough show included a 40% larger missile display than last year. The *Black Knight* and the Australian-built *Malkara* SSM were put on public exhibition for the first time and a 25-foot model of the de Havilland *Blue Streak* was shown. English Electric, in cooperation with **Minneapolis-Honeywell Regulator,** showed a 27-pound miniature stabilized platform less than a cubic foot in volume, with a life of 1000 hours, storage capability up to five years, and ability to withstand 40 G's of shock and linear acceleration of 30 G's at temperature of minus 65° to 180° F.

A cutaway of **Bristol Siddeley Engines,** Thor BT-1 Ramjet for the *Bloodhound* was also shown for the first time.

Avro Weapon Division of the **Hawker Siddeley Group** announced full-scale test of *Bluesteel,* counterpart of the U.S. *Hound Dog*.

Congress Approves Medal Honoring Robert Goddard

WASHINGTON—President Eisenhower is expected to sign soon a bill to provide a gold medal in honor of the late Prof. Robert H. Goddard, known as the "father of modern rocketry."

The Senate passed the legislation and sent it to the White House last week. The bill authorizes $2500 for the medal.

Goddard, who died in 1945, did pioneer work in experimental rocketry in the early part of this century.

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V. J. Braun

V. J. BRAUN, ASSISTANT DIRECTOR FOR PLANNING, ENGINEERING DIRECTORATE

V. J. BRAUN

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more about the missile week

• VANDERBERG AFB, CALIF.—A SAC crew for the first time fired a **Convair** *Atlas* at 1:49.5 P.M., EDT, Sept. 9 giving the United States its first operational ICBM. The big missile roared 4300 miles westward across the Pacific Missile Range and landed near Wake Island.

• DOWNEY, CALIF.—The Navy announced successful completion of laboratory tests on the vitally-important inertial navigation system for *Polaris* submarines. It said a prototype engineering model will now be tested aboard the USS Compass Island, the *Polaris* program's surface test ship.

• WASHINGTON—The Army Quartermaster Corps plans to buy more than 1000 more German Shepherd dogs during the next 10 months for sentry duty at *Nike* and other missile sites throughout the nation.

• MCGUIRE AFB, N.J.—The first operational *Bomarc* a missile squadron joined the nation's anti-aircraft defense forces. The 60-odd nuclear-tipped **Boeing** missiles have a 200-mile range.

• EGLIN AFB, FLA.—Air Force officials said the 400-mile range *Bomarc B* is expected to be operational in about 15 months. Tests are being conducted at both Eglin and Cape Canaveral.

• EDWARDS AFB, CALIF.—Stoppage in the LOX lines forced cancellation of the first powered flight of the *X-15* rocket plane. Trouble occurred Sept. 4 after the plane was aloft and about to be released from a B-52 at 38,000 feet for a low altitude, low-speed run.

• WASHINGTON—One of the Navy's new *Terrier* guided missile frigates authorized in the FY 1960 budget will be named after the late fleet Admiral William F. (Bull) Halsey.

• WASHINGTON—Construction funds for hardened *Mace* sites were excluded from the compromise House-Senate $1.3-billion military construction program for FY 1960. Air Force was directed to draw on prior funds if a decision is made to go ahead with *Mace*. Under the measure AF gets $777 million; Army—$263 million and Navy—$204 million. So-called "no-year" funds of $57 million were provided to cover outstanding *Bomarc* and *Nike-Hercules* construction projects.

'Mobot' Developed To Handle 'Hot' Materials

ALBUQUERQUE, N.M.—Even Tom Swift would probably be amazed at the new "Mobot Mark II" just developed by **Hughes Aircraft Co.** The mobile robot with hydraulic muscles and closed-circuit TV eyes, will be used at Sandia Laboratories here to handle dangerous materials in radioactive environments. It will be remotely controlled by an operator safely out of the "hot" area behind dense concrete walls.

Mobot can pick up and move large heavy objects in and out of radioactive test rooms. It can handle hand tools for assembly and dismantling of equipment under test, and operate machine tools.

Constructed on a powered chassis resembling a fork truck, Mobot has a vertical reach of ten feet and a horizontal reach of three feet. The hydraulic handling arms can lift 150 pounds and the lift platform 1500 pounds. It weighs 4500 pounds and is controlled through a 200-foot cable. This first model is designed for indoor use but outdoor types are deemed practical.

Mobot's designers predict great potential for the mechanical marvel in the space age. One suggested possibility is in lunar exploration. Such a unit, remotely controlled from earth, could collect samples, run tests, and explore on command.

Other possibilities include underwater exploration and all manner of reactor refueling, waste disposal, and decontamination operations.

New Strides Made in Liquid Hydrogen Handling

BOULDER, COLO.—Several new developments in liquid hydrogen storage and transportation facilities were disclosed last week by Dr. R. H. Kropschot of the National Bureau of Standards' Cryogenic Laboratory here.

An evacuated powder, silica aerogel-aluminum, having twice the heat conductive resistance of powders previously analyzed, would provide a relatively cheap and convenient insulation for liquid hydrogen transportation trucks.

Another development reported is a multiple-layer insulation system with four times the heat-flow resistance of the best evacuated powders. This method, more expensive than the powder technique, consists of alternating layers of poor conductors and good reflectors.

Combination of the multiple-layer concept with an intermittent, high-vacuum system would result in low heat-leak transfer lines of long service duration. Carbon dioxide inserted in an annular space around the line would condense when cryogenic fluids were introduced, producing the vacuum.

Engineer D. A. Van Gundy pointed out that any hydrogen gas leakage would be adsorbed by the carbon dioxide and that the high-vacuum insulation occurs only when the line is in use.

Screen Show Missiles Small as .22 Bullets

WILMINGTON, MASS.—A new catadioptric light screen sensitive to hypervelocity projectiles as small as .22 caliber has been developed by **Avco's** RAD Division here. Used in ballistic range hypervelocity instrumentation, the screen is part of shadowgraph equipment for recording missile attitudes and aerodynamic flow. The system allows exposure times in the order of 10-7 and 10-8 seconds.

• DAYTON, OHIO—Scientists at Wright Air Development Center are testing the reactions of airmen who spend two-day periods in a broomcloset-size land-based space capsule. Some 40 airmen are expected to take part.

Have sidearms, will travel

When SAC slings a poir of GAM-77 Hound Dog air-to-ground missiles under the wings of the new B-52G bomber, it has what amounts to a brond-new manned weopon system.

For the Hound Dog's jet engine drives it at supersonic speed to o target hundreds of miles away. Its self-contoined inertiol autonavigator, set before lounch by the B-52's crew, can't be jammed, can't be decoyed.

The GAM-77 Hound Dog progrom got underway in August, 1957. The missile is alreody in its flight test phase. Thonks to acceleroted development, it will be deployed by 1960.

SAC's and ARDC's "blue-suit" integrotion progroms further speed the Hound Dog's operational status. As every other test missile comes off the production line, holf the crew ossigned to it is from the Air Force.

The Missile Division of North Americon Aviation is weapon system contractor for the GAM-77 Hound Dog.

MISSILE DIVISION

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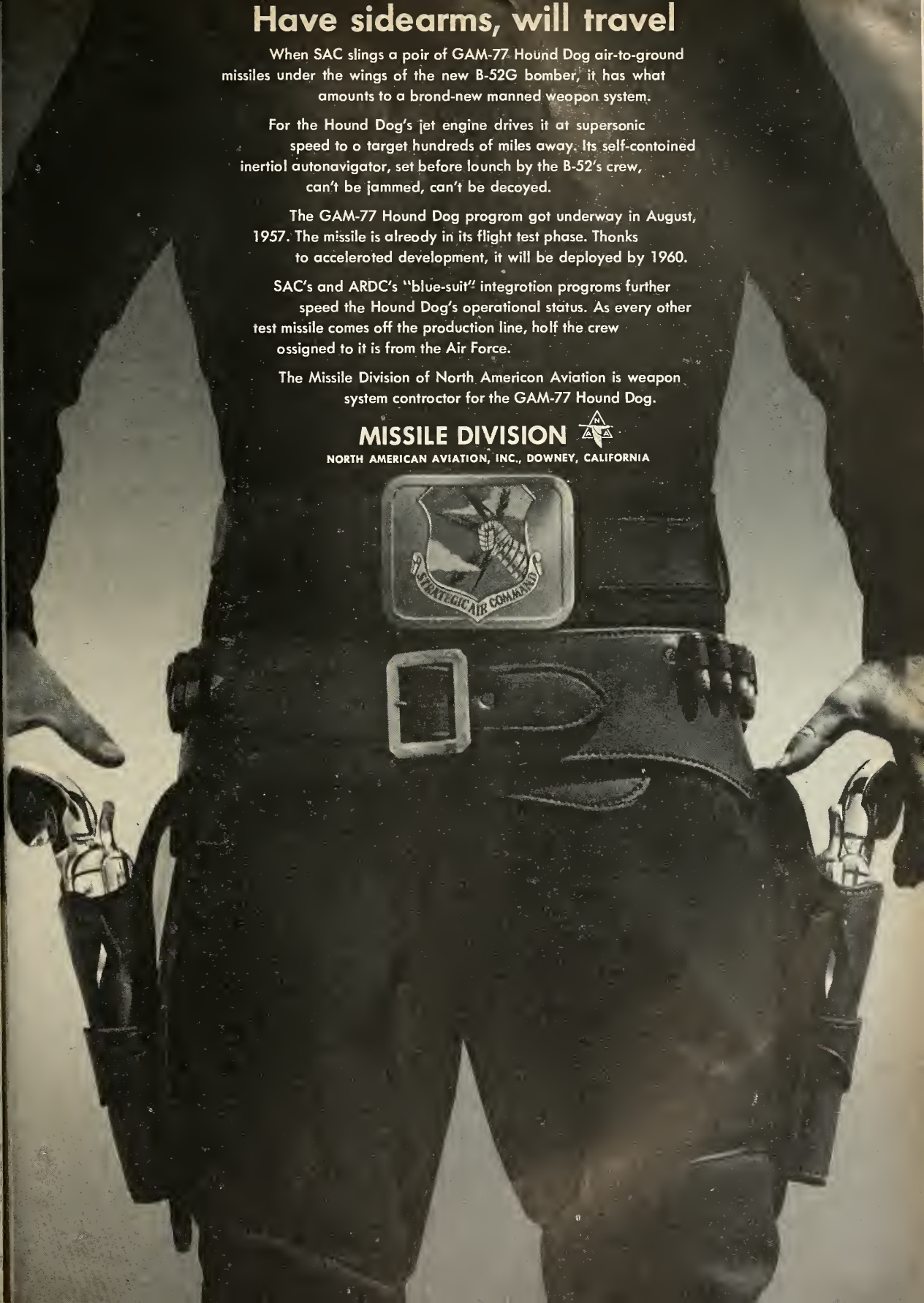


soviet affairs . . .

By DR. ALBERT PARRY

If *Lunik* for Mikoyan, what for Khrushchev? . . .

It would be just like Khrushchev to prepare a "first" in rocketry before he leaves for the States, so as to make news at the exact time of his meeting with President Eisenhower in Washington. Be it the first successful Soviet hit on the moon, or the first Russian man in space, the headlines would be vastly more effective if Nikita happened to be on U.S. soil at the moment. Remembering that *Lunik* was launched last January while Mikoyan was visiting here, one may guess that Khrushchev's scientists may have orders to try, anyway.

Why has he vetoed a rocket-base visit exchange? . . .

The likeliest explanation is Khrushchev's fear that Ike, being a general, would learn more from a look at a Soviet rocket establishment than Khrushchev, a civilian, could gather from an inspection of a similar U.S. installation.

Of course, Khrushchev's 24-year-old son Sergei, who is accompanying him to America, has a job in the Soviet missiles and rockets effort. Unlike Nikita, he speaks some English. Conceivably he could be of some use to his dad on a tour of one of our rocket bases. But, from what we hear, Sergei is too new at his rocketry to be much help.

As propaganda, Nikita's 'peaceful' refusal . . .

to see U.S. rockets may be more valuable to Khrushchev than any satisfaction of his curiosity about our plants and bases. Here are quotes from his "explanation" to some questioning Americans of why he would neither visit a U.S. rocket base nor invite President Eisenhower to view a similar Soviet base:

"You (Americans) want to add a bad taste to our meetings. If we would go journeying to each other in order to sneak a look at who has what sort of rockets and just where they are located, then it all comes down not to peace but to war preparations. But our aims are different. I am going to the U.S.A. with full knowledge that they have pretty strong military means. And even if I am offered a view of, say, rocket-paunching pads, I will decline."

The Soviet premier continued: "I think that were we to include, in the sojourn of the President of the U.S.A. in our country, visits to the points where we make our rockets and where these rockets are located, the President could have said: 'For what did you invite me? To frighten me? . . .' On our part this would not have been hospitable. Therefore we will not permit ourselves to offer to the President anything of the kind."

No 'rockets in the pockets' . . .

is Khrushchev's cry. He declared that "all of us—Russians, Ukrainians, Belorussians, Kazakhs, all the peoples of the Soviet Union—are very hospitable." He recited a list of national dishes, from various Soviet regions, that he could offer to such an honored guest as Ike. "We have many tasty dishes, please—we won't refuse anything to our guests. But the main thing, in our sincere and hearty conversations we must convince (Americans) that we do not plot anything bad against the United States and other countries. But if, during my talk with the President, a rocket would peep out of one of my pockets, and another rocket from another pocket, what kind of hospitality would that be, what kind of talk?"

Check 'em in the vestibule . . .

Khrushchev concluded: "Time was when on coming to negotiations people left their weapons in the vestibule. Talks were weaponless. But here you want us, after we have invited the President of the U.S.A. for a conversation about peace, to show to him the places where we make our rockets and where we launch them." This, said Nikita, would be "absolutely inadmissible."

House Group Urges More R&D

WASHINGTON—The House Space Committee has charged that the Administration isn't spending enough money on military research and development.

The committee also is hitting out at pressures within the Pentagon and Administration to narrow the participation of the Army in space (M/R Aug. 31).

The committee made its position clear on both issues in a newly issued report called "Basic Scientific and Astronautic Research in the Department of Defense."

The report called on the Administration to review its military R&D budgetary policies "at the earliest practical time."

"In view of the swift scientific pace going forward today, research and development money clearly seems inadequate," the report said. "This is the case apparently at all levels of military government."

The committee specifically hit at the amount of R&D money that is being made available to the Army and Navy.

"The amount allocated for research within the total Administration budget appears inadequate," it said. "The amount allocated to the Army within the Defense Department budget appears inadequate. And the amount allocated by the Army within its own budget may also be inadequate . . ."

As for the Navy, the committee said at present R&D funds make up only 8.5% of the Navy budget for FY 1960 and recommended the amount be increased to "10% or so." The price tag—more than $150 million extra.

The 1960 Navy budget provides $970,920,000 for R&D—$522 million of it for basic and supporting research.

The committee said pointedly: "National security today is as dependent upon research as Elizabethan England was dependent upon the fleet of Sir Francis Drake."

Turning to space, the committee noted "the actual capability of all services to use space is still in its formative stages" and "many scientific answers in relation thereto are unknown."

Therefore, it said "a duplication of research and development effort in these fields is by no means unwarranted but is, in fact, essential in many cases."

It specifically said the Army has "interests in space which warrant vigorous and expeditious research in such allied areas as the use of space or space vehicles for communications, weather interpretation, surveillance, reconnaissance and the like."

The committee also recommended that:

- The Defense and State Departments "immediately take steps to speed up effective liaison with outstanding scientists and science programs in other countries."
- The United States seriously consider strengthening its defences against missile-launching submarines by prohibiting foreign submerged submarines from operating within 200 miles of U.S. coasts.
- The Air Force must find means to increase and stabilize its pool of in-house R&D talent.

Tests Show Progress With *Mercury* Capsule

CAPE CANAVERAL—*Big Joe* test results last week indicated that the *Atlas* ICBM has developed a new problem but that major components of the project *Mercury* space capsule are well on their way towards becoming operational.

The *Atlas* booster's two outside engines failed to separate, considerably reducing the planned range and altitude. Air Force officials said it was the first time this malfunction had occurred.

The boiler plate capsule's retrorockets used to insure clean separation of the capsule from the *Atlas* booster fired as programmed, and the nitrogen control jets pivoted the blunt end of the capsule down into proper position for descent.

The capsule was picked up by a destroyer.

Designated the *Big Joe* tests, the capsule was to have been hurled to an altitude of 100 miles and a speed of 17,250 mph in order to test components against maximum heat and reentry shock.

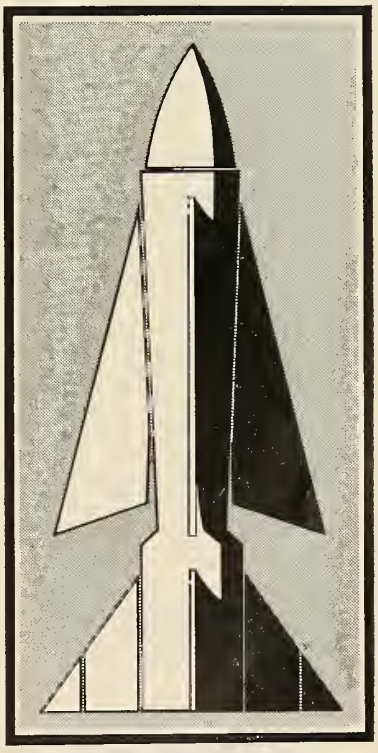
Artificial 'Lightning' Used To Shape Metals

FARMINGDALE, L.I.—Man-made "lightning" has been harnessed by **Republic Aviation** engineers here to shape high-strength metals. The "spark bomb," as it is called, converts electrical energy directly into mechanical power. It offers the possibility of a small cheap metal-forming tool that could replace conventional hydraulic presses that cost a half-million dollars and require large floor space.

In operation, electric power is stored by a battery of capacitors. This energy is released in 40 millionths of a second under water, creating a high-velocity shock wave that stretches the metal back into the desired shape. Presently, about 600 horsepower has been realized with the technique; hopes are for much higher power levels.

According to Republic scientists, the technique is particularly valuable for forming newer steel and titanium alloys and other advanced materials which have practically no stretchability. Such materials require complicated equipment of tremendous force to shape them to the close tolerances and smoothness required.

Eagle Is Depicted



THE NAVY's *Eagle*, seen in this artist's conception, is a nuclear-tipped high-speed missile designed for launch against aircraft from relatively low-speed carrier planes. The Bendix missile, with a range of about 100 miles, is under research and development.

missile business . . .

BY WILLIAM E. HOWARD

Quick response in getting industry to solve some of its tougher technical problems is reported by the Navy's BuWeap (formerly BuOrd and BuAer). Back in April, BuOrd handed representatives of 200 major companies a book detailing about 200 of the most pressing research needs, and telling why they were roadblocks to the development of superior weapons. Much to the Navy's amazement a half-dozen firms have already come in with tentative solutions to about 25 problems. And only four months have gone by.

Not knowing just what the services needed most . . .

in the way of research long has been a baffling problem to industry. Companies have largely had to depend on word of mouth to determine the long-range interests of DOD. Often the lack of proper information has sent a company down a dead end—at its own expense.

The Navy realized more than a year ago that a lot of industrial research was being misdirected and decided upon the direct approach: tell what was needed and why. It took a year of snooping around the various Navy research agencies to compile the "Research Problem" book. But the effort looks like it will pay off handsomely.

The entire book is classified, but many individual . . .

problems are not. They cover every facet of naval operations, with particular emphasis upon ASW, air defense warfare, offensive warfare and supporting research. The Navy, for example, wants someone to develop an electrically and acoustically silent battery-powered motor to cut out electrical noise that degrades electronic circuitry. This one will take a breakthrough in the present state-of-the-art.

Take missile warheads. The Navy requires a low-cost method of producing high-quality continuous rod-type warheads with a minimum number of possible variables in the manufacturing process. The method "should eliminate as many of the presently used individual parts and joints as possible by incorporating new rod forming and manufacturing techniques." The reason: aircraft target speeds and skin toughness are increasing steadily and the cutting action of continuous rod warheads is expected to become more effective than blast or fragmentation types.

On the other hand, Problem 61 in the book . . .

asks development of a more effective fragmentation warhead—"possibly by increasing the duration of the lethal fragment cloud." Present anti-aircraft bursts last but 5 milliseconds and cover an area 80 feet in diameter. Present complex arming devices for solid rocket propellants also are a problem area. The Navy wants something simpler—and more reliable.

Interestingly enough, the Navy has use for a *less* accurate gyro than those available now. It would be put in short-range missiles (for one minute or less). The idea is to come up with a gyro that is cheaper; the very precise ones in production today are too expensive to use in the short-range missiles.

The book has problems for everyone . . .

big and small companies alike. Available from BuWeap, it should be on every company shelf. For most of the solutions will lead to either research or production contracts.

Incidentally, the Army has picked up this approach from the Navy and is publishing a similar classified problem book for industry in about a year, as mentioned in this column Aug. 17. The Air Force ARDC also has a similar program going. So, henceforth, no company-funded research need go to waste.

— letters —

Solid Coverage

To the Editor:

On behalf of the entire company, I take this opportunity to express our appreciation for the excellent coverage given us in Frank McGuire's review of "The Role of Solids" in the July 27th issue.

He handled a difficult and complex subject with remarkable competence and we appreciate his earnestness, caution, intelligence and courtesy . . . He will always be welcome at **Grand Central Rocket Co.** . . .

Cledo Brunetti
Vice President and
General Manager
Grand Central Rocket Co.
Redlands, Calif.

Hits the Nail

To the Editor:

You have hit the nail pretty nearly on the head in your recent editorial, "Components Reliability: What's Needed?"

The solution is by no means direct since the big men in the field are predominately either speculative scientists or "weapon system" enthusiasts, both somewhat blinded to the tedious attention to detail which is required.

R. A. Hawkins, Manager
Reliability and Quality Dept.
Avco Research and Advanced
Development Div.
Wilmington, Mass.

Pioneer Chronology

To the Editor:

I noted with interest the article by Erica Karr in your Aug. 3 issue, "BMD's Radical Approach to ICBM Pays Off."

Her list of highlights erred once.

"Deepest probe into space by a man-made object was *Pioneer I's* 71,300-mile journey during which it picked up data confirming existence of the Van Allen radiation belts and confirming they would not be insurmountable obstacles for man in space, (October, 1958)."

I believe your magazine reported the flight of *Pioneer IV* in March, 1959, and the fact that it entered orbit in the solar system far beyond the range of previous U.S. space probes. I also understand that Dr. James Van Allen received highly useful radiation measurements from *Pioneers III* and *IV*, launched for NASA by the Army Ballistic Missile Agency.

Gordon L. Harris
Public Information Officer
Headquarters, U.S. Army Ordnance
Command
Redstone Arsenal, Ala.

The article, written around the Air Force Ballistic Missile Division's fifth anniversary, did not go into space projects of other agencies. BMD's achievements were listed in order of date and Pioneer I's October 1958, journey did set a record at that time—Ed.

contracts

MISCELLANEOUS

$1,600,000—**Talco Engineering Co.**, a subsidiary of The Gabriel Co., for manufacturing rocket motors, rotational and vertical thrusters and other components.

$100,000—**The Siegler Corp.**, Olympic Division, for development of five rate and reference precision frequency generators to be used as part of the Mark II Azusa missile tracking and retrieving system for ICBM's. (Sub-contract from **Convair Division, General Dynamics Corp.**)

$60,000—**DynaMetric, Inc.**, Pasadena, Calif., for special purpose camera equipment. (Sub-contract from **Eastman Kodak Co.**)

NAVY

$360,000—**ACF Industries, Inc.**, Avion Division, Paramus, N.J., for production of radar beacons for use in tesing *Corvus* air-to-surface missiles.

$114,357—**Mincom Division, Minnesota Mining & Mfg. Co.**, Los Angeles, for seven track record/reproduce magnetic recording system.

$76,175—**Bendix Computer Division, Bendix Aviation Corp.**, Los Angeles, for a digital computer with associated components.

$25,680—**Raymond Engineering Laboratory, Inc.**, Middletown, Conn., for magnetic tape recorder.

ARMY

$3,260,609—**Pacific Construction, Ltd., Honolulu, Reed & Martin Co.**, Fairbanks, Alaska and **H. B. Zachry, Inc.**, San Antonio, Tex., for *Nike-Zeus* facilities on Kwajalein Island in the Pacific.

$2,942,000—**Westinghouse Electric Corp.**, Washington, D.C., for rocket and guided missile proximity fuses.

$1,858,211—**Beacon Construction Company of Massachusetts, Inc.**, Boston, for construction of *Nike-Hercules* facilities at Offutt AFB.

$1,809,209—**Beacon Construction Company of Massachusetts, Inc.**, Boston, for construction of *Nike-Hercules* facilities at Lincoln, Neb.

$1,676,814—**Douglas Aircraft Co.**, Santa Monica, Calif., for missile technical services. (Two contracts.)

$590,766—**Wayne Construction Co. and Reed & Martin, Inc.**, Seattle, for construction of *Nike-Zeus* facilities on Johnston Island in the Pacific.

$539,100—**Benz Construction Co.**, Lubbock, Tex., for construction of *Nike-Zeus* facilities at Point Mugu, Calif.

$328,939—**Western Electric Co., Inc., N.Y.**, for *Nike* spare parts and components. (Seven contracts.)

$225,871—**General Electric Co.**, Utica, N.Y., for satellite communications study.

$119,987—**Gilfillan Brothers, Inc.**, Los Angeles, for engineering services for the *Corporal* missile.

$57,473—**Gulton Industries, Inc.**, Long Branch, N.J., for accelerometers.

$40,000—**Douglas Aircraft Co.**, Santa Monica, Calif., for guided missile supplies and services.

$37,500—**Aerojet General Corp.**, Azusa, Calif., for activation and operation of launching equipment.

$28,939—**Professional Design Co.**, Agawam, Mich., for engineering, design and drafting services for XM79 launcher.

$27,550—**Lansdale Tube Co.**, Lansdale, Pa., for transistors.

AIR FORCE

International Business Machines, Federal Systems Division, Oswego, N.Y. for development of a lightweight digital computer for the achiever all-inertial guidance for the *Titan* missile. (Sub-contract from **AC Spark Plug Division, General Motors**). Amount not disclosed.

Thiokol Chemical Corp., Reaction Motors Division, has received a "significant" contract for the advanced development of mechanical features in pre-packaged liquid rocket engines. Amount not disclosed.

U.S. Steel Co., Consolidated Western Steel Division, for the fabrication of 14 *Atlas* ICBM launchers. (Sub-contract from **Convair Astronautics Division, General Dynamics Corp.**) Amount not disclosed.

The Rucker Co., Oakland, Calif., for hydraulic power systems for *Atlas* missile launching sites at Forbes AFB, Topeka, Kan. Amount not disclosed.

$36,655,000—**Avco Corp., Research and Advanced Development Division**, Wilmington, Mass., for basic research through prototype development of the re-entry vehicle (nose cone) for the *Minuteman* ICBM.

$29,209,851—**General Electric Co., Missile and Space Vehicle Dept.**, Philadelphia, for production of nose cones for *Thor* missiles.

$5,000,000—**Martin Co., Orlando**, for continued research and development work on the *GAM-83B* air-to-surface guided missile.

$2,321,900—**Martin Co.**, Baltimore, for repair and modification of *TM-61/76* missiles and related equipment.

$415,926—**Telecomputing Corp., Cook Batteries Division**, Denver, for production of specialized batteries to be used as electric power sources for the *Atlas* and *Minuteman* missiles. ($295,000 subcontract from **Convair Division, General Dynamics** and $120,926 subcontract from **Autonetics Division, North American Aviation, Inc.**)

$398,452—**Martin Co.**, Baltimore, for supplies and services for maintenance of *TM-61/76* weapons systems components.

$209,100—**Allen B. DuMont Laboratories, Inc.**, Clifton, N.Y., for various electron tubes.

$207,147—**Radio Corp. of America**, Harrison, N.J., for various electron tubes.

$206,630—**Sylvania Electric Products, Inc.**, N.Y., for various electron tubes. (Three contracts.)

$170,640—**General Electric Co.**, Owensboro, Ky., for various electron tubes.

$148,770—**Sundstrand Corp.**, Rockford, Ill., for transmission assemblies, spare parts, maintenance tools and test equipment for *SM-62A* missiles.

$145,651—**Martin Co.**, Baltimore, for supplies and services for maintenance of *TM-61C* weapon system components.

$44,358—**Stanford University**, for continued study of fluid dynamic problems in diffusers and ducts.

$42,240—**The Dayton Rubber Co.**, Dayton, Ohio, for various tube assemblies.

$28,470—**Flexonics Corp.**, Maywood, Ill., for various tube assemblies.

BIDS

Dayton Air Force Depot, Gentile Air Force Station, Dayton, Ohio. Att: Directorate of Procurement and Production.—Tube electron type 6N7 in a/w MIL-E-1/633 dated 4 Mar. '54 S/N 5960-188-8519—27,000 ea. RFP 33-604-60-4066Q—Bid opening 22 Sept. '59.

U.S. Army Engineer District, Los Angeles, Corps of Engineers, 751 S. Figueroa St., Los Angeles 17, Calif. Construction of radar tower and utilities at Norad Control Center (JMDC), San Pedro Hill, Los Angeles County, Calif. . . . Job . . . IFB ENG-04-353-60-11—Bid opening 29 Sept. '59.

—when and where—

SEPTEMBER

New York University's College of Engineering, Titanium Metallurgy Conference. For Information: Dr. Harold Margolin, New York University, University Heights, New York, Sept. 14-15.

Society of Automotive Engineering, Display of USAF Ground Support Equipment for Manned and Unmanned Aerospace Vehicles, Milwaukee Arena, Milwaukee, Sept. 14-15.

Institute of the Aeronautical Sciences, Western Regional Meeting on Frontiers on Science and Engineering, Los Angeles, Sept. 16-17.

Army Signal Corp., Conference on Effects of Nuclear Radiation Semi-conductors, Western Union Auditorium, New York, Sept. 17-18.

Standards Engineering Society, 8th Annual Meeting, Investment in Survival, Somerset Hotel, Boston, Sept. 21-22.

Instrument Society of America, 14th Annual Conference and Exhibit, International Amphitheatre, Chicago, Sept. 21-22.

Industrial Nuclear Technology Conference, sponsored by Armour Research Foundation of Illinois Institute of Technology, Nucleonics Magazine, and Atomic Energy Commission, Morrison Hotel, Chicago, Sept. 22-24.

Advisory Group for Aeronautical Research and Developments (AGARD) of the North Atlantic Treaty Organization, Aachen, Germany, Sept. 24-25.

Institute of Radio Engineers, American Institute of Electrical Engineers, 8th Annual Industrial Electronics Symposium. Mellon Institute, Pittsburgh, Sept. 30-Oct. 1.

OCTOBER

Institute of the Aeronautical Sciences, Anglo-American Aeronautical Conference, Hotel Astor, New York, Oct. 5-7.

Advertisers' Index

Employment

The Warm Side of the Cold War

The visit to this country of Nikita Khrushchev is significant in several ways. Historically, he is the first Russian chief of government to set foot on American soil. Historically, also, he arrives near the second anniversary of his nation's greatest technological triumph—the orbiting of *Sputnik I.* Politically, he is linked to the Administration's hopes of cutting down the military budget. Morally, he holds the hope of the West for a lessening of tensions, for disarmament, for global sanity.

It is very difficult to believe that the Soviet Premier will really change any of his communistic spots during his visit here, or immediately thereafter. However, we do believe it is far better for East-West protagonists to meet personally on almost any terms than to stand glowering at each other across the oceans and continents. And there is always the hope that the visit will enlarge the Premier's outlook.

With this in mind we would like to call his attention to the lead story in this issue of this magazine—a story dealing with the peaceful uses which American industry has found for products and techniques developed during the Cold War of the past decade.

Khrushchev's contempt for capitalism is well and widely known. Alluding to America on Oct. 10, 1957, he said: "There are still reactionary militarist forces in the world which are preparing for war and which do not want disarmament, fearing to lose their profits. The capitalists are worried about their profits."

It would be strange indeed if capitalists were not concerned to some extent about their profits, profits being one of the prime bases of capitalism. But it might surprise the Soviet Premier to learn the trend this concern takes.

As detailed in this week's story, an M/R survey revealed that during the past decade military, missile and space research has produced countless new products, new industrial techniques and even entire new industries for peaceful, civilian usage. While working to produce better defense vehicles and spacecraft, American industry has never lost sight of the fact that it is inherent in its very nature to be always searching for ways to improve the everyday living of the American people. Missile optics produce better eyeglasses; the material created for a radome also makes more durable kitchenware; the search for a new fuel produces a new medicine and thus on.

No democratic society has ever looked favorably on military expenditures. The attitude has always been, understandably, that military spending is almost literally waste, that a dollar for defense could be spent for some worthwhile purpose if defense weren't necessary.

Within our military budget, which accounts for from 10 to 15% of our gross national income, many items have been produced which have great economic (as well as military) value. They have lessened man's labors, improved his health and well-being, lengthened his life span. This is not and never will be an argument for increasing military budgets, of course; but it does demonstrate that these military expenditures have brought civilian benefits which otherwise might not have resulted—or at least would have been years longer in arriving.

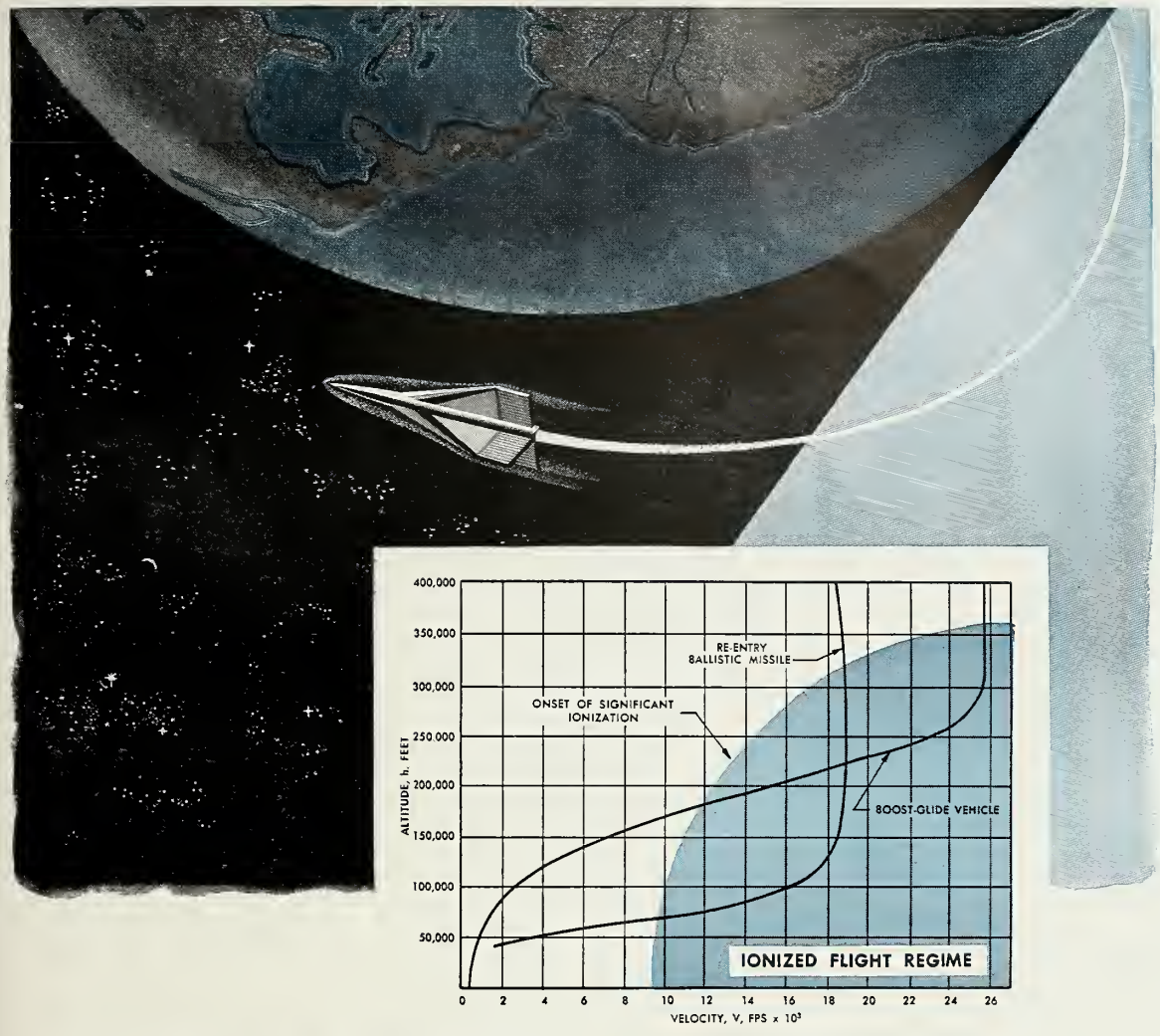
The point which we hope will not be permitted to escape the attention of Premier Khrushchev is this:

> **Not only can this country devote its economy to building one of the greatest defense machines in the world, aid its western allies both militarily and economically, create and carry out a potentially great space program—it can do this and at the same time give its citizens the highest living standard ever known.**
>
> **Not only has this country accepted the challenge of the Cold War which the Russians have forced upon us, but in effect we are making it pay for itself through our vast production system and consumer capacity.**

We think this is a tribute to the American system and to American industry. We doubt that the same thing is even remotely true in Mr. Khrushchev's country; his own technical leadership isn't geared to think of civilian well-being, either industrially or spiritually.

If this one fact can be brought home to the Soviet Premier it may both enlighten and discourage him somewhat—enlighten him to the fact that though we don't try to force our way of life on the world, we like it; and discourage his hopes of changing that fact.

CLARKE NEWLON



COMMUNICATION

. . . through a plasma sheath

When man goes into the outer atmosphere, communication with ground installations will be a major problem. The shock wave preceding a hypervelocity vehicle flying at altitudes between 70,000 and 350,000 feet will cause the oncoming air to be heated to extremely high temperatures. Result: a sheath of ionized particles around the vehicle.

Communication through this plasma cannot be achieved with conventional equipment. That's why Bendix Systems Division is engineering a communications system in frequency bands specifically designed to penetrate the hypersonic shock layer. The solutions of these problems are common to hypersonic flight and ballistic missile re-entry.

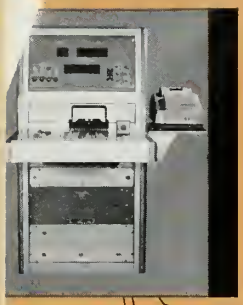
The Bendix Systems Division, using the nearby University of Michigan's Ford Nuclear Reactor, is also developing radiation-resistant communication equipment to provide extreme reliability over long operating periods. These techniques are applicable to both nuclear-powered vehicles and space programs.

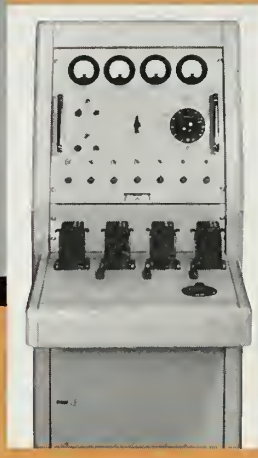
Bendix communications experience is also being applied to other programs for which the Systems Division has management and engineering responsibility—the Navy's EAGLE System and the Air Force's AN/AMQ-15 Weather Reconnaissance System, for example.

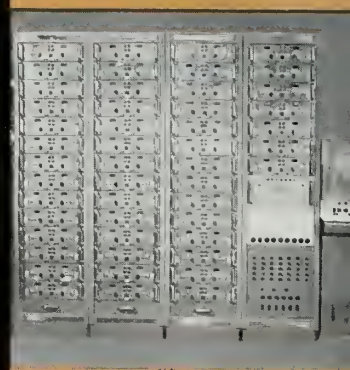
Better engineers and scientists are invited to write for further information on Bendix Systems Division.

Bendix Systems Division
ANN ARBOR, MICHIGAN

Bendix
AVIATION CORPORATION







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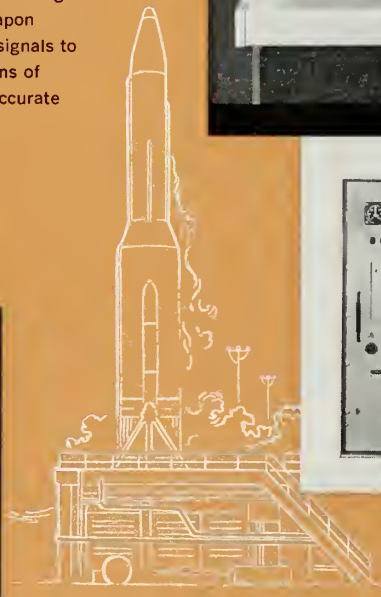
For example, SMI's TS 539 Air Data Computer Test Set is used for checking out elements of the Hughes Aircraft Company MA-1 aircraft and weapon control system. The TS 539 provides both electrical and pneumatic signals to the computer under test, achieving extremely high accuracy by means of electronically controlled force balance sensors. Mach readings are accurate to .7 millimachs and altitude readings within 15 feet at a speed of 1.4 Mach and an altitude of 30,000 feet.

Write today for further information on the TS 539 Air Data Computer Test Set and for details on SMI capability in test equipment.

Engineers: Investigate the opportunities available now at SMI in the fields of aircraft and missile instrument-control systems development.



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