

APRIL 1960/\$1

AIR FORCE

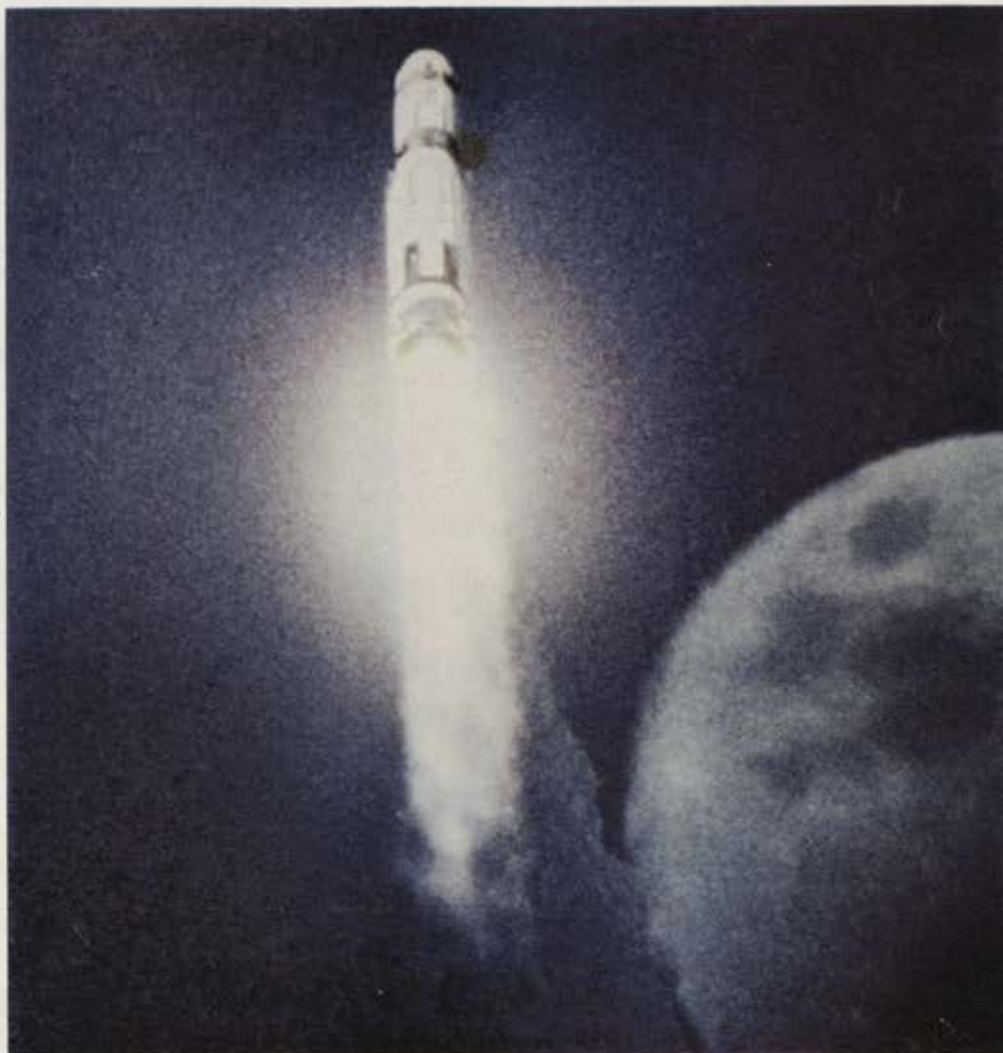
The Magazine of Aerospace Power

Published by the Air Force Association

SPACE DIGEST

THE SPACE AGE IN PERSPECTIVE

Missile and Space ALMANAC



▶ *Martin Titan ICBM, launched by USAF from Cape Canaveral, appears to be passing the moon in this unusual photo symbolizing missilery as the key to manned spaceflight.*



1951 First to fly a shaft turbine helicopter anywhere.

1954 First to fly a helicopter powered by twin turbines.

1956 Kaman flew the first helicopter to be powered with a gas turbine designed specifically for helicopters.

1959 Kaman converts its production 100 percent to turbine powered helicopters, becoming the first major helicopter company to take this forward step.

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The Vertol 107, twin-turbine-powered helicopter, offers a new concept of dependability for all-weather, around-the-clock support of ICBM dispersed launching sites.

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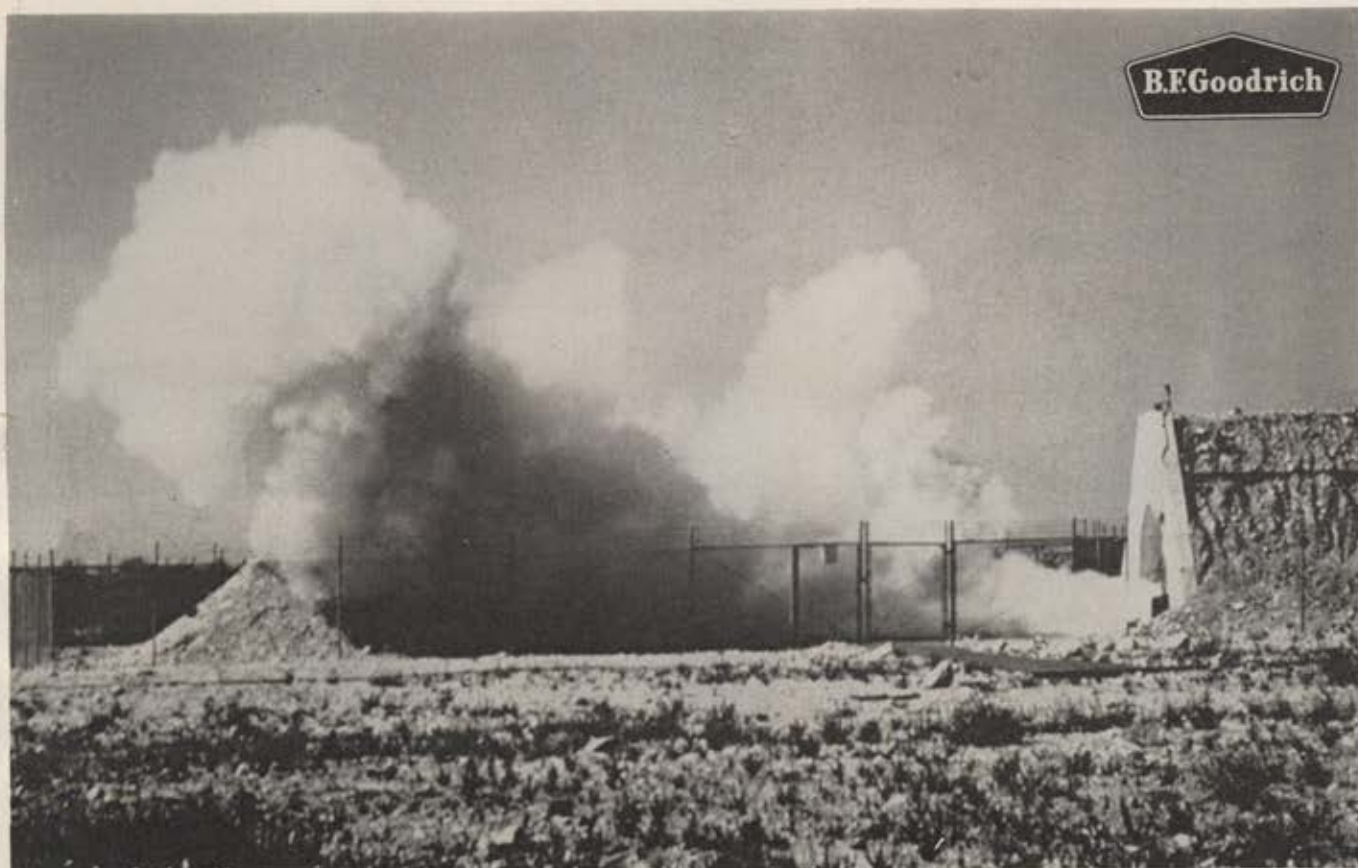
For command inspection and high priority maintenance of missiles at scattered sites, the all-terrain Vertol 107 offers travel time reductions up to 90%. In addition, since personnel can be shuttled back and forth between home base and launching areas in minutes, the need for extensive house-keeping facilities at each site is eliminated. The Vertol 107 Model II can carry a 5,000-pound payload internally, externally—or, if necessary, half-in half-out—over a mission radius of 100 nautical miles—even on a hot day at 7,000-foot elevations.

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Lowering a rack of small rocket motors into curing pit at the BFG Rialto plant after propellant has been poured into the cases. B.F. Goodrich has been engaged in composite solid propellant research since 1952—in motor production since 1957.

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AIR FORCE SPACE DIGEST

Volume 43, Number 4 • April 1960

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Imagination, Brains, and Guts

John F. Loosbrock, Editor

WE DON'T have time to read a tenth of the stuff that comes across our desk each day. But once in a while a gem shows up that gives us pause for thought. One such was a copy of a recent speech by Emilio Q. Daddario, a Democratic congressman from Connecticut who serves on the House Committee on Science and Astronautics.

Mr. Daddario was talking about Columbus and the difficulties he encountered:

"He [Columbus] was required to submit his proposal to the so-called Talavera Commission of learned men for review and to justify his requirements. They held hearings in the year 1486, and issued their report in the year 1490, four and a half years later. They judged that the promises of Columbus 'were impossible and vain and worthy of rejection.' They reported to their royal majesties that it was 'not a proper object for their royal authority to favor an affair that rests on such weak foundations and which appears uncertain and impossible to any educated person, however little learning he might have.'"

Sound familiar?

Let's take another excursion back in time. Not quite so far, though, only back to 1909 and the first military airplane.

It could carry a pilot and one passenger at a speed of forty-two and one-half miles per hour for one hour. It cost about \$30,000. Its useful life was approximately thirty flying hours. The cost per passenger-mile in 1909 dollars was about \$25. (In today's dollars that would be about \$80.)

Let's be orderly and logical as we sit on a 1910 version of Columbus' Talavera Commission. We would conclude, from the evidence at hand, that airplanes are terribly expensive and that payloads are too small. We would foresee only limited military uses for them, primarily in reconnaissance. And commercial air transport would be economically out of the question.

Yet in fifty years speed has increased more than one order of magnitude, useful life has increased by three orders of magnitude, and direct operating costs for a jet transport are about three cents a passenger-mile.

How wrong can you be?

In 1945, Dr. Vannevar Bush, wartime director of the Office of Scientific Research and Development, said this about the future of missiles:

"There has been a great deal said about a 3,000-mile, high-angle rocket. In my opinion, such a thing is impossible and will be impossible for many years.

"The people who have been writing these things that annoy me . . . have been talking about a 3,000-mile, high-angle rocket, shot from one continent to another, carrying an atomic bomb, and so directed as to be a precise weapon which would land exactly on a certain target, such as a city.

"I say, technically, I don't think anybody in the world

knows how to do such a thing, and I feel confident it will not be done for a very long period of time to come. . . . I think we can leave that out of our thinking. I wish the American public would leave it out of their thinking."

Yet only fifteen years later, Lt. Gen. Bernard A. Schriever was able to tell a Washington audience the following success story, which we think is worth quoting:

"In February 1954, Dr. John von Neumann and his colleagues—representing the best scientific and technical brains in America—told the Air Force that an operational intercontinental ballistic missile could be achieved by this country in from six to nine years—provided that an all-out development effort—with the highest national priority—was initiated immediately. . . .

"On September 1, 1959, the Department of Defense announced to the American people that the Atlas ICBM had become operational. This was just a little over five years from the time that the accelerated ICBM program had gotten under way—and beat the most optimistic forecasts of the Von Neumann committee."

General Schriever went on to make further comparisons between predictions and actualities.

The Von Neumann committee predicted that the first operational ICBMs might have a reliability of fifty percent. Atlas' reliability factor is much higher.

The committee set an optimistic range of 5,500 nautical miles. Atlas has a range of more than 7,000 miles.

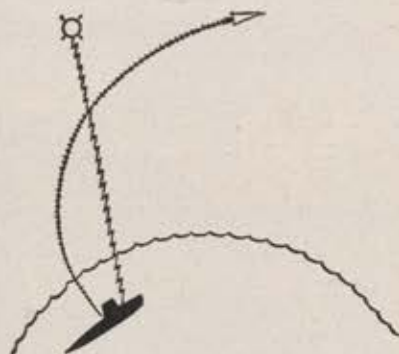
In 1954 an accuracy goal of five miles was considered realistic. Today Atlas is hitting within two miles of the target, based on a statistical average of fifteen consecutive shots. General Schriever pointed out that this was comparable to an expert rifleman placing fifteen consecutive shots in a four-inch bull's-eye at 300 yards.

The history of weapon systems shows that we always tend to expect too much progress in a short time and underestimate greatly the results over the long term. The reason is quite simple.

Short-term progress is limited by such factors as delayed decisions, shortages in money, manpower and facilities, and unforeseen acts of God—fires, floods, and tornadoes. On the other hand, progress over the long haul is speeded up by things you didn't know when you started. Examples include unexpected breakthroughs in basic research, discovery of new ways to apply old knowledge, often achieved through simple trial and error, and the correction of mistaken assumptions made from erroneous data.

The point is that when you have a good program, run by men with imagination, brains, and guts, let 'em run it for all they're worth and you'll get your money back and more with it. But if you nitpick, look over their shoulders, monitor them to death, and needle them with talk of "technical feasibility" and "when's the payoff?", you'll inevitably lengthen the timetable, increase the cost, and compromise the results. A good horse will run better with a loose rein than under a flailing whip.—END

How engineers
will hang
an electronic "star"
to simplify
navigation



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

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

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

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

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

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

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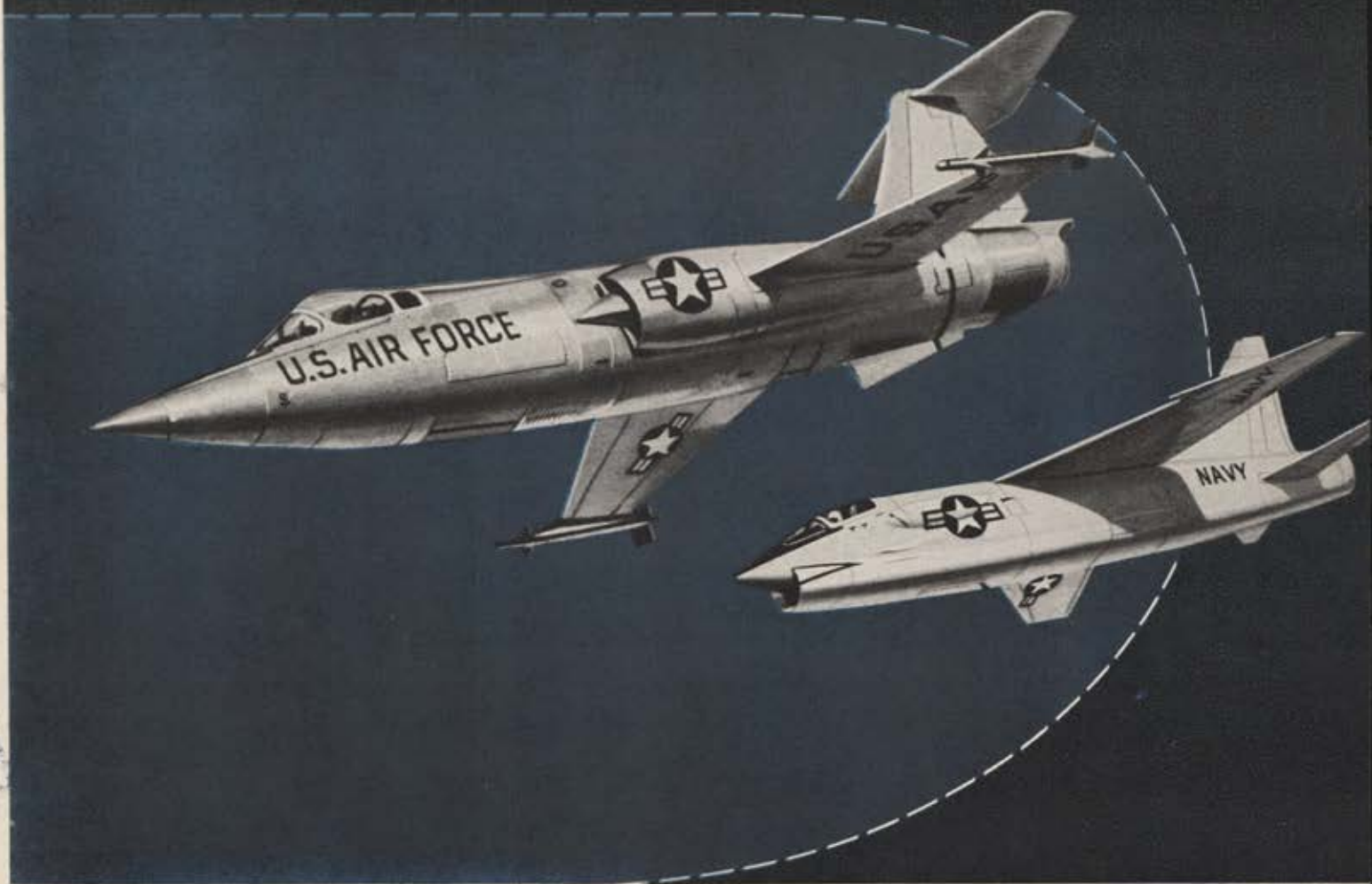
miles — through quick, *on-site* installation of these modification kits.

Only the "building block" designing of the original Gilfillan GCAs makes possible this low cost up-dating to today's jet climb out and penetration requirements.

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AIRMAIL

Time for Leadership and Discipline

Gentlemen: Your hard-hitting editorials should have much more general circulation than is presently accorded, particularly the one in February.

The alarming indifference of our people to the near-disaster situation in which we now find ourselves must be dispelled by whatever means available in our communication system. I am well aware that our military leaders are under tremendous political pressure not to discuss publicly the true state of our military unpreparedness vis-à-vis the Soviet Union; notwithstanding, men of the highest caliber in their fields, Tom Power and Max Taylor, speak their pieces like the dedicated Americans they are.

It seems to me that the national sand glass has almost spilled its last grain when so great an expert as George F. Kennan, in evident desperation, pens this eulogy to the American politico-social system: "This country, with no highly developed sense of national purpose, with its overwhelming accent on personal comfort, with a dearth of public services and a surfeit of private gadgetry, and with no social discipline, has no chance of competing with a purposeful, serious, and disciplined society like the Soviet Union."

Now is the time for great political leadership, no matter what the dollar cost, and for a high level of social discipline. Without these the cost may well be—oblivion.

Thos. J. Sullivan
Tucson, Ariz.

Still With Us

Gentlemen: I thought you might be interested that the premise in General Taylor's book, *The Uncertain Trumpet*, quoted by you in the review on page 105 of the March issue is still the current policy of the Army.

It so happens the day after I read your book review I was reading the material in the Staff Development Course No. 45-0004, Lesson 16—Land Power and United States Army Doctrine.

This quotes from Army Pamphlet No. 20-1, January 22, 1958 and sets forth exactly the same premise.

One paragraph reads as follows: "To be adequate, the national military program must contain properly weighted provision for deterrence of general war, deterrence of local aggression, defeat of local aggression, and survival in general war. This four-pointed program with its relative priorities is fundamental. . . ."

It looks like the 1956 Staff Report is still the official policy of the US Army.

Robert Kahn
Lafayette, Calif.

Defenders of the Exchange

Gentlemen: I wish to highly commend Frederic M. Philips for the article "Unfair Competition to Retailers," which appeared in the February 1960 issue of *AIR FORCE/SPACE DIGEST*.

It can be generally agreed that the American retailer takes on the hue of a "predatory businessman" when he attacks the limited purchasing power of the average serviceman. I could well agree with the philosophy of *not* underselling legitimate retail business or of *not* providing low-cost purchasing privileges to the American serviceman, *but* only on the basis that the serviceman's income was raised to the level of similar workers in the industrial field.

If these complaining retailers wish to eliminate the so-called "unfair competition" let them actively and purposefully lobby in Congress to have the take-home pay of the American serviceman raised to subsistence levels equal to that of the average industrial worker.

These same retailers could also assist the serviceman in procuring housing with rent at nonusurious levels. In this way they could enjoy the everlasting thanks and patronage of these marginal-income Americans.

Christopher S. Smith
Union, N.J.

Gentlemen: May we congratulate you on the excellent article appearing in the February issue of *AIR FORCE Magazine* on the subject of Retail Association's criticisms of the Exchange and Commissary.

I think this is one of the best arti-

cles that have been written on this subject.

F. Scott Wilder, Publisher
*Post Exchange and Commissary:
The Magazine of Merchandising
to the Armed Forces*
Red Bank, N.J.

Space and Survival

Gentlemen: May I add a hearty amen to your article "A Strange Dualism," by William Leavitt, in the February issue of *AIR FORCE/SPACE DIGEST*. Everything coming out of our space programs that has military application should be exploited as a matter of highest priority. But there are not "two" programs. They are one and the same, and the sooner we realize it, the better off we will be.

Lt. Gen. James M. Gavin, USA
(Ret.)
Cambridge, Mass.

VIP Trip

Gentlemen: All of us here at the Transport Division are very much pleased with Claude Witze's excellent story "Operation Monsoon" in your February issue. It's the first piece I've seen on the amazingly complete job Bill Draper and his people do in transporting the Very VIPs.

I had no idea myself of the detail that went into this last mission but can see that it is not just chance that these missions go off without—publicly at least—a single hitch.

The use of jets is not only proving to be a boon to the common ordinary businessman or vacationer but is making drastic changes in international relations. As we see it, all of this can't but help this troubled world.

Gordon S. Williams
Public Relations Manager
Transport Division
Boeing Airplane Company
Renton, Wash.

One More for the List

Gentlemen: In your February issue a list of institutions participating in machine translation research was given ["Speaking of Space"]. We noted that our name was not included in this compilation. C-E-I-R has been inter-

(Continued on following page)

ested in the MT problem since the spring of 1958, when we subcontracted with Georgetown University to program the Code Matching Technique developed there by Ariadne Lukjanow. This system was demonstrated before officials of NSF, CIA, and each of the services on August 20, 1958.

Miss Lukjanow and an associate, Dr. Rudolph Loewenthal, have recently joined the staff of C-E-I-R, Inc., and are engaged in the design of an improved system, the essentials of which were presented to the field at the recent National Symposium on Machine Translation held at Los Angeles, February 2-5. The technique is known as the Unified Transfer System, and a full and detailed report on the system has been printed and is available to any interested parties.

I. Seligsohn
Dir. of Technical Information
C-E-I-R, Inc.
1200 Jefferson Davis Highway
Arlington, Va.

New Division for AAS

Gentlemen: Congratulations are certainly in order for your fine February issue of AIR FORCE/SPACE DIGEST Magazine. In particular I would like to thank you for the article "Off the Ground" which appeared on page 102. This article will certainly assist our present membership drive a great deal. . . .

2d Lt. John D. Johnston, Pres.
Arnold Air Society Alumni
Association
Albuquerque, N.M.

Gentlemen: . . . Gus Duda's article "Off the Ground" will certainly aid our membership drive which is now in process. Each day is bringing new inquiries and membership applications due to the widespread popularity of AIR FORCE/SPACE DIGEST. . . .

Working so closely with the AAS Alumni Association and the cadets of Arnold Air Society at National Headquarters, University of Pittsburgh, I have found your magazine very beneficial in giving me a wider knowledge of the Air Force. The articles are most interesting and informative.

Pauline Ann Luntz, Adm. Sec'y
AAS Alumni Association
Pittsburgh, Pa.

Worthy Partner

Gentlemen: As National Commander of the Civil Air Patrol, I wish to express the appreciation of our 70,000 members for the outstanding factual article published in the February issue

of AIR FORCE/SPACE DIGEST, "The Air Force's Junior Partner," by Louis Alexander.

The four-page layout was an excellent job of reporting and Mr. Alexander deserves the gratitude of every CAP member for his precise handling of the resume of CAP activities, mission, and capabilities. . . .

The mission and accomplishments of CAP are often hidden "under a bushel." It is only through the splendid support of publications and organizations such as the AFA that the entire and true efforts of CAP can be fully brought to light before the American public. The Civil Air Patrol is dedicated to the support of the Air Force, our national security, and the perpetuation of *Aerospace Power for Peace*.

I am extremely pleased with CAP's recognition in your publication, and I extend my personal thanks to the staff for your consideration and support—and a "well done" to Mr. Alexander.

Brig. Gen. Stephen D. McElroy
National Commander, CAP
Ellington AFB, Tex.

Outstanding Squadron

Gentlemen: As a member of AFA since its inception and as secretary of the Lincoln Squadron, may I say how pleased we are that our squadron was named "Squadron of the Month" for February. Not only were we highly honored, we were impressed with the quality of reporting displayed by Mr. Duda in his account of the activities we have carried on.

Such programs as we do have here would not be possible without the excellent help and cooperation we receive from the staff of the Air Force Association.

Frank E. Sorenson
The University of Nebraska
Lincoln, Neb.

Interesting Conjecture

Gentlemen: On page 92 of the February issue of SPACE DIGEST it was reported that the Soviet scientist V. Cherenkov suggests that, in order to absorb more solar energy, we create a ring of crushed powder around our planet. This brings to mind several results and consequences which are not of advantage to us.

First, the increased absorption of radiation will bring about an increase in the mean average temperatures over all the earth. This will have two effects of great advantage to the land masses of the Sino-Soviet areas

(Continued on page 16)

Systems management competence in design, fabrication, structural construction, installation, operation, training, and maintenance of:



1. Space surveillance systems



2. Transportable communications systems



3. Instrumentation, control, and switching systems



4. Telecommunications systems



5. Integrated land, sea, and air communications systems



6. Data systems



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AIR FORCE / SPACE DIGEST • April 1960



SYSTEMS
MANAGEMENT
by ALPHA

ONE STATION TWO TALENTS

1. Stations with the *dual* capability of tracking earth satellites *and* deep space probes are being engineered and constructed by Alpha Corporation as part of Alpha ground-based surveillance systems for space research. A station tells the user the location of the vehicle... collects and processes telemetered data... transmits command communications. Alpha integrated communications systems link each tracking station to a computing facility, providing a complete surveillance complex for all locative and communications functions.

More than 600 designers, engineers, scientists, and constructors are teamed and oriented at Alpha Corporation to assume total management responsibility world-wide for complete projects of the magnitude described. These specialists select the most dependable equipments and services from industry to provide the ultimate in systems reliability.



SYSTEMS DESIGNERS, ENGINEERS, CONSTRUCTORS, WORLD-WIDE | RICHARDSON, TEXAS | TELEPHONE DALLAS ADams 5-2331

—melting of the polar ice caps with the concomitant increase in temperate weather and rainfall, thus creating a large livable land area, formerly unused, for agriculture and expansion of population—far inland and above future sea levels. This increased land use would come at a time when we must necessarily start relocating our tremendous population, and manufacturing facilities, inland to higher ground. This also would mean loss of well established transportation sys-

tems, rich agricultural lands, sea facilities, and a real strain on our whole economic structure.

Second, these belts would, to some extent at least, follow magnetic axes, even if they could mostly be contained in a sixty to 300-mile width. To my knowledge, which I'll admit is very limited, this could mean an excellent defense against missiles for the Sino-Soviet entente while leaving us free of any such aid.

You must realize this is all con-

jecture, and I may be extremely pessimistic, but conjecture today is fact tomorrow, even though tomorrow be fifty or a hundred years from now. I might add that there are few articles, editorials, or just plain reports in your publication which are not thought provoking. . . .

Dr. Stanley K. Norman
Hamilton, Ohio

Second Go-Around

Gentlemen: Your answer to my letter (February '60 issue) indicates that I didn't get my point across. Aren't you making the task too hard when you say that we haven't time to straighten out our economics and politics? I think you've been a voice in the wilderness for airpower so long you've forgotten that the people can help you.

The reverse is actually true. You're not going to get the people to demand an adequate defense until they are informed on the subject of money and where it goes. Just demanding more money for defense won't solve your problem, because the hard-won increase in the defense budget today is the welfare budget of tomorrow; and you're right back where you started.

My original gripe was that the people aren't aware that welfare is replacing the defense budget. They aren't going to do anything about it until they know, and you're not going to help your cause until you tell them.

L. S. Abbott
Wichita, Kan.

Good Investment

Gentlemen: . . . I have heard much discussion as to the value of Flight Pay Insurance sponsored by AFA, particularly since the premium and policy adjustments were made about a year ago.

Considerable discussion has been generated by exclusion number fourteen, which states, "The policy shall not cover loss to any Member resulting from a disease or disability pre-existing the effective date of coverage, or a recurrence of such disease or disability, whether or not a waiver has been authorized by appropriate medical authority in accordance with regulations or directives of the service concerned."

It is obvious that this clause is open to varied interpretation and I am happy to report that the Insurance Division of AFA has proven to me that they are living up to their obligation to look after the insured.

Capt. Charles A. Stone
Bossier City, La.

FIRST IN THE JET AGE!

with Jet Age Inc. Eng.

Southwest Airmotive isn't just First In The Jet Age with jets — it's First In The Jet Age with pistons, too. Realizing most of its friends must look a propeller in the face for years to come, SAC has expanded its famous recip engine shop into a finely-equipped new home. Engine exchanges are a big item here. The mechanic in the background is assembling an exchange Pratt & Whitney R-985-14B (\$2,650.) for a Twin Beech. I'm looking at an exchange Lycoming GSO-480-B1B6 (\$4,750.) for a Twin Bonanza, and in the foreground there's a Lycoming GO-480-B (\$3,450.) for an Aero Commander. They also offer the Continental O-470-B or M (\$2,560.) for the Cessna 310, and many others. Move over Jet Jockeys — Southwest Airmotive is big enough for Piston Pushers, too!



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AIRPLANES • ENGINES • SERVICE • SUPPLY

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Jets

27 million jet flight hours

... demonstrate General Electric's leadership
in the design and manufacture of jet engines.

From the historic moment in 1942 when twin General Electric I-A engines powered the first jet flight in America, G-E engines have logged 27 million jet flight hours. And, G-E jets like the J33, J35, J47, T58, J85, J79, and CJ-805 have consistently set new standards of performance and reliability.

Today, a General Electric engine:

- Powers the aircraft which has possessed the world's speed, altitude and time-to-climb records all at the same time—an unprecedented triple crown.
- Shares in the Collier Trophy for "the greatest achievement in aviation in America" ... during 1958.
- Has been chosen to power the world's newest and fastest commercial jetliners and the first American turbine-powered commercial helicopters.

GENERAL  ELECTRIC



27 million jet flight hours mean

Reliability

for air-breathing weapon systems

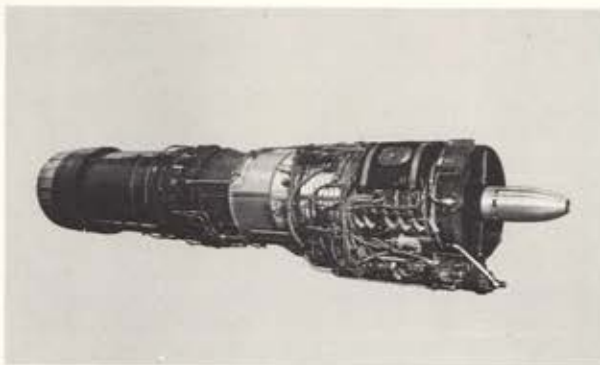
For almost two decades jet thrust has been increasing rapidly. G.E. has helped lead the way. Each new G-E engine has added to a remarkable record of reliability. Today, the J79-powered Lockheed F-104 has established an outstanding in-commission rate with USAF.

Sea forces will soon be strengthened by the McDonnell F4H and the North American A3J—the fastest, highest-flying aircraft in Navy history.

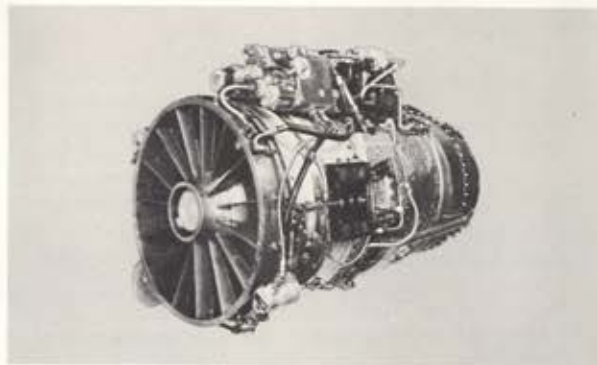
USAF's fastest, highest-flying bomber, Convair's B-58, is J79-powered. And, USAF's J79-powered Lockheed F-104 has held simultaneously the world's speed, altitude, and time-to-climb records—an unprecedented triple crown.

At the other end of the flight propulsion spectrum, G-E small gas turbines will soon enter operational service with the Air Force and Navy. The Navy's newest ASW and utility helicopters will be powered by the T58, which has demonstrated its reliability in thousands of demanding test hours.

The high performance J85 turbojet will soon enter USAF service powering McDonnell's GAM-72 decoy missile and Northrop's T-38 jet trainer.

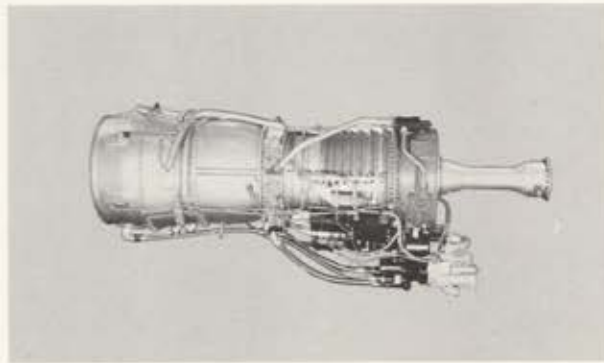
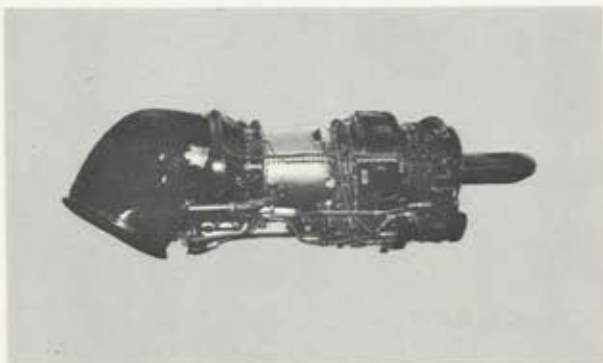


J79 After more than three years of production, G.E.'s J79 remains the most advanced U.S. production turbojet. The record-breaking J79 provides more than 15,000 pounds of thrust, yet some models weigh as little as 3200 pounds. J79-powered aircraft have logged considerably more than half the world's Mach 2 time. Six Mach 2 air weapons are J79-powered: McDonnell F4H Phantom II, North American A3J Vigilante, Convair B-58 Hustler, Lockheed F-104 Starfighter (all pictured in main illustration), Grumman F11F-1F Super Tiger, and Chance Vought Regulus II missile.



J85 Advanced aerodynamic and mechanical design make G.E.'s J85 turbojet the highest thrust-to-weight ratio powerplant in its class. Weighing just 525 pounds and delivering 3850 pounds thrust, the reheat J85-5 powers Northrop's T-38 Talon supersonic trainer (pictured in main illustration) and N-156F Freedom Fighter (right). Another J85 version (above), which weighs 325 pounds and produces 2450 pounds thrust, is in production for the McDonnell GAM-72 decoy missile (right).





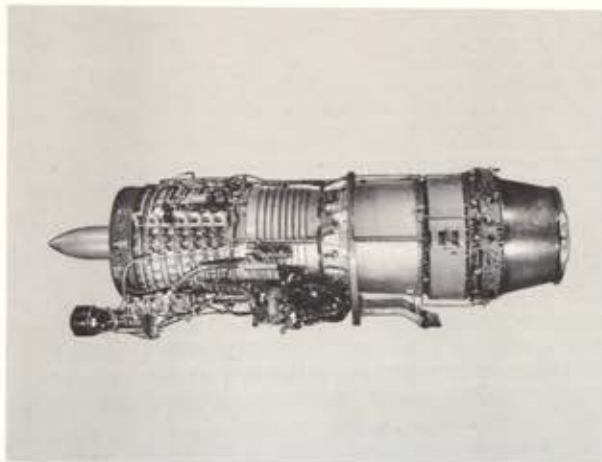
T58 The T58 brings important benefits to helicopters—increased payloads or range, faster cruising speeds, greater endurance. Engines shipped have averaged significantly better than guarantees of 1050 shp, 0.64 SFC, and 271-pound weight. A 1250 shp growth version enters production this year. T58 has been flight tested in single and twin engine helicopters including Sikorsky's HSS-1F, HSS-2 (left), and S-62; Kaman's HU2K (left); and Vertol's YHC-1A and H-21D.

T64 Low SFC and attractive power-to-weight ratio make G.E.'s versatile T64 turboprop/turboshaft ideally suited for a variety of aircraft. Among them: helicopters and fixed wing designs (right), skycranes, new VTOL/STOL designs. Turboprop configurations, with gearbox above or below centerline, deliver 2570 eshp at .522 ESFC. Turboshaft versions produce 2650 shp at .506 SFC. All models have common power sections, differ only in gearing and accessories.

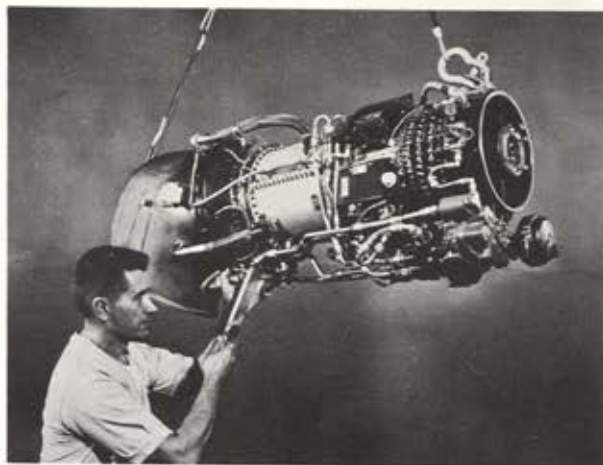


GENERAL  ELECTRIC

27 million jet flight hours mean
Thoroughly Proven Powerplants
for commercial aviation



CJ-805-3 G.E.'s first commercial engine, the CJ-805-3, enters airline service this spring. It will provide the power to carry passengers in Convair 880 jetliners at 615 miles per hour. The CJ-805 weighs 2800 pounds, delivers more than 11,000 pounds of thrust. It is 110 inches long, 32 inches in diameter.



CT58 The CT58 is the first U.S. turboshaft to be FAA-certificated. It will power the twin-turbine Sikorsky S-61 and Vertol 107 (both in main illustration above) which begin passenger service next year. Sikorsky's CT58-powered single-engine S-62 is being offered to helicopter operators and corporations.

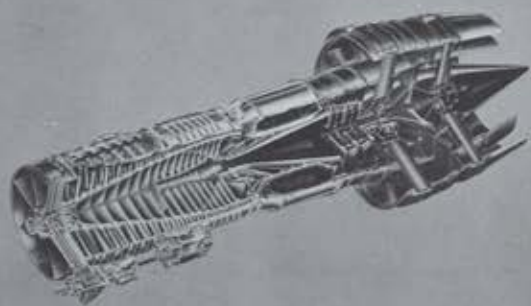
GENERAL  ELECTRIC



G-E engines will be the most thoroughly tested yet to enter airline service. For example, General Electric's CJ-805-3 flight test program was the first of its kind ever undertaken by a U.S. manufacturer at his own expense to test a commercial turbojet under flight conditions. The CJ-805 powered Convair 880 (top) has exceeded all of its performance guarantees and performed reliably in flight test. Delta Air Lines' first Convair 880 established speed records on its maiden coast-to-coast flight.

Jetliners powered by CJ-805-3 or -23 engines have been ordered by American Airlines, Avensa (Venezuela), Capital Airlines, Civil Air Transport (Formosa), Delta Air Lines, REAL (Brazil), Scandinavian Airlines System, Swissair, and Trans World Airlines.

At the other end of the power spectrum: America's first turbine-powered commercial helicopters, already on order by all three of the nation's major helicopter airlines, will be powered by G-E CT58 engines. Next natural step: turbinization of helicopters and transports owned and operated by industry.



CJ-805-23 General Electric is flight testing its leased B-66 with aft-fan CJ-805-23 engines. When tests began, it marked the first time an engine manufacturer had test flown a turbofan engine as the primary powerplant of an aircraft. The twin aft-fan engines are performing reliably—proving themselves prior to airline service. CJ-805-23 engines will power the Caravelle VII and Convair 600.



CF700 Compared to turbojets in its class, the CF700 turbofan will provide higher thrust per dollar, greater range, shorter take-off, and less noise. The CF700 will combine the proven J85 gas generator and a scaled-down version of the CJ-805-23 aft-fan to produce 4000 pounds sea level thrust at 0.69 SFC. Flight-worthy CF700's are scheduled for April, 1961, with FAA-certificated engines available in February, 1962.

27 million jet flight hours mean *Greater Capability* for tomorrow's aerospace missions

Twenty-seven million jet flight hours form a solid foundation upon which General Electric research and development can build to meet the needs of the near and distant future.

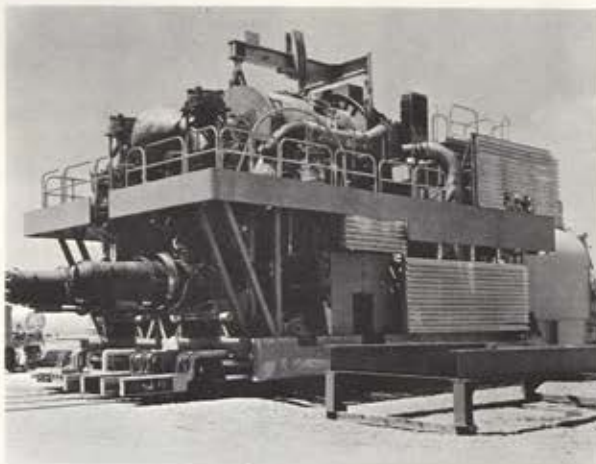
The Mach 3 North American B-70 Valkyrie bomber, for example, represents the next stride forward for manned aircraft. G.E. is developing the highly advanced J93 engines which will power it.

General Electric, under contract with USAF and the AEC, is developing a nuclear propulsion system for America's first nuclear-powered aircraft, as revolutionary as the B-70.

In rocket, VTOL, and space power and propulsion, systems now being investigated at General Electric will help make propulsion progress.

To achieve the challenging objectives of the present and the future, G.E. applies its knowledge and experience, and marshals R&D facilities among the most complete in the nation.

G.E.'s more than 100 research laboratories strive for new basic knowledge which can be applied to aerospace progress. For example, at the pioneering General Electric Research Laboratory, basic research is leading to advances in metallurgy, cryogenics, and other sciences vital to aerospace progress. These activities supplement the direct efforts of extensive aircraft gas turbine R&D facilities at Evendale, Ohio, and Lynn, Massachusetts.



NUCLEAR PROPULSION

This special test assembly was designed and built by General Electric under contract. It consists of a nuclear reactor, shield, controls, and two modified J47 engines. General Electric first successfully operated a turbojet on nuclear power in 1956. Development progress is continuing.





J93 The General Electric Mach 3 J93 will power the North American B-70 Valkyrie to cruising altitudes above 70,000 feet and speeds of more than 2000 mph.



TOMORROW'S VTOL

Currently under development, General Electric lift fan engines hold promise for a new generation of aircraft which can take off straight up, hover, and move forward at high speeds.



ROCKET POWER

Development concepts at G.E. include plug nozzle engines (below) which are markedly smaller than conventional engines of the same thrust.



ION ENGINES

In the void of space, a few ounces of thrust can control vehicle flight paths. One way to achieve this thrust: electrical propulsion. G.E. is investigating an ion engine which electrostatically accelerates mass, such as cesium ions, to produce thrust.

GENERAL  ELECTRIC

Milestones

in General Electric's 27 million jet flight hours



In 1942, the first jet flight in America was General Electric powered. Twin I-A engines (above) powered the Bell P-59 at 450 mph.



The J47 powers Boeing B-47 Stratojet bombers, backbone of America's deterrent strength during the past decade.



North American's F-86 Sabre Jets, powered by General Electric J47's, scored a 14-1 victory ratio in Korea.



America's first Mach 2 engine, the J79, won accolades for performance and reliability. Vice President Nixon (center) presented the Collier Trophy to (left to right) USAF pilots Major Walter Irwin and Lt. Col. Howard Johnson, G.E.'s Gerhard Neumann and Neil Burgess, Lockheed's Clarence Johnson for F-104/J79 design and flight.

(186-38)

GENERAL ELECTRIC ENGINES POWERING THESE AIRCRAFT HAVE FLOWN MORE THAN 27 MILLION JET FLIGHT HOURS

BELL XP-59A
BELL XP-83
BOEING B-47
BOEING KB-50
CHANCE VUGHT REGULUS II
CHASE XC-123A
CONVAIR B-36
CONVAIR B-58
CONVAIR 880
CONVAIR XB-46

CONVAIR XP-81
DOUGLAS RB-66A
DOUGLAS XA-26F
DOUGLAS XB-43A
DOUGLAS XB-53
DOUGLAS XF4D
DOUGLAS D-558
GRUMMAN F11F-1F
KAMAN HU2K

LOCKHEED P-80
LOCKHEED F-104
MARTIN XB-48
MARTIN XB-51
McDONNELL F4H-1
McDONNELL GAM-72
NORTH AMERICAN B-45
NORTH AMERICAN F-86
NORTH AMERICAN F-86D

NORTH AMERICAN F-86H
NORTH AMERICAN XFJ-1
NORTH AMERICAN FJ-2
NORTH AMERICAN A3J-1
NORTH AMERICAN XT-39
NORTHROP N-156 F
NORTHROP T-38
NORTHROP XF-89
NORTHROP YB-49

REPUBLIC XP-84
REPUBLIC XF-84J
REPUBLIC XF-91
RYAN FR-1
RYAN XF2R-1
SIKORSKY HSS-1F
SIKORSKY HSS-2
SIKORSKY S-62
VERTOL H-21D
VERTOL YHC-1A

FLIGHT PROPULSION DIVISION

GENERAL  ELECTRIC

CINCINNATI, OHIO AND LYNN, MASSACHUSETTS

AEROSPACE WORLD

Frederic M. Phillips

ASSOCIATE EDITOR

A flash of flame on a Florida beach marked the birth of a loquacious little planet last month.

It was Pioneer V, to date America's greatest space achievement. By early April, the ninety-four-pound, beach-ball-size sphere was expected to be about four million miles from earth, clipping along at a speed of some thousand miles a minute toward Venus and the sun. It would actually have gone some fifty million miles since its March 11 launching from Cape Canaveral, Fla., on the nose of a USAF Thor-Able rocket. Far less mileage than that separated it from our planet because we were moving in the same general direction at present.

Pioneer V was designed to perform a number of research projects in space, at the same time paving the way for other launches already planned by the National Aeronautics and Space Administration. Most immediately impressive Pioneer V characteristic was its ability to keep in touch. Its radio gear was considered the most powerful ever sent beyond the earth-moon system. Early in Pioneer V's career, it broke the old distance record for deep-space communication with earth, 407,000 miles, set by Pioneer IV last year before it ceased transmitting.

Pioneer V joined Pioneer IV, which weighed in at 13.4 pounds, and Russia's one-and-one-half-ton Mechta in orbit around the sun. Superior radio equipment and other advanced instrumentation, as well as a different orbital path, distinguished the new member of the family.

Also more than mildly impressive to the layman was one estimate of the length of time it will remain in orbit: 100,000 years. Other experts hoped only for "decades." A major hope was that, however long Pioneer V lives, its electronic voice would remain strong enough to keep relaying

secrets back from the sunny side of the solar system.



The flying saucer, like a cold-war Kilroy, keeps turning up here, there, and everywhere—year in and year out. Two sighting reports came this month from seemingly reliable sources.

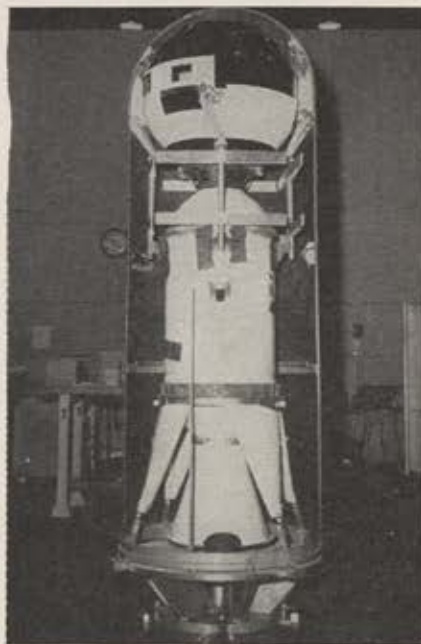
The first was from Alaska. Several persons living in the 150-mile stretch between Nome and St. Michael notified authorities that "silvery flying objects" passed overhead on the night of Sunday, February 14. One man near Nome said "a number" of these objects flashed by at a "tremendous" clip at an altitude of 2,000 to 3,000 feet, then curved "up and away."

An Elmendorf AFB information

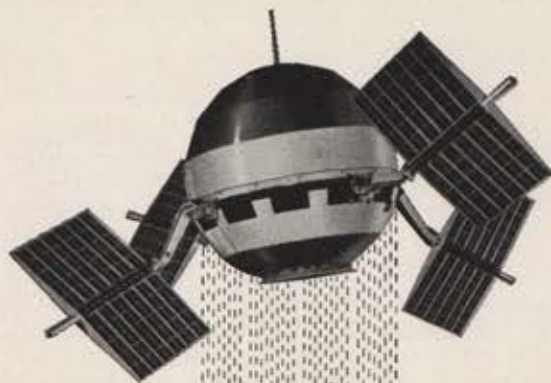
officer, Maj. Roy E. Haines, noted that "some said the objects were low and slow, others that they were high and fast." In Colorado Springs, a North American Air Defense Command spokesman confirmed that officials were looking into the matter.

Three weeks later, a Dubuque, Iowa, flying instructor informed federal authorities that he had seen "three silver, saucer-shaped objects" moving at about 200 miles an hour 20,000 feet over the Mississippi River. "They didn't look like planes or weather balloons and left no vapor trails," Charles Morris, thirty-one, later told newsmen.

The objects showed up, he said, in the late afternoon sun as he and
(Continued on page 27)



Pioneer V. Two views of NASA's heavenly beachball. Right, above, three-stage Thor-Able launching rocket provided by Air Force Ballistic Missile Division lifts off with new planetoid aboard. Sphere's instrument package was designed and built by Space Technology Laboratories, systems engineers for USAF space efforts. Left, Pioneer sits atop third stage of rocket booster, both under fiberglass shroud, during the final stages of prelaunch technical check-out.



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



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

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

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

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

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

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

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others stood watching a stunt plane performing over the river on March 5. Aviator Morris was filming the stunt plane with a moving picture camera; he was understood to have turned his film on the mysterious objects and supplied a certain amount of supporting footage with his official sighting report.



The missile month was mixed.

Titan achieved new glories on February 24, boosting a dummy warhead 5,000 miles down the Atlantic Missile Range from Cape Canaveral, longest Titan flight thus far. The missile performed perfectly for the second time in a ten-month test period. Happiest moment came when, two minutes up and out from Cape Canaveral, the ninety-two-foot bird's troublesome second stage ignited with a great, triumphant puff.

Next try, however, on March 8, second-stage malfunction was back to haunt USAF and Martin Company technicians. The bird flew for fifty-eight seconds. The shot was judged a "partial success." Its new all-inertial guidance system was believed to have functioned satisfactorily.

That same day, a Convair Atlas, also testing a fully developed inertial guidance system, blazed out from the Cape for its twenty-first successful launch in succession. But the winning streak ended there.

Two days later, an after-dark launch attempt flopped. The Atlas on this occasion rose a few feet slowly and majestically, then toppled over and exploded in a boiling inferno. It was the second Atlas explosion in one week. The first did not take place during a launch. On March 5, an Atlas blew up on its operational pad at Vandenberg AFB, Calif., during a SAC fuel-transfer training exercise. It was the first major accident of its kind. No personnel were injured.

USAF's newest and oldest long-range missiles each had a happy outing on March 3. Boeing's Minuteman, a second-generation solid-propellant ICBM in an early developmental stage, shot several hundred feet into the air from its underground silo at Edwards AFB, Calif. The flight was Minuteman's sixth successful tethered test. In these tests, some 2,000 feet of nylon cable hold the nose cone and arrest the missile in flight.

Snark, the Northrop intercontinental cruise missile, took a 5,000-mile hop down the Atlantic Missile Range. Snark travels at only 600 miles an hour. Atlas, by comparison, zooms

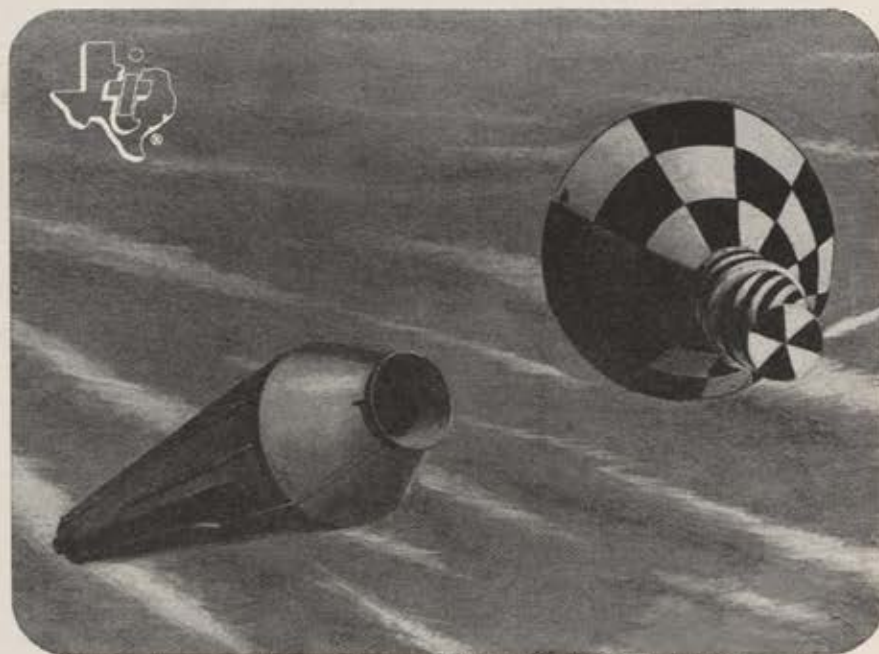


With 96th F-1 Squadron deactivated, its former Commander, Brig. Gen. Milton Ashkins—who now heads 73d AD—presents Hughes Award the outfit won for air defense proficiency to NORAD's General Kuter. At right, Hughes' Jack Rowe.

along at about 18,000 mph. Operational Snarks are deployed at Presque Isle AFB, Me.

Also on the missile scoreboard: The first SAC firing of the command's air-launched guided missile, the North

American Hound Dog, took place on February 29 from a B-52G over the Atlantic Missile Range. The plane launched two of the 500-mile-range missiles, which were delivered to SAC
(Continued on page 29)



N.A.S.A.'s Project MERCURY, first U.S. manned Space Capsule, built by McDonnell Aircraft.

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PHILCO. TECHREP DIVISION

the month previous. And a Boeing Bomarc B air-defense missile blew up on its launch pad at Cape Canaveral on March 5. It was the seventh straight launch failure for the Super Bomarc. Bomarc A missiles are operational on site at McGuire AFB, N. J.

Two operational IRBMs, both well past the test stage, also were in the news. The last of sixty Douglas Thors turned over to Britain's Royal Air Force was flown to Britain in a Douglas C-124 Globemaster on March 8. Thors will keep coming off the production line for use in space projects, among which was Pioneer V. An unconfirmed report widely printed in this country also said that Chrysler Jupiters had arrived in Italy for the scheduled deployment there.



"It looked as if a giant foot had stepped on the city and squashed it flat."

This was Agadir, Morocco, as seen from an Air Force cockpit last month.

Two earthquakes and a resultant tidal wave laid the Arab resort city low on February 29. US armed service rescue teams reached the scene almost immediately.

The Air Force flew supplies in and casualties out, and also provided more than a hundred men for round-the-clock duty helping dig victims from the debris. At the same time, dependents at US bases in Morocco collected clothes, blankets, and money for the relief effort.

During the first few days after the earthquake struck, an average of one Air Force or Navy plane every twelve minutes put down at an undamaged French airfield south of the city—most of them MATS C-124 Globemasters and C-130 Hercules aircraft under the operational control of Headquarters USAFE, at Wiesbaden Air Base, Germany.

On-the-spot aid came from personnel at the several SAC bases in Morocco—Ben Guerir, Boulhaut, Nouasseur, and Sidi Slimane—as well as the Navy at Port Lyautey and French military units stationed in the area.

Among those dug from the rubble by a relief team from Nouasseur were an Air Force officer, Lt. Jerald E. Martin, his wife and daughter. He is stationed at Sidi Slimane. Head of the team was Capt. William R. Andrews, a SAC civil engineer.

More than 500 casualties were airlifted to Moroccan hospitals. Hundreds of others were treated at USAF base hospitals.

Estimates of the total number of



Maj. Gen. Arno H. Luehman, USAF Director of Information, awards Legion of Merit to Maj. Ray Houseman for outstanding service in information field. The major has been transferred from New York to Saudi Arabia. His mother looks on.

Moroccan dead in flattened Agadir ranged from 6,000 to 12,000.



A few loads of scrap from the billion-dollar salvage grounds of Davis-Monthan AFB, Ariz., have been converted to a resort hotel.

GLs in the Korean War novel *Wake*

Me When It's Over used battle-line scrap to build their own hotel. Filming the novel, Twentieth Century-Fox hit on Davis-Monthan, final resting place for USAF planes and equipment, as a likely source for building supplies to duplicate this fictional feat.

The moviemakers hauled away sev-
(Continued on page 31)



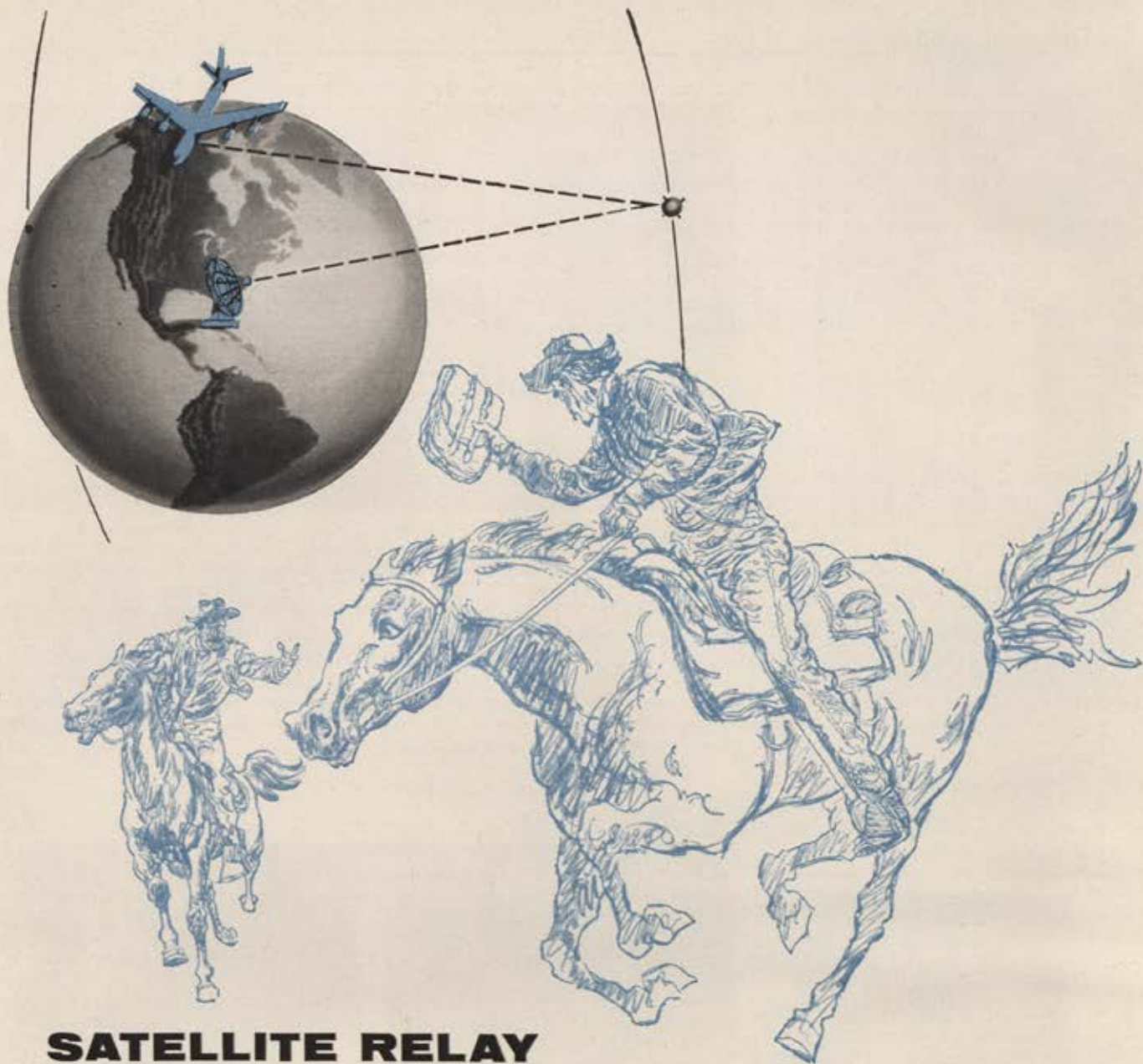
USAF BOMARC Missile produced by Boeing Airplane Co —equipped with TI-built PDM/FM/FM telemetry system.

TI TELEMETRY IN MISSILE SYSTEMS

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SATELLITE RELAY

... for modern long-range communications

Pony Express riders began an American tradition for the reliable relay of important messages over long distances. Today, Bendix is proud of its role in extending this tradition to SAC communications through the active radio relay satellite program.

Under Project STEER, Bendix has prime responsibility for the entire communication system. STEER will use polar orbit satellites to relay commands and pilot messages between Air Force ground stations in the United States and SAC bombers ranging on global missions. The ideal vantage point of a satellite relay will permit utilization of line-of-sight advanced UHF techniques. The fading and interference problems inherent in the

ionospheric transmissions of present HF long-range communications will be avoided.

Other space age projects at the Bendix Systems Division include magnetohydrodynamics, highly reliable radiation-resistant communication equipment, interpretation and prediction of infrared reconnaissance, new satellite stabilization techniques, and communication methods to penetrate the ionized shock layer surrounding hypersonic vehicles. Additional projects involve satellites for weather and ground infrared reconnaissance, and for radio navigation.

Opportunities are open to better engineers and scientists interested in participating in advanced space programs in an ideal scientific climate.

Bendix Systems Division

ANN ARBOR, MICHIGAN



eral truckloads of old propellers, navigators' blisters, jet intakes, wing tanks, pierced-steel landing mats, assorted pipe, wire, canopies, time-worn bomb casings, miscellaneous pieces of fuselage, and the like. Today, the odds and ends from Davis-Monthan are a striking movie-lot hostelry.

Skilled studio workmen performed the actual construction. But actors stood in for them at some points for the purpose of filming. Both the building of the scrap-heap hotel and the finished product figure in the picture.

★ North American X-15 test pilot Scott Crossfield says this is one of his favorite stories: "I was out at Wright-Patterson going through the various tests they say flyers should take from time to time. One of the examiners asked the guy next to me, 'How would you like to be a famous test pilot like Crossfield?' He answered, 'No thanks, it's bad enough being a chimpanzee.'"

Space pioneer Crossfield, speaking to an Aviation Writer's Association luncheon in Washington early this year, also drew chuckles when he described his experimental craft as "the first-class compartment of the B-52 mother plane which carries it aloft." He added, "As old fighter pilots, the only thing some of us find dangerous about planes like the X-15 is that we have to go up with a bomber first."

★ On George Washington's birthday, a former Air Force officer and AFA member of our acquaintance paid a visit to Bowie, a place in nearby Maryland where horses run around a track. The patrons, if this is an area where you are not familiar with the state of the art, are allowed to place bets. Our friend says he had this in mind when he went to the track, and hoped that one or two good tickets would help him forget some of the current headlines. Bowie, on a national holiday, looked like a good outlet.

Sure enough the card showed, in the third race, a pony named Tooeey Spaatz. Here was an opportunity. General Spaatz ran first as Chief of Staff. There was every reason to believe he could keep it up. Well, you guessed it—Tooeey Spaatz ran a poor fifth. But all was not lost. In the sixth race there was an entry tagged Ira Eaker—another general, one who made history with the Eighth Air Force. Surely he would head for the Wild Blue Yonder. Our friend made for the two-dollar window, but before he could grab a ticket the loud speakers aborted the mission: Ira Eaker was scratched.



Chuting missile. Martin Mace drifts to earth beneath parachutes after flight at Holloman AFB, N. M. Missile is reused after such recoveries in Mace crew training program at base.

The Air Force veteran says he is going back to Bowie some day soon. He will look for an entry named MacArthur, Radford, or Manual Training.



Elsewhere in the aerospace world:

A "mystery satellite" occupied national attention briefly. The Department of Defense announced existence of what appeared to be an unidentified satellite on February 10, some two weeks after US tracking stations picked it up. In early March, DoD said that it appeared to be the carrier rocket of the Air Force's Discoverer V satellite launched last August.

A North American X-15 aerospace vehicle completed two more flights and was turned over to the Air Force and NASA at the beginning of March. On February 11, in its fifth powered flight, the X-15 reached an altitude of 80,000 feet in a four-minute flight over Edwards AFB, Calif., after launching from a B-52. On February 17, pilot-engineer Scott Crossfield took the X-15 through its first power dive, attaining a speed of 1,400 miles an hour and a pullout pressure of six Gs. On the 29th, the first of the three X-15s in existence was accepted from the manufacturer to enter a USAF-NASA test program.

The bodies of five US World War II airmen were discovered in the Libyan desert on February 10. Their
(Continued on page 33)



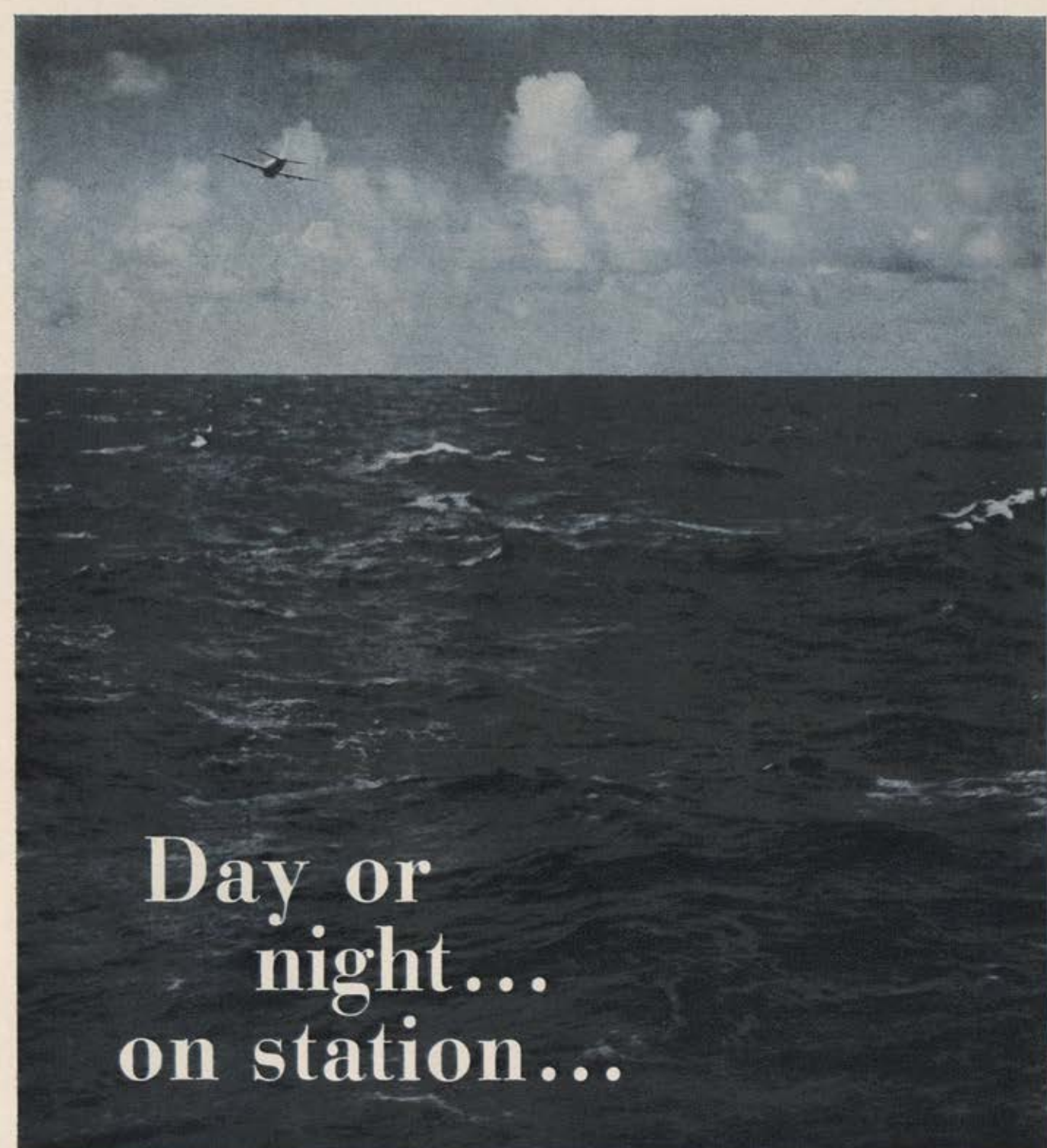
U. S. Army Signal Corps SWALLOW AN/USD-4 Combat Reconnaissance Drone
Produced by Republic Aviation—Equipped with TI Surveillance Sensors

TI IN SURVEILLANCE SYSTEMS

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gation systems of maximum accuracy and reliability. These systems make use of periodic starlight information...day or night...to correct for the gyro drift inherent in all pure inertial systems.

Autonetics stellar-inertial subsystems now in test meet requirements for ASW, AEW and reconnaissance.

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INERTIAL NAVIGATION / ARMAMENT AND FLIGHT CONTROL / COMPUTERS AND DATA SYSTEMS

forced-down B-24 Liberator, Lady Be Good, was found in the desert last May in a high state of preservation. There was no sign of the eight-man crew at the time.

France joined the US, Britain, and Russia in the "nuclear club" with the explosion of an atomic device in the Sahara on February 13. She was expected to follow this with explosion of an operational A-bomb and then, possibly, an H-bomb.

The State Department announced on February 17 that USAF's third Ballistic Missile Early Warning System (BMEWS) station will be erected on Fylingdales Moor, Yorkshire, England. The first two sites are in Greenland and Alaska. Earlier speculation had suggested that the third might be in Scotland rather than England.

USAF failed in an attempt to put its Discoverer X satellite into orbit on February 19. The satellite was destroyed within a minute after launch when it veered toward land, the first launch failure in ten Discoverer shots.

A test version of a USAF Midas early-warning satellite burned up about five minutes after takeoff from Cape Canaveral on February 26, due to malfunction of retrorockets that were to have separated its two stages.

An automatic bomb alarm system to report nuclear attacks anywhere in the nation to Air Force command centers was announced on March 7. It will not be a warning network, but a post-attack signal system.

A suburban Washington, D. C., high school senior and a freshman at the Massachusetts Institute of Technology have communicated with each other by bouncing ham radio signals off US and Russian artificial satellites, it was reported on March 10. So far as is known, scientists have not yet accomplished this feat.

Russia has ordered four US helicopters, two from Sikorsky and two from Vertol, for the use of Premier Khrushchev and other Red dignitaries. They were of the types Mr. K was flown in during his visit here last year. A Soviet spokesman in Washington explained on March 10 that Russia makes its own copters, but "you started earlier on them," and so have better ones.

Thirty-six Navy picket destroyers retired from duty patrolling the Atlantic and Pacific flanks of the DEW Line early in March, leaving this responsibility in the hands of naval patrol aircraft. The ships took up other duties or entered the mothball fleet. The move coincided with con-



Then-and-now pump pictures provide interesting contrast. Left, Kellogg F5L from Curtiss NC-4 that made the first Atlantic crossing in 1919. At right, Kellogg AP6V, four of which are installed in the McDonnell F-101 Voodoo jet fighter. Old model was a masterpiece of design simplicity. New model is a bit more sophisticated.

tinuing USAF fighter-interceptor cutbacks regretted by NORAD but dictated by budget and technological factors. At the same time, also in the air defense area, NORAD received a USAF green light to construct an underground combat headquarters in the Colorado Rockies—an on-again-

off-again project in the recent past.

Gen. Nathan F. Twining, Chairman of the Joint Chiefs of Staff, left the hospital in Washington on March 14, following convalescence from an appendectomy on February 22. General Twining, who was operated on (Continued on following page)



Environmental testing of TARMac ASR-4 Airport Surveillance Radar System, developed and produced for the Federal Aviation Agency.

TI IN HEAVY RADAR SYSTEMS

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AEROSPACE WORLD

CONTINUED

for cancer last year, was said to be in "good condition."



STAFF CHANGES . . . On April 1, Brig. Gen. Paul L. Barton, Commander, Hq. Northern AMA, Pacific, AMC, will become Deputy Commander, Air Materiel Force, Pacific Area, AMC, and on August 1, General Barton will be reassigned to duty as Director of Logistics Plans, DCS/Materiel, Hq. USAF, Washington, D. C. . . . Effective April 15, Maj. Gen. William M. Canterbury, from duty as DCS/Research and Engineering, ARDC, to Commander, AF Research Division, ARDC, Washington, D. C. General Canterbury's post will be assumed by Maj. Gen. Marcus F. Cooper, who is now Assistant Administrator, Office of Plans and Requirements, FAA, Washington, D. C. . . . Brig. Gen. Chester W. Cecil, formerly Assistant CofS, Comptroller PACAF, now with DCS/Administration and Logistics, PACAF. . . . Maj. Gen. James V. Edmundson, from Assistant Director to Deputy Director, Personnel Procurement and Training, Office, DCS/Personnel, Hq. USAF, Washington, D. C.

Brig. Gen. Lee W. Fulton, from duty with DCS/Materiel, ARDC, Andrews AFB, Washington, D. C., to DCS/Materiel, MATS, Scott AFB, Ill. . . . Brig. Gen. Frederic C. Gray, formerly with DCS/Operations, Hq. 12th AF, TAC, Waco, Tex., and additional duty of Deputy Commander, 12th AF, is now Director of Operations and Training, TAC, Langley AFB, Va. . . . Effective July 10, Brig. Gen. Donald L. Hardy, Director of Plans and Programming, AMC, Wright-Patterson AFB, Ohio, will become Commander, Hq. MAAMA, AMC, Olmsted AFB, Pa. . . . Maj. Gen. William T. Hefley, now Commander, Hq. AMFEA, AMC, will become Commander, Hq. WRAMA, AMC, Robins AFB, Ga., on July 16. . . . On July 1, Brig. Gen. Bertram C. Harrison, Deputy Director, Personnel Procurement and Training, DCS/Personnel, Hq. USAF, Washington, D. C., will assume duty as Deputy Commander, OCAMA, AMC, Tinker AFB, Okla. . . . Brig. Gen. Royal Hatch, Deputy for Air National Guard Affairs of Continental Air Command, will become Deputy Chief of Staff, Personnel, of USAFE, in early May.

Brig. Gen. Benjamin G. Holzman from Commander to Vice Commander, Hq. AF Research Division, ARDC,

Washington, D. C., on April 15. . . . Brig. Gen. Harold E. Humfeld, from Commander, 17th Air Division, SAC, Whiteman AFB, Mo., to Commander 40th Air Division, SAC, Wurtsmith AFB, Mich. . . . Maj. Gen. Robert B. Landry, now Assistant DCS/Personnel, Hq. USAF, Washington, D. C., to Commander, Hq. SMAMA, AMC, McClellan AFB, Calif., on June 23. . . . On July 1, Brig. Gen. Lawson S. Moseley, Jr., now Assistant CofS, Plans (A-5) Hq. PACAF, will become Director, Research Studies Institute, Air University, Maxwell AFB, Ala. . . . Maj. Gen. Harry C. Porter, Commander, Air Materiel Force, Pacific Area, AMC, will become Director of Plans and Programming, AMC, Wright-Patterson AFB, Ohio, on July 10. . . . Maj. Gen. George E. Price, Commander, Hq. SMAMA, AMC, McClellan AFB, Calif., will, on August 1, become Commander, Hq. AMFEA, AMC.

Brig. Gen. Paul T. Preuss, former Deputy Director of Research and Development, DCS/Development, Hq. USAF, is now Assistant Administrator, Office of Plans and Requirements, FAA, Washington, D. C. . . . Brig. Gen. Robert C. Ruegg, Deputy Director, J-4 (Logistics), Central Control Group (Office, JCS), Hq. USAF, Washington, D. C., will become Deputy Commander, SBAMA, AMC, Norton AFB, Calif., on August 24. . . . On May 21, Brig. Gen. George F. Schlatter, Assistant CofS, J-3, Hq. Caribbean Command, will be assigned to duty as Assistant to Commander, Hq. USAF, Bolling AFB, Washington, D. C. . . . Brig. Gen. Avelin P. Tacon, Jr., now Commander, 831st Air Division, TAC, George AFB, Calif., will become Deputy Commander, 12th AF, TAC, Waco, Tex., on June 5. . . . Brig. Gen. Ralph L. Wassell, now Assistant DCS/Research and Engineering, ARDC, Andrews AFB, Washington, D. C., will on April 15 become Deputy Director of Research and Development, DCS/Development, Hq. USAF, Washington, D. C. . . . Brig. Gen. John W. White, Deputy Chief of Defense, Atomic Support Agency, Hq. USAF, Washington, D. C., will on August 1 become Commander, 3079 Aviation Depot Wing, AMC, Wright-Patterson AFB, Ohio. . . . Brig. Gen. Delmar E. Wilson, former Commander, 36th Air Division, SAC, Davis-Monthan AFB, Ariz., is now Commander, 821st Air Division, SAC, Ellsworth AFB, S. D.

RETIRED. . . . Brig. Gen. Robert O. Cork.—END

MOLECULAR ELECTRONICS

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

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

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

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

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

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

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

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

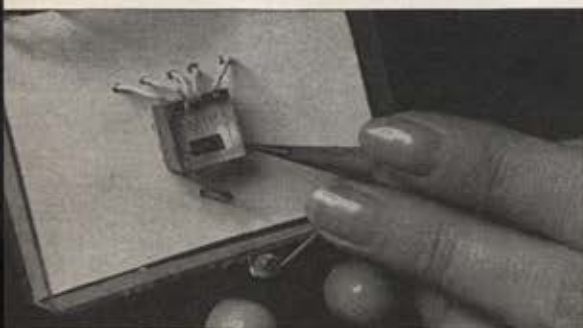
Prediction: only two to five years from now, the pattern of electronic systems will be changed to the core as a result of this historic Westinghouse breakthrough in research and development. Reliability, miniaturization and simplicity will show exponential progress.



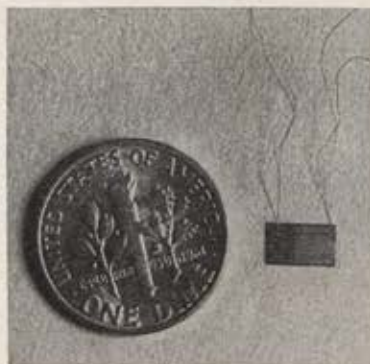
Westinghouse presents working proof of the principle of molecular electronics



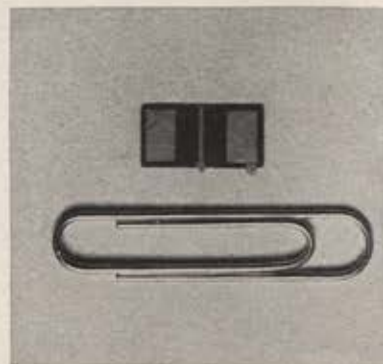
POWER AMPLIFIER: Button-sized molecular electronic device held by girl with a pair of tweezers performs the same amplifying function as a conventional 5-watt amplifier, has a frequency range from zero to 20,000 cycles. Working element is a block about as large as the head of a pin.



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



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



MULTIVIBRATORS: bi-stable, monostable, and astable—covering frequencies from 1 cycle or less to 3 megacycles. Shown is a free running multivibrator alongside paper clip.



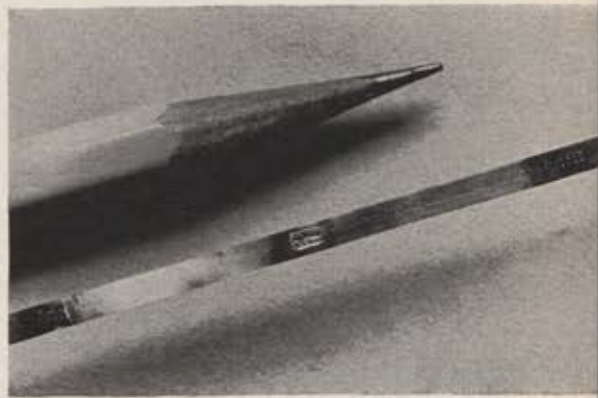
LIGHT TELEMETRY SUB-SYSTEM: a single light-responsive monolithic element delivers output whose frequency is a measure of light intensity.



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



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



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

The meaning of molecular electronics

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

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

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

ENVIRONMENT: inherently more resistant to g-loads because of their small mass and few components,

Westinghouse-developed molecular systems show promise to be temperature and radiation resistant as well. New semiconductor materials and new large crystal surfaces point to very high temperature and power-handling capabilities.

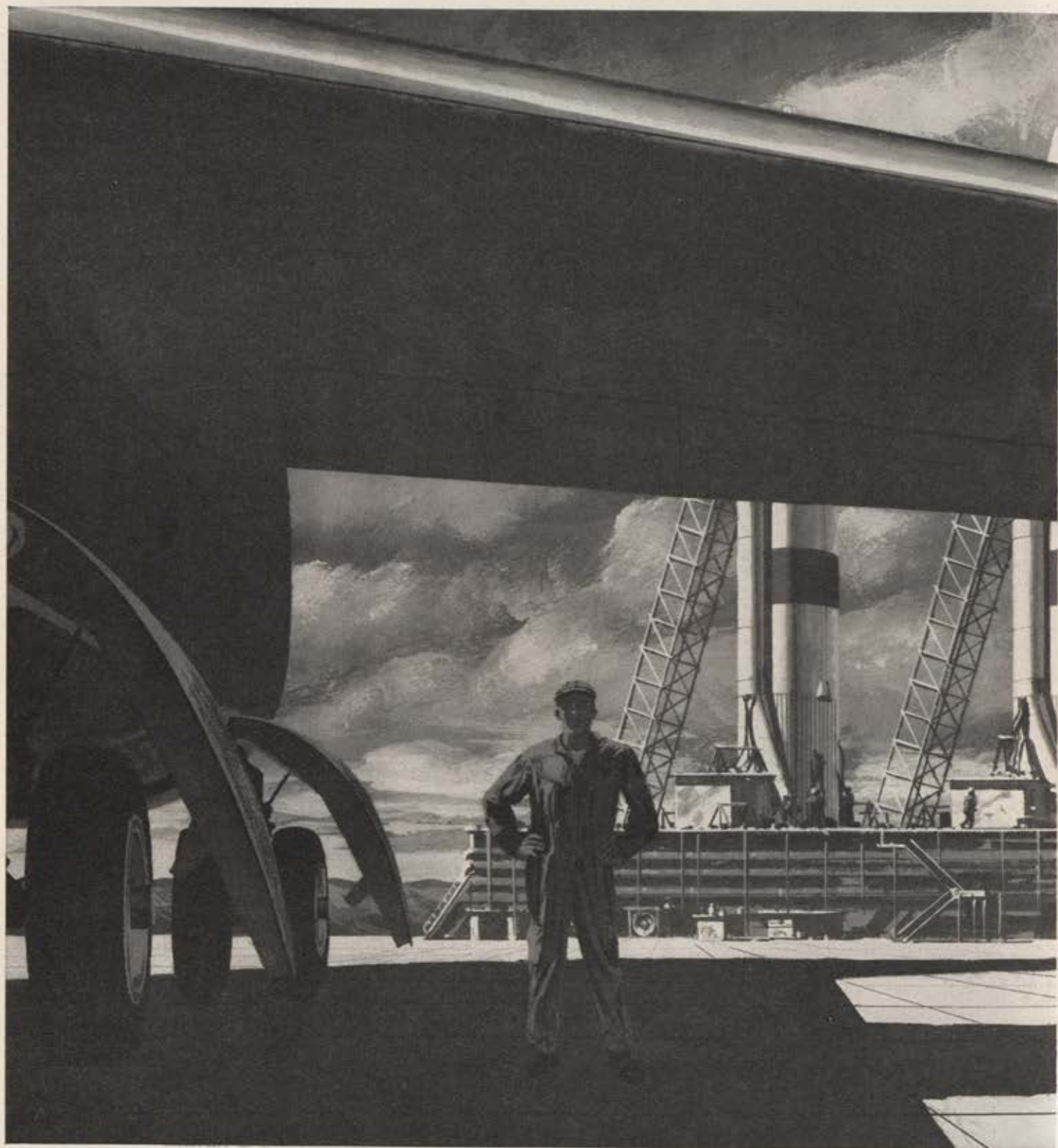
FUTURE: progress in this new field is so rapid, and the advantages so great, that the molecular electronics concept will find wide applications in air/space electronic systems within 3-5 years . . . In particular, look for great advances in the state of the art in these areas: telemetering • fire control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

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

J-02311-1-3

WESTINGHOUSE / DEFENSE PRODUCTS

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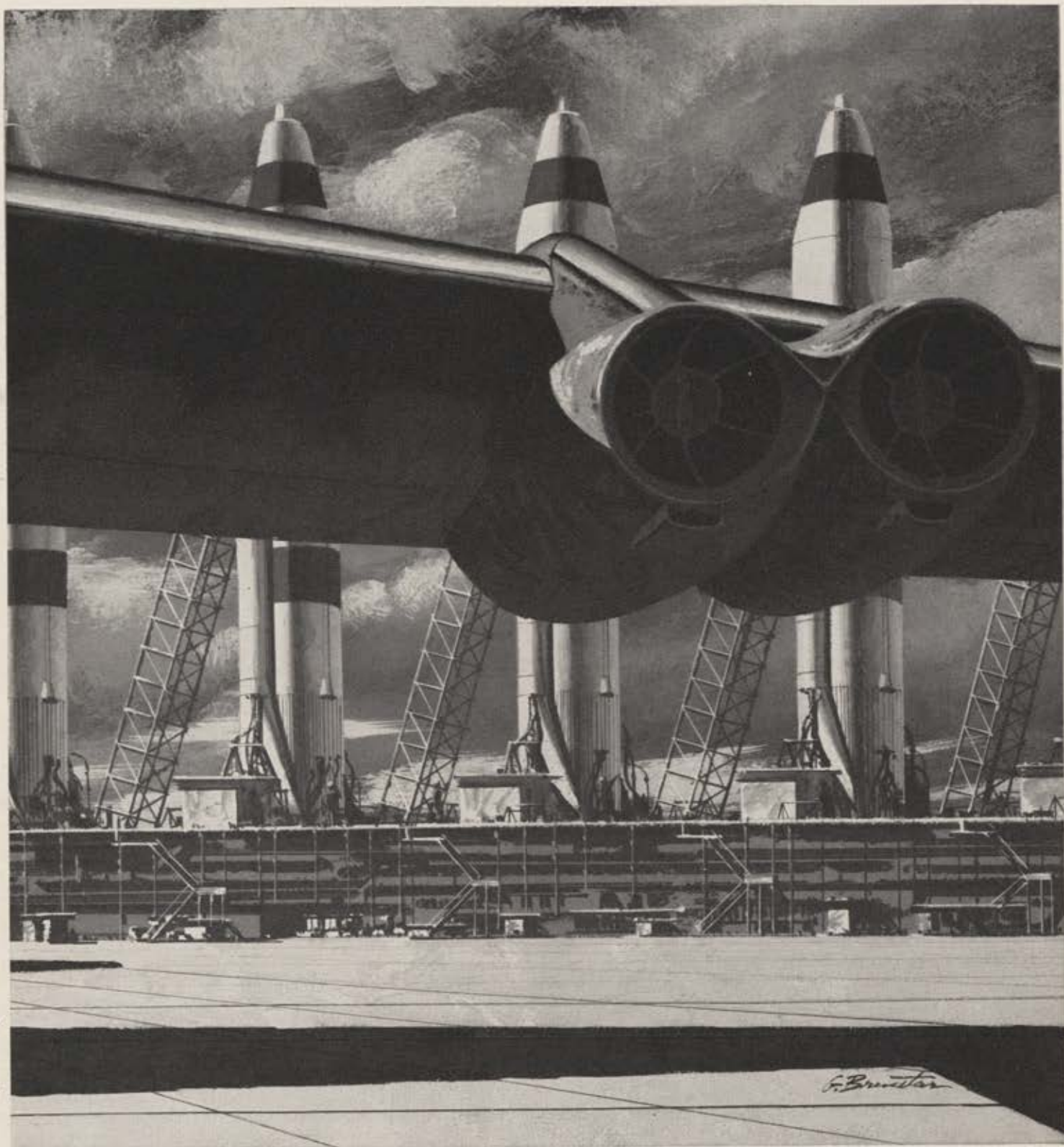
Mix:

The art of winning a war
by preventing it

Americans don't start wars. The principle of non-aggression is rooted deep in our national character and conscience.

That's why this country's military strategy is based on the ability to deliver swift and deadly retaliation once an aggressor moves. It's also why—in this thermonuclear age—America's retaliatory power must be more resourceful, more versatile than ever before. We must have the power of *total retaliation*—plus the swift, all-round capability to meet *any threat* to world peace, anywhere, anytime.

Today missiles loom large at the world's conference tables, but the strategists around those tables know that missiles alone cannot provide



for the full spectrum of military action short of total war. Some victories are achieved only by man's unique ability to capitalize on opportunity... make decisions... and care about the result. Only a man can investigate... return... report. Only a man can be recalled. That's why only the "mix" of both man and machine has retaliatory power *plus* versatility —*plus* the will to win.

America's balance of manned and unmanned weapon systems must be kept real enough to give a potential aggressor constant pause. That's why today the Strategic Air Command has the Atlas ICBM and the B-52 bomber. That is why tomorrow, in the day of the Minuteman ICBM, we

will have a high-performance airplane—the B-70 Valkyrie multi-purpose bomber. From U.S. bases, this 2,000 mph aircraft with its advanced equipment and multiplicity of weapons could strike almost any trouble spot in the world within three hours.

The Mach 3 airplane is being developed to meet these military realities. Together with the missile, it provides a flexible, mobile strike force capable of devastating retaliation. It is a recipe for *preventive* retaliation—real and fearful enough to avert the war that must not happen.

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Claude Witze

SENIOR EDITOR

The Republicans Testify

WASHINGTON, D. C.

Thomas G. Lanphier, Jr., a now-retired vice president of the Convair Division of General Dynamics Corp., recently told some congressmen he thinks the United States is in the process of losing World War III. A few days later Thomas S. Gates, the Secretary of Defense, said he doesn't agree with Mr. Lanphier and "I don't think very many other people do."

For his reply, Mr. Gates deserves a good conduct ribbon specifically marked as a tribute to the man's intellectual honesty. He did not impugn Tom Lanphier's motives, accuse him of political ambitions for himself or anyone else, or scream that he has no right to criticize the Administration. Mr. Gates disagrees with Mr. Lanphier, which is legitimate and proper and entirely what Mr. Lanphier expected.

It is on the record that a number of other people have taken a different approach to the man from San Diego. Senator Francis Case (R.-S. D.), for example, delivered the opinion that Mr. Lanphier did not go far enough when he quit his job but also should "make it clear that he has divested himself of any major stock interest in General Dynamics Corp., and also any stock option rights he may have in that or any other corporation with missiles to sell." One of Mr. Case's colleagues, Senator Hugh Scott (R.-Pa.), joined in the cry with a demand that "those who wish to engage in propaganda in an attempt to increase purchases of munitions by this country [should] disassociate themselves either from munitions makers or from the armed forces, wherever they may find themselves."

This concept, that nobody with stock in a defense business or wearing a uniform has a right to criticize our military stature, would gag most Americans who have any substantial knowledge of the subject. As Mr. Lanphier pointed out to the House Science and Astronautics Committee, we are in a technological war in which science and industry are teamed with the military to determine the quality of our forces in being, and of the future. This, clearly, is a message that still has not been delivered in the halls of Congress.

It is unfortunate that Mr. Lanphier had to make his bow on Capitol Hill before this particular committee, which is headed by Rep. Overton Brooks (D.-La.). His two-hour stint in the witness chair was marred by political bickering, most of it instigated by Republicans who were determined to hang the name of Stuart Symington around Lanphier's neck. There was a time in his career when the witness worked in the Pentagon for Mr. Symington. The latter, at this writing, is reputed to be on the prowl for the Democratic presidential nomination. Mr. Lanphier says he admires Mr. Symington but insists that his present crusade is his own and is aimed only at lessening the peril to the nation.

The charge that Mr. Lanphier is a tool of the Symington camp was put most bluntly by Rep. James G. Fulton (R.-

Pa.), who accused the witness of loyalty to the Democratic senator and, of all people, Harry S. Truman. In his eagerness to discredit Mr. Lanphier on still another front Mr. Fulton tackled his arithmetic with all the fervor and intelligence of William Jennings Bryan trying to prove that man is not a mammal. The witness said there are fewer than 100 bases on which we keep our retaliatory nuclear striking power. He added, taking his figures from Gen. Thomas S. Power, SAC Commander, that the Russians could destroy this power with about 300 ballistic missiles. Moments later Mr. Fulton produced a speech in which President Eisenhower spoke of 250 *military* bases controlled by the Western powers. Ah-ha, said Mr. Fulton with index finger outstretched, you have come before us ill-informed and you are wrong by 150 bases. The witness appeared to despair. He did not bother to explain that almost none of the 250 bases mentioned by the President, outside of the 100 targets harboring retaliatory power, are any more important than the garrison on Governor's Island in an all-out nuclear war. Mr. Fulton does not choose to know that ninety percent of the free world's deterrent is in SAC. The congressman's harangue was ignored in the news reports, which is a loss mainly to the voters of Pennsylvania's Twenty-seventh District, who ought to know about these things.

It never has been made clear why it was the Brooks Committee, a pathetically poor platform, that took the first opportunity to put Mr. Lanphier on the stand. He resigned his post at Convair to avoid embarrassing his employer. He was bound to embarrass the company because he was setting out to fight the Administration's defense program, which he considers a peril to the nation and the free world. The Brooks Committee is supposed to be concerned with science and astronautics, a field in which Mr. Lanphier is interested and well informed. But the source of his ire is the defense posture, the neglect of the force in being.

In sharp contrast to the Brooks Committee hearings are those of the Senate Subcommittee on National Policy Machinery, headed by Henry M. Jackson (D.-Wash.). The chairman has defined his purpose as the determination of "how well our federal government is now organized to discharge its heaviest single responsibility—devising and carrying out an over-all national security program which is bold enough, wise enough, and soon enough to assure the survival of our country."

Early witnesses before the Jackson Committee were Republicans whose credibility, earnestness, and qualifications should not be questioned. One was Robert Lovett, a former Secretary of Defense, who did not criticize the President by name but listed a number of failings in executive leadership. He found, in fact, that there are so many people involved in the making of decisions that they "blanket the whole Executive Branch with an embalmed atmosphere." In the Pentagon itself, Mr. Lovett finds too much politics. He also laments the lack of national goals for which the military professionals can do their planning, the committees

(Continued on page 45)

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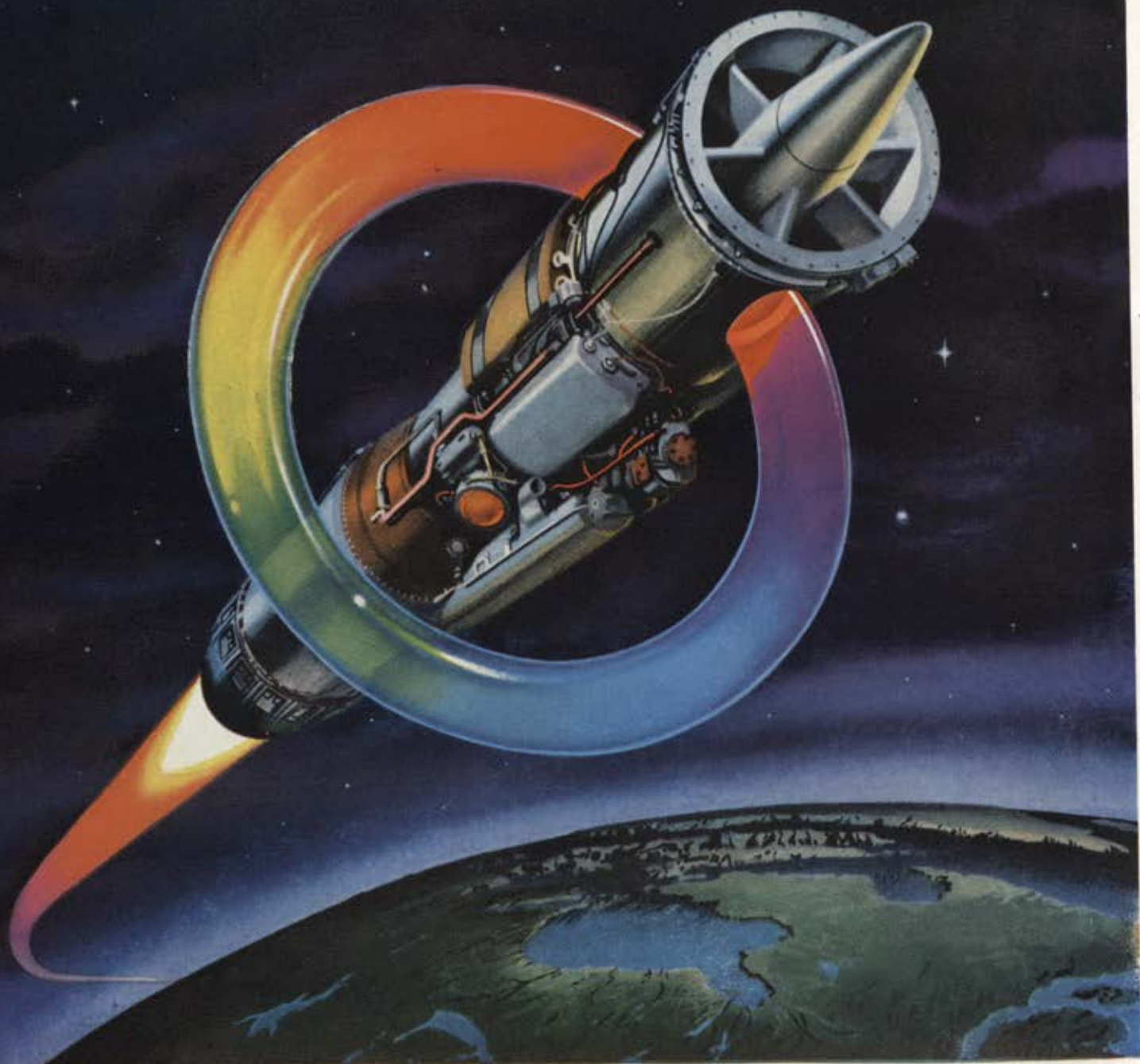


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upon committees, the loss of executive authority, and the wandering of personnel into areas in which they are not competent.

Thomas J. Watson, Jr., another Republican and president of International Business Machines Corp., also disputed the concept that we are not in a race with the Russians and declared, "We have got to throw our economy into full scale competition" even if it means "a departure from our present way of life." He said higher taxes may be one of the first things we must accept. Throwing the challenge directly at Mr. Eisenhower and the Bureau of the Budget, Mr. Watson added: "I do not agree with people who suggest that we must not push our economy to any point necessary to win in competing with the Soviet because we might lose what has made our country great. If we do not impose the strains necessary to win, it is obvious that at best we will live in a Soviet-dominated world, and at worst in a Soviet province." And: "I would rather have greater control by our government under our present system than to discover one day that business as usual had not been sufficient to win the battle."

Another witness was Robert C. Sprague, a Republican, chairman of the Federal Reserve Bank of Boston. This man, not running for President or seeking to promote any candidate, said we face a clear threat to our survival and have not awakened to the fact. He said we have the resources to do what is necessary. He said that key officials frequently do not have all the facts or have the wrong facts. He also said that Congress should do more to stiffen the American backbone.

On the Jackson Committee these men are heard and taken seriously. They are not challenged on their facts, for their political leanings, or for their audacity to criticize the White House. They are not accused of ignorance. No member of the Jackson Committee waved his finger and introduced irrelevancies into the record. The hearings are held with dignity in an absence of bickering.

It still is too early to say what may result from these studies, those that are competent and those that are less so, but certainly the issues are being made more clear. Before Congress leaves for the coming conventions it may sense public support for some improvement in the situation. A nation that can afford Smell-o-Vision and AromaRama and \$750,000,000 a year for private swimming pools can pay for its security. Dr. James P. Baxter, III, president of Williams College—yes, he's a Republican—told the Jackson Committee he knows he has suggested spending a lot more money. He also hates inflation. But, he added, "I am willing to pay more taxes if it is necessary to do the things we need to do, and I believe that our entire people would feel the same way if they realized all that is at stake."

Leadership for Space

An excellent and germane illustration of what some of the critics are talking about was placed before the Brooks Committee by William M. Holaday, Chairman of the Civilian-Military Liaison Committee that is supposed to function as part of the national space effort. Mr. Holaday, who left no trail of glory behind in the Pentagon after his stint there as missile czar, complained on the stand that his committee lacks authority and has nothing to do. He said he is discouraged. Asked what he and his committee had done to assist relations between the Army and the National Aeronautics and Space Administration, for example, his reply was, "nothing." In fact, he said, he feels he was discouraged from taking any role in the proposed transfer of the Army Ballistic Missile Agency to NASA. "If you don't

want to get anything done," Mr. Holaday said at one point, "appoint a committee."

In his formal statement he said his committee has no other duty than providing a channel of advice and consultation between NASA and the Department of Defense. He could list only five items on which actions had been recommended, then suggested that there are *several* channels available to resolve issues. Further, he said the committee is incapable of making firm decisions. Yet, Mr. Holaday reported, the committee does not want to be abolished, as proposed by the President.

This appearance may be duplicated a few times in the weeks to come as the study of our space effort continues. There are almost as many points of view as there are people invited to give them. At this writing there are indications the House committee is preparing to give deep soundings to the proposal of Dr. William H. Pickering that there should be a reorganization along the lines established by the Atomic Energy Commission. This would put a military application division in NASA and curb the Defense Department's direct participation. Management experts have been called to testify, including some from AEC itself. There also are some from industry, including Hilliard W. Paige of General Electric, who has endorsed a combination of the programs under military control.

The Administration seems to have a fair solution in mind for Mr. Holaday's problem, which is to abolish his job and his committee. At the same time it cannot be expected to support the Pickering proposal for the good reason that the parallel between atomic energy and space technology is pretty weak. One recent witness, however, did point to a place where improvement is needed. He was Dr. George R. Arthur, president of the American Astronautical Society. Said he: "Any of the several plans for achieving spaceflight and advancing space technology can be realized provided we have strong leadership at the top."

How to Stay in the Middle

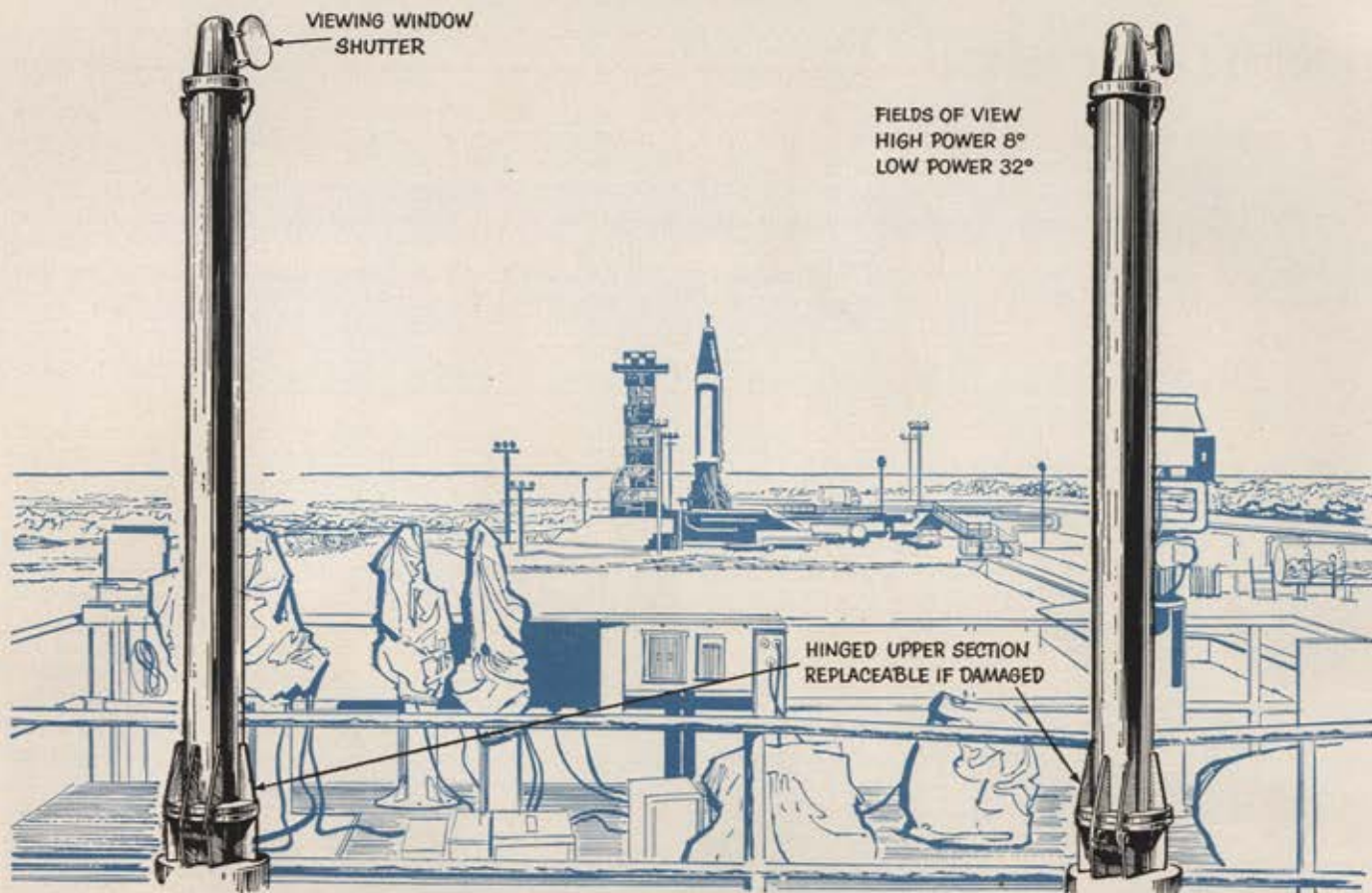
The basic controversy was between the National Council of Churches of Christ in the USA and a smaller group of religious fundamentalists who find the Council's approach an anathema. USAF had a fundamentalist on its manual-writing staff at Lackland AFB and his material was not properly reviewed before it got into the hands of Reservists, including some who are *not* fundamentalists. Until the boss and Chief of Staff, Gen. Thomas D. White, got on the stand at a congressional inquiry it appeared that USAF never would escape the morass. The general told the committee his organization had goofed and steps are being taken to make sure it can't happen again. In the meantime, a British publication reports, the order of the day is: "If you can write, don't."

The offending statement, to the Council, was one that said the Communists have been successful in their efforts to infiltrate the clergy. When the manual was withdrawn the action aroused the ire of the House Committee on Un-American Activities, which believes the statement is correct.

In his appearance before the House subcommittee of the Committee on Armed Services, USAF Secretary Dudley Sharp said that in withdrawing the manual no attempt was made to pass on the truth or falsity of statements in it. He added that it remains a duty of the Air Force to warn its men against "the fact that our churches are a target for Communist attempts at infiltration."

So far, there has been no missionary zeal exercised against this thesis. Probably it is safe to say the funda-

(Continued on page 47)



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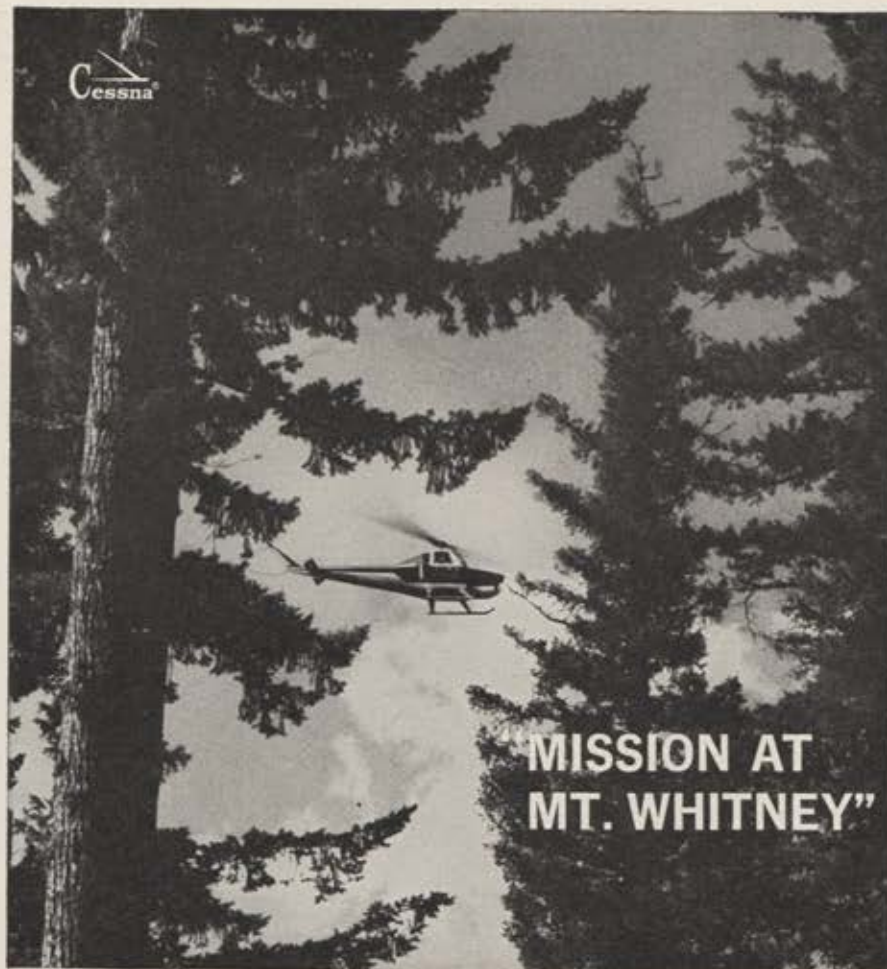
mentalists believe the Reds are successful in their effort and the Council thinks they have failed. It is not the Air Force's place to agree, or disagree, with either of them. There are other areas where Soviet penetration has been notably successful and if you look up toward heaven you can see one of them. The Air Force has a mission up there and it must be pursued in the interests of preserving our freedoms, including freedom of religion.

The Airlift Crisis

By April 15 Chairman L. Mendel Rivers, (D.-S.C.), of the National Military Airlift Subcommittee of the House Armed Services Committee, hopes to have both Army and Air Force critiques of Puerto Pines/Big Slam on his desk. The exercise is a joint endeavor involving the Military Air Transport Service and the Continental Army Command. In it, more than 200 transport aircraft have moved about 20,000 soldiers and nearly 12,000 tons of cargo. The test is for MATS—can it accelerate to emergency operations and keep it up for two weeks? Mr. Rivers, who started a comprehensive study of our airlift capability only a couple of weeks before the demonstration, will use the results to help form some new conclusions for consideration by Congress.

Preliminary to Big Slam, which was visited by members of the committee, the military services and MATS were given an opportunity to tell the Rivers group what they think about the adequacy of our airlift. It is inadequate in quantity and quality. Witnesses for the Air Force made it clear that civil airlines are not a complete answer to the military requirement.

Over on the Senate side, A. S. Mike Monroney, (D.-Okla.), has said he will support legislation calling for modernization of MATS to the tune of \$100 million instead of the \$50 million being sought for fiscal year 1961. There is some suspicion that this surge of generosity results, in one degree or another, from the Senator's disappointment with the airlines. We have had some discussion of a proposal that Uncle Sam guarantee loans to permit the carriers to buy more efficient cargo equipment. To the amazement of those solons who have lent a sympathetic ear when MATS was under attack as an anti-American monstrosity, the guaranteed loan program did not receive rousing support from the carriers. After all, a business that can justify an investment can raise money. Guaranteed loans, some-



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how, seem most attractive until they raise the possibility of increasing competition, possibly at the expense of penalizing an existing structure.

In its presentation to the Rivers committee, MATS argued strongly for use of more airlift and said it is selling this mode of transport to the Defense Department. Not, it was made clear, in order to move more by military aircraft, but to increase the use of civilian carriers. As the total requirement goes up, it was pointed out, civil air augmentation will increase.

This case, combined with what the committee learns from the results of

Big Slam, now may result in constructive action. The need for new aircraft is critical. As in the past, USAF must lead the way.—END

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(See page 174 for details)



Business end of the Titan—by Avco—The nose cone for the Air Force's Titan—designed to withstand the scorching heat and incredible shock of atmospheric re-entry—is a product of Avco research. Now, with the successful flight of this ICBM, the Air Force has assigned two new and important projects to Avco: an advanced design nose cone for the Titan and the nose cone for the third generation of intercontinental missiles—the mighty, solid-fueled Minuteman.

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SPACE


DIGEST

THE SPACE AGE IN PERSPECTIVE

APRIL 1960

AIR FORCE MAGAZINE AND SPACE DIGEST'S

FIRST ANNUAL MISSILE AND SPACE ALMANAC

FOR
1960

THERE is never time or space enough for everything. One of the pleasures of publishing is the continual effort to disprove that truism. In this special issue of AIR FORCE Magazine and SPACE DIGEST, we have attempted to put between covers a compendium of useful information on the world of missilery and astronautics. You will find comprehensive listings of all military missiles, a list of US space projects, a missile and space glossary, material on the how's of rocketry, and vital statistics of the cosmos. In addition, we have included the thoughts of important men who bear the responsibility of building American missile and spacepower, plus our own views of the implications of the new age. We hope you will find this issue a useful reference.—THE EDITORS



THE MILITARY MISSION

JOHN F. LOOSBROCK

Editor, Air Force Magazine and Space Digest

WHEN we began SPACE DIGEST in November 1958, we chose the editorial path of what Associate Editor Bill Leavitt termed "space realism."

We believe that our peaceful pursuit of tomorrow's goals in space is best ensured by living safely through today on earth. We also believe that the Lord, in His wisdom, knew that man would not have to be born with wings if he wanted to fly through the air nor with a self-contained earth environment if he wished to venture farther. So He did man a much greater favor. He gave man reason—an intellectual key with which to unlock the secrets of the universe. And He gave man a will—the freedom of choice with which to stimulate the brain to do man's bidding.

Using these tools man has flown through the air, to every cranny of the globe. And man has sent his instruments into space, to be followed ultimately and inevitably by man himself. But at the same time man's free will has led his brain into paths of mischief, of theft and murder, of war and pillage. He has created instruments of destruction which can, in the twinkling of a historical eye, erase the accomplishments of hundreds of centuries. This is the paradox of good and of evil, of peace and of war, as impossible to separate one from another as to part man's will from his intellect.

Surely, against the backdrop of history, it is no longer possible to argue logically that there is little need for this nation to exploit the military potential of space and to exploit it with urgency, diligence, and imagination. If we do so, and thereby gain an honorable and lasting peace, the road will automatically be open to peaceful

exploitation. If we do not, someone else inevitably will, and we will find ourselves in a world shaped by those bold enough to become our masters.

This is not an attempt to degrade the scientific achievements of United States satellites. They have been manifold. But it is specious reasoning to pretend that we can profitably separate "peaceful" space from "military" space. Like the earth upon which we walk, the sea over which we sail, and the atmosphere through which we fly, space holds great advantages for both military and civilian use, and it is dangerous and misleading to try to split the two.

Our first national duty is to preserve a free world, from which spacecraft of the future may take off with serenity and to which they can return with confidence. This is the only possible way to ensure the achievement of our national goal of utilizing space for peaceful purposes. The horse must be put before the cart.

How, then, do we use space for national survival and eventually for controlled peace in a better, richer world?

One of the best ways is to increase our knowledge of the enemy's actions through reconnaissance, surveillance, and improved communications. But before blindly leaping into space to meet these requirements, the military planner must take a cold look at the advantages and disadvantages. He doesn't go into space "because it's there," as a mountain climber does, but rather because it allows him to do things there that he cannot better do anywhere else. Space is an extremely hostile environment. It is difficult and expensive to operate within. One must have a real need to go there before it is worth the effort.

On the other hand, space as an operational

medium offers several real, measurable military advantages:

It offers greater altitude and longer line of sight.

Once you are in it, or your devices are in it, the effort required to stay there is quite small. You get a free ride, so to speak, once in orbit.

Space offers the opportunity to pass over enemy territory without violating national sovereignty or committing a hostile act.

By seizing upon these advantages this country can immeasurably better its deterrent position by reducing the vulnerability of the retaliatory force—both manned aircraft and missiles. With an acknowledged missile gap approaching, we need earlier warning against surprise missile attack. Another fifteen minutes—the time it takes to drink a hot cup of coffee—would make all the difference in the world.

With thirty minutes' warning—instead of fifteen—SAC's manned bombers would be off and winging for Russia before the missiles came crashing in upon them; our liquid-fueled ICBMs plus the IRBMs in Western Europe would be topped off and ready to go; NATO's tactical air forces would be airborne, ready to supplement SAC on close-in targets; our national decision-making machinery would gain precious time to assess the situation; and those civilians fortunate enough to possess a fallout shelter could take cover. We would achieve an immeasurably stronger military posture.

We have the technical capability to do this. No breakthroughs are needed, beyond the mental breakthrough required to pursue military space programs with the kind of intensity, funding, and priorities accorded the intercontinental ballistic missile program over the past few years.

The military space system closest to attainment is Midas (Missile Defense Alarm System). Midas, a product of collaboration between the Air Force's Ballistic Missile Division and Lockheed, is a satellite bearing infrared, heat-seeking sensors which will locate and track ballistic missile firings anywhere in the world.

Even the brief, five-minute "glimpse" afforded by the powered portion of ballistic missile flight will allow computers on the ground to compute the trajectories.

Beyond Midas is Samos, a photo-reconnaissance satellite, also a Lockheed product. It will furnish visual evidence that may indicate an attack is imminent. It is designed to provide strategic warning of an impending attack, rather than tactical warning that an attack has been launched.

To be ready in time to be of value, Midas and Samos demand support, both in terms of under-

standing of their underlying concept and in providing funds, facilities, and people. Neither is an isolated, one-shot satellite, but a complete system, involving several satellites in orbit simultaneously and, equally important, supporting electronic data-processing and communications systems on the ground. These include long lead-time items that must be developed and produced under the concept of concurrency.

Neither Midas nor Samos is the end of the line in its field. Each has great growth potential—Midas in the form of more definite warning and pin-pointing of targets through improved infrared techniques; Samos in the shape of better picture resolution, wider fields of coverage, improved picture processing—all designed to get more and better information into the commander's hands more quickly.

Beyond early warning and reconnaissance—the immediate needs—lie communications satellites to better utilize the information derived, satellites to garner weather information (both meteorological weather and the so-called "electronic" weather which affects electromagnetic communications systems), and satellites to aid in navigation and aerospace traffic control.

As the size requirements for military satellites increase there will be a need for bigger boosters, and for new concepts in booster design—something that is cheap, easy to build, recoverable for other shots. And when satellites get beyond a certain weight—some say 5,000 pounds, others 10,000—it will be possible to replace some of the electronic equipment with the human hand, eye, and mind—to change course, perform in-flight maintenance, to provide the commander on the ground with human judgment as well as raw information. Satellites could be kept operating longer, space-borne electronic equipment could be less complicated, photos could be developed and interpreted on the spot.

This is the military mission in space, these and other systems yet unforeseen.

Their achievements will make it possible for the free world to keep the peace on earth. Armament control and reduction will begin to make sense. Improved communications and travel will further shrink the globe. International funding could provide enough money for peaceful, "far-out" space exploration and exploitation on a scale large enough to be rewarding. Inevitably and inexorably benefits of a peaceful nature will flow across an earth protected from destruction.—END



*Fundamental Air Force policy: Weapon systems for use anywhere in aerospace must contribute to the security of the country. . . .
An American military space capability can ensure the freedom of space vital to civil exploration.*

Research and Development Today For Military Space Systems Tomorrow

*LT. GEN. ROSCOE C. WILSON, USAF
Deputy Chief of Staff, Development*

FOR THE first time in history, man is beginning to put space to his uses. He is on the threshold of a new frontier of incomprehensible vastness—a frontier offering him at once a promise and a threat.

USAF has long had an active interest in this frontier. For example, we began research on a long-range ballistic missile as early as 1946. The Air Force has always sought to exploit the classic military advantages of greater speed, altitude, and range. The "ever higher, faster, and farther" principles cause us to look on space as the natural extension of our operating area. This is particularly true since there is no fixed point at which the atmosphere ends and space begins. To designate the dimension extending outward indefinitely from the earth's surface, we were forced to coin a word. We chose the word "aerospace," not as a public-relations device but as a practical term embracing the entire operating area.

USAF does not wish to exploit space simply because it is there. We regard space as a *location* which has important uses for the nation's security. Under national policy the purely scientific exploration of this location is not an Air Force mission. Exploration is a task assigned to the

National Aeronautics and Space Administration.

Space is sometimes visualized as a function or a military program. Neither is correct. While we view space as a location which lends itself to certain military tasks, we do not consider space as the exclusive province of the Air Force. Both the Army and Navy have functions which may need to be carried out in space. The Navy's Transit navigation satellite and the Army's Courier communications satellite are examples. The Air Force assists the other services in such projects since we are charged by the Secretary of Defense with providing and launching the boosters for all military space systems.

The Air Force does not compartmentalize its activities into space and nonspace functions because we are concerned with the whole realm of aerospace. However, we do give special attention to systems using space. Within the Air Staff, the office of my Assistant for Advanced Technology acts as a focal point for space matters, including liaison with NASA. Other elements of DCS/Development are also involved: The Directorate of Research and Development monitors research relating to space; the Directorate of Development Planning includes space matters in its long-range



plans. While the DCS/Development as a whole assists the Chief of Staff in policy and direction relating to space, we are not the sole interested agency; virtually all the normal Air Staff functions apply to space systems. The corporate judgment of the Air Force is also brought to bear on these matters, through such bodies as the Weapons Board and the Ballistic Missile Committee. The latter is composed of senior Air Staff officers and the Office of the Air Force Secretary.

Air Force policy concerning space has come into sharper focus as the result of research study and experience thus far in this field. It is fundamental policy that USAF weapon systems for use anywhere in aerospace must contribute to the security of the United States. Beyond that, the major criterion for the choice of a particular system is its relative effectiveness as compared with other means of meeting a requirement. This criterion applies to all systems, without regard to where in aerospace the system would operate. In applying this criterion to space, we consider that a space system is relatively more effective if (1) it offers the only means of doing the job; or (2) it is the best way to do the job and is not excessively expensive (for example, very early

warning of hostile ICBM launchings); or (3) it offers a more economical way of doing a job (as may well be true of a communications satellite system).

The initial space systems being proposed by the Air Force illustrate the application of these policies. Midas and Samos are informational systems—designed to provide information vital to our security in the missile age. Midas, the Missile Defense Alarm System, uses satellites whose infrared sensors detect a ballistic missile as it rises through the atmosphere. This system offers the earliest effective means of warning of actual enemy launchings. Samos is a reconnaissance satellite system. Constantly orbiting, it could provide detailed pictures of the surface anywhere on the earth. Such a system would do much to correct the imbalance in military information available to this country as compared to the Soviet Union. Samos would make a major contribution to our national security.

Both Midas and Samos are passive systems—they present no offensive threat. Like a burglar alarm, they threaten only would-be transgressors.

Our research and development program relating to space is being actively pursued on a num-

ber of other fronts. One of the key efforts is for a manned capability in space—for we are convinced that man's intelligence and judgment will be as vital for certain missions in space as these qualities are for many missions in the atmosphere. The X-15 research airplane is a step in the direction of manned spaceflight. Dyna-Soar, also a research project, will bring us closer. Designed as a rocket-boosted manned vehicle it would "fly" above the atmosphere at near-orbital speed, then reenter and land aerodynamically at a place of the pilot's choosing. The application of this development toward a maneuverable, orbital space vehicle is obvious. What military usefulness would a manned maneuverable vehicle—some follow-on to Dyna-Soar—have in space? There are a number of possible uses. For example, it might be used to send a man to repair and maintain operational satellites in orbit. If our security so required, it might be able to serve as a patrol or inspection vehicle or even perform other military operations in space.

One of our important, although perhaps less dramatic, efforts related to space is in applied research. We are trying to develop better techniques to apply to future weapon systems. A typical effort in applied research is to develop reliable electrical power generation with minimum weight. To do so, we are working on conversion of solar energy mechanically, chemical conversion (a sort of continuous battery), and direct conversion of heat from solar or nuclear sources. We have already achieved some significant developments in nuclear power sources.

Propulsion is the latchkey that opens the door to space—and we give it research emphasis accordingly. Unfortunately, our engineering knowledge at present will not tell us precisely how to scale up a missile engine to increase its thrust. Thus, we must, to some extent, "cut and try" with each propulsion project. In chemical propellants, we now are operating well below their theoretical limits of impulse. The result is that only a small percentage of a rocket's gross weight is payload—and costs per pound of payload are high. At present, each pound in orbit costs at least \$1,000. To solve such problems, propulsion research is going forward on improved liquid and solid fuels, nuclear rockets, ion rockets, and magnetohydrodynamic devices. There is every reason to believe we will get startling increases in thrust in the years ahead—undoubtedly within this decade. Increased impulse will not only permit much larger payloads but reduce costs per pound as well. But, of course, we must earn

these advantages through effective research and development.

We are seeking eventually to reduce payload-in-orbit costs to perhaps a tenth of their current levels. One possible means is by use of recoverable boosters. Today we are losing a very expensive booster whenever we launch an object into space. The situation is rather like building a jet airliner for a one-way trip and throwing it away when we get there. We are studying at least two ways of recovering boosters. Parachutes in the main stage are a possibility; another is use of an advanced aircraft of the B-70 class as the first stage. In any case, some form of recoverable booster undoubtedly will become a part of our future inventory.

It is apparent that boosters larger than ICBMs will be required for some future military space systems. In this connection, we hope to benefit greatly from the technological knowledge that NASA obtains in its development of very large boosters for the civilian space program. We also expect the NASA program to reflect military needs when these will not interfere with the achievement of their own needs. However, great differences exist in required characteristics between the civil and military programs. Military needs include quick reaction time, mass producibility, compatibility with weapons and control systems, long life, and other characteristics not essential to the civil program. These differences demand the closest coordination whenever joint use of a vehicle is planned. It is my personal opinion that even with the closest kind of coordination the exigencies of the military requirements may require a booster program designed to meet military needs in an economically feasible manner.

In addition to basic and applied research, and development of systems, our research and development program includes much study and planning. We must give early consideration to aerospace systems which might become the basis for our future security. Our study must also take account of a potential enemy's probable future capability. In these studies we do not confine ourselves to the near-term, but also look some ten to twenty years ahead. The Air Force does not rely entirely on its own resources for such studies; we are assisted by very able scientific and industrial organizations.

Perhaps I can give you some idea of possible future space systems by mentioning some of our study areas. Basically, we recognize that offensive and defensive space systems have some unique characteristics of great military value:

Another Way
RCA Serves Science
Through
Electronics



Systems Development for Space Technology

TELEVISION CAMERAS

Design a miniaturized camera system for taking "snapshots" from a satellite. Drastically reduce bandwidth to conserve power, yet maintain high resolution picture quality. The entire unit must operate unattended in a space environment.

Astro-Electronic Products Division took these demands in stride and developed several electronic camera systems scheduled for use in space science experiments. One of them is pictured above.

A special, ruggedized 1/2-inch Vidicon gives this compact camera a TV resolution capability of 500 lines. Because still pictures are to be transmitted, video bandwidth is cut to 62.5

kc by using a very slow (2 sec.) scanning rate. A specially designed, ruggedized shutter, designed for minimum of 100,000 operations, immobilizes the image and eliminates smear. The camera, less lens, is only 5 inches in length and weighs approximately 2 lbs. The transistorized camera electronics, including the power converter, is housed in a container measuring 6 x 6 1/4 x 3 inches.

Such a camera can be used to look at the earth's cloud cover from space, map the moon, study the solar system, or monitor the space vehicle itself. 1-inch Vidicon versions of these cameras are capable of 800 to 1,000 lines resolution. This is typical of the way AEP approaches problems, going beyond the bare requirements to develop space systems which can adapt to meet the needs of tomorrow.



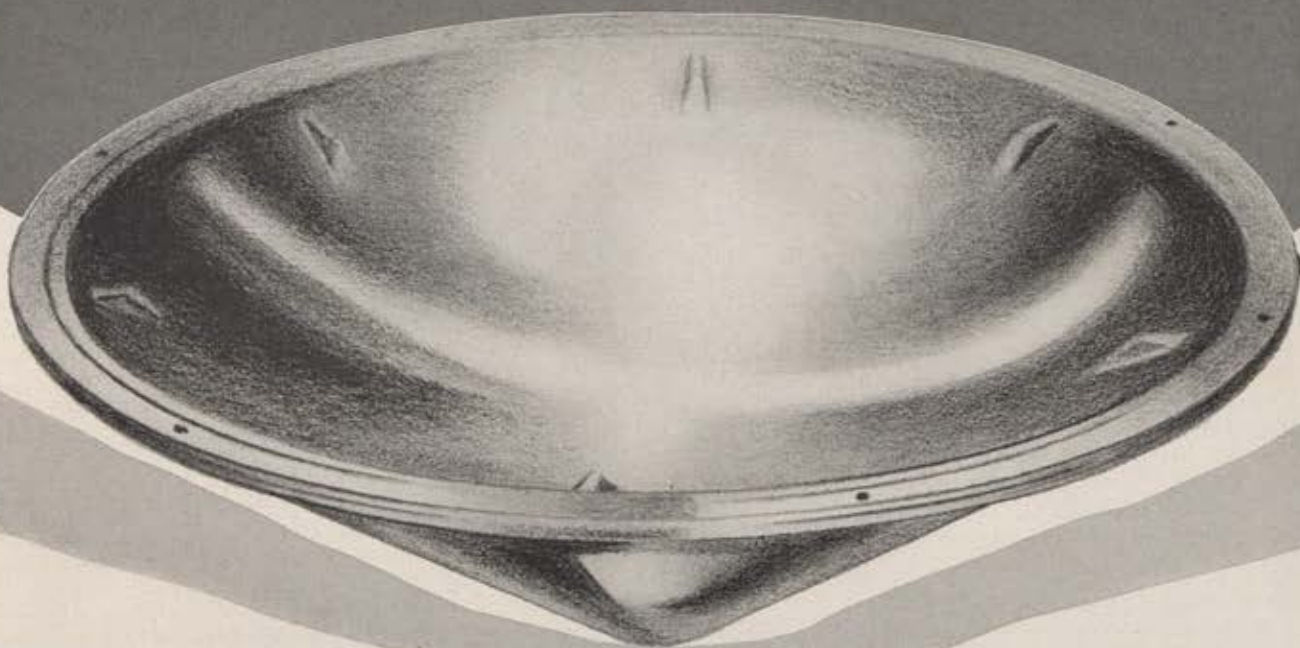
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Astro-Electronic Products Division

Princeton, N. J.

AM and FM Command Receivers—Another AEP Capability





RE-ENTRY SHIELDS



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- They would have tremendous speed and unlimited range.

- They could give simultaneous coverage of large areas of the earth's surface.

- They could be remotely based and consequently less vulnerable.

- They could be capable of very short time-to-target—in some cases, possibly five minutes or less.

In considering space systems we must include the ICBM, which travels through space. We can be sure that there will be important improvements in ballistic missiles, improvements which will make them more effective weapon systems and which will complicate the problem of defense against them. I should mention that we have devoted much effort in basic and applied research and conceptual study to defense against ballistic missiles. We have concluded that a defense is practicable. In our view, the defensive action should be directed at the boost phase of a missile's flight before measures to frustrate the defense could be taken. Such a defense system would have to be space-based and its time in development would preclude an operational system in the near future. Thus our defense for the present must rely primarily on the power of our strategic offensive forces.

Beyond ICBMs are space-based offensive systems which seem likely to be developed in the future. We are aware that the USSR is capable of developing such systems. It is probable that low-orbit systems would be attained first. Our studies of possible low-orbit offensive systems include one employing an advanced Dyna-Soar type vehicle.

Other offensive systems based more deeply in space are also possible in the years ahead—although probably coming at a later period of time than the low-orbit types. As an example of such possible developments, we have studies on systems dispersed and hidden in the vast reaches of space 100,000 miles or more from the earth.

Turning to the defensive area again, we realize that a need may exist to inspect satellites and determine their intentions, and we are studying the means of doing so.

In addition to the studies in offensive and defensive possibilities in space, we are also studying those other classical military functions of reconnaissance or surveillance and supporting services. Being considered in these areas are such matters as space logistics and supply, the repair and maintenance of orbital-based equipment, and the rescue of personnel in space.

From the foregoing discussion of possible military space systems, one should not conclude that future USAF military developments might make man's new frontier unsafe for peaceful exploitation. This is far from true. A US military capability may well ensure the freedom in space which is essential to our civil ventures. The peaceful exploration of space presents a bright promise, and we are giving the fullest support to the civil effort in this direction. As a practical matter, military developments have thus far provided the essential facilities and boosters for the civil program. There is every probability that future military developments for space will also provide techniques beneficial to peaceful, and even commercial, ventures.

The explosive growth of technology is the dominant factor affecting our security in the space age. Whether we wish it or not, we are faced with a technological struggle unparalleled in our history. The stakes are obvious.

The struggle, which is long-term in nature, is a singularly difficult one because the scope of technology has become so broad. The richness of the expanding technology offers many avenues for exploitation by ourselves or a potential enemy. We cannot afford *not* to investigate the most promising techniques. However, the costliness of development efforts, and the many prospective techniques available force us to discriminate carefully. We must make sound choices and select the most significant items for development.

Keeping pace with the onrush of technology is a national challenge of great magnitude. It involves not only the government and military but virtually all our scientific, industrial, and educational resources. The Air Force is very conscious of this challenge and is striving constantly to maintain a dynamic research and development program that anticipates our security needs. Working together with our scientific and industrial partners, we are confident that we can maintain the technological capability that will make possible our security in the future.—END



A 1928 West Point graduate, General Wilson won his wings in 1929. Associated for many years with research and development, during World War II he was assigned to the Manhattan District Project which developed the world's first nuclear capability, also saw overseas duty in the Pacific theater.



Stairway to space

Sometime in the 60's, America may have a manned station in space—and it could look a lot like this scale model by Lockheed.

We have much to learn before it can be built. Research is our stairway to space—basic research that seeks to discover the new rather than develop the known. We cannot predict what such research will discover, or when—but we delay it or curtail it at our peril.

Today, at Lockheed's Missiles and Space Division, more than 5,000 scientists and engineers are engaged in one of U.S. industry's broadest research and development programs. One group is conducting private industry's largest, most diversified program of fundamental research in space physics. Already they have made massive contributions to America's space technology—particularly in the Discoverer, MIDAS, and Samos satellite programs of the U.S. Air Force.

LOCKHEED

MISSILES & SPACE DIVISION

*Testing and training, telescoping time,
USAF's missilemen at Vandenberg AFB
are taming the space-age "beasts" that give
true meaning to the term "aerospace power"
—creating capabilities for vital deterrence
and for the peaceful exploration
of space . . .*

OPERATIONAL AEROSPACE POWER

AS THE first Air Force command to attain an operational ICBM capability, the 1st Missile Division at Vandenberg Air Force Base, Calif., has been accorded keen national interest. Additional attention is centered on our responsibility for training the crews that will man all of the Strategic Air Command's ICBM sites across the nation and for supporting development of polar-orbiting satellite systems—Discoverer, Samos, Midas.

Vandenberg has become, in fact, the prime focal point for transition from the development to the operational phases of the ICBM program and other important segments of the military space program.

In one sense Vandenberg is operating at the peak of a pyramided national effort to launch all of our ICBMs and the Thor IRBM from a realistic, operational environment. In another sense, we are operating at the base of an inverted pyramid of SAC's expanding ICBM capability.

Measured against a comparable margin of advancement in the manned bomber field, the picture of Vandenberg shapes up like this: We have undertaken crew training exercises, operational test exercises, and the attainment of operational readiness with the Thor, Atlas, Titan, and Minuteman systems on a scale that corresponds roughly to the progression from the B-17 through the B-52—which took some twenty years.

Certain conclusions that are now emerging out of the total experience gained in our operations here will serve to highlight the practical implications of the missile era in terms of training methods and operating concepts. Because these findings will have a direct influence on our careers in command, staff, and technical assignments, they should, in my view, merit the close and immediate attention of everyone who wears a blue suit. Even more critical is the continuing effect they will have on the direction, pace, and success of

*MAJ. GEN. DAVID WADE, USAF
Commander, 1st Missile Division
Strategic Air Command*



our efforts to employ aerospace power as an effective military instrument of controlled peace.

Everything we have accomplished up to this point at Vandenberg has confirmed the earlier predictions concerning the strategic implications of the ballistic missile era. This is not surprising when we consider the fact that the actual performance of Thor and Atlas missiles launched at Vandenberg under simulated combat conditions has equaled or exceeded original estimates.

Where the Atlas is concerned, the launches here on September 9, 1959 and January 26, 1960 conclusively demonstrated the fact that ICBMs can contribute greatly to our deterrent posture. They provide a capability for quick reaction against targets at intercontinental range, and their relative invulnerability to defensive measures will virtually guarantee their ability to apply nuclear warheads against aggressor targets within less than thirty minutes.

Launched in retaliation against heavily defended target systems, ICBMs would open the way for the flexible employment of manned bombers against targets of uncertain location.

These conclusions are further reinforced by the experience gained at Vandenberg in our combat training launches of the Thor intermediate-range ballistic missile. Here again were cases in which the demonstrated capability of a ballistic missile was found to exceed our estimates.

However, there were some early assumptions made in forecasting problems of training and supervision that are now being modified by experience.

Among these were predictions expressed in some quarters that ballistic missiles would be too complex for Air Force technicians to maintain and operate. Although we have developed a profound respect here for the intricacy of ballistic missiles, we have not found it necessary to stand in awe of them. In fact, the officers and airmen who have come into our crew-training program with a background in the electronic, mechanical, and hydraulic components of aircraft have moved quickly and effectively into the missile crew.

Another preconception that has been disproved at Vandenberg was the opposite view that countdown procedures would produce boredom and lower morale. On that point most of the people instructing and training in our programs here would welcome the introduction of a small amount of routine into their schedules. This has been denied them up to now by a continuous process of modification and refinement in the equipment

they use and the procedures they apply. To meet this challenge requires the same high level of enthusiasm and job interest as does the task of keeping current in manned aircraft operations.

One of the most important tests facing us in the missile program is a new problem in leadership and supervision. Just as we have developed valid yardsticks for evaluation of aircrew performance, we need now to develop similar standards for measuring the competence of our missile crew technicians. This would enable us to prepare fully documented justification for both alert pay and spot promotions.

The crew members who inspect, repair, check out, and launch our missiles are far more than glorified caretakers for little black boxes. During an actual countdown, for example, a missile systems analyst technician has to cope with more than forty sources of possible malfunction and recommend the best trouble-shooting approach from a number of alternate solutions.

Additionally, a member of a missile launch crew or guidance crew must have a high degree of competence in both operational and maintenance fields. When he pushes a button, he must understand the function and sequence of operations actuated in completing that single step in the checkout or countdown operation.

For this reason, we have eliminated the clear-cut division of maintenance and operating skills that has always been built into our manned aircraft organizations, and have merged these activities into operator-maintenance functions.

In missile operations, as in manned aircraft operations, the man who is trained and dedicated in his job is still indispensable.

We have never bought any part of the claim that ballistic missiles are the first in a series of fully automated weapon systems that will create a dead-end pathway of career progression. To the contrary, our association with the Discoverer program and our preparations to support the more advanced polar-orbiting Samos and Midas systems have provided a clear indication that ballistic missiles will play a transitional role in bridging the gap between manned aircraft operations and manned spacecraft operations. The boosters, guidance systems, flight attitude control techniques, and reentry and recovery methods being proved out now will provide the technical means and the broad base of technical knowledge essential to the introduction of manned space vehicles.

A brief look at particular aspects of our program will be useful in validating the broader out-



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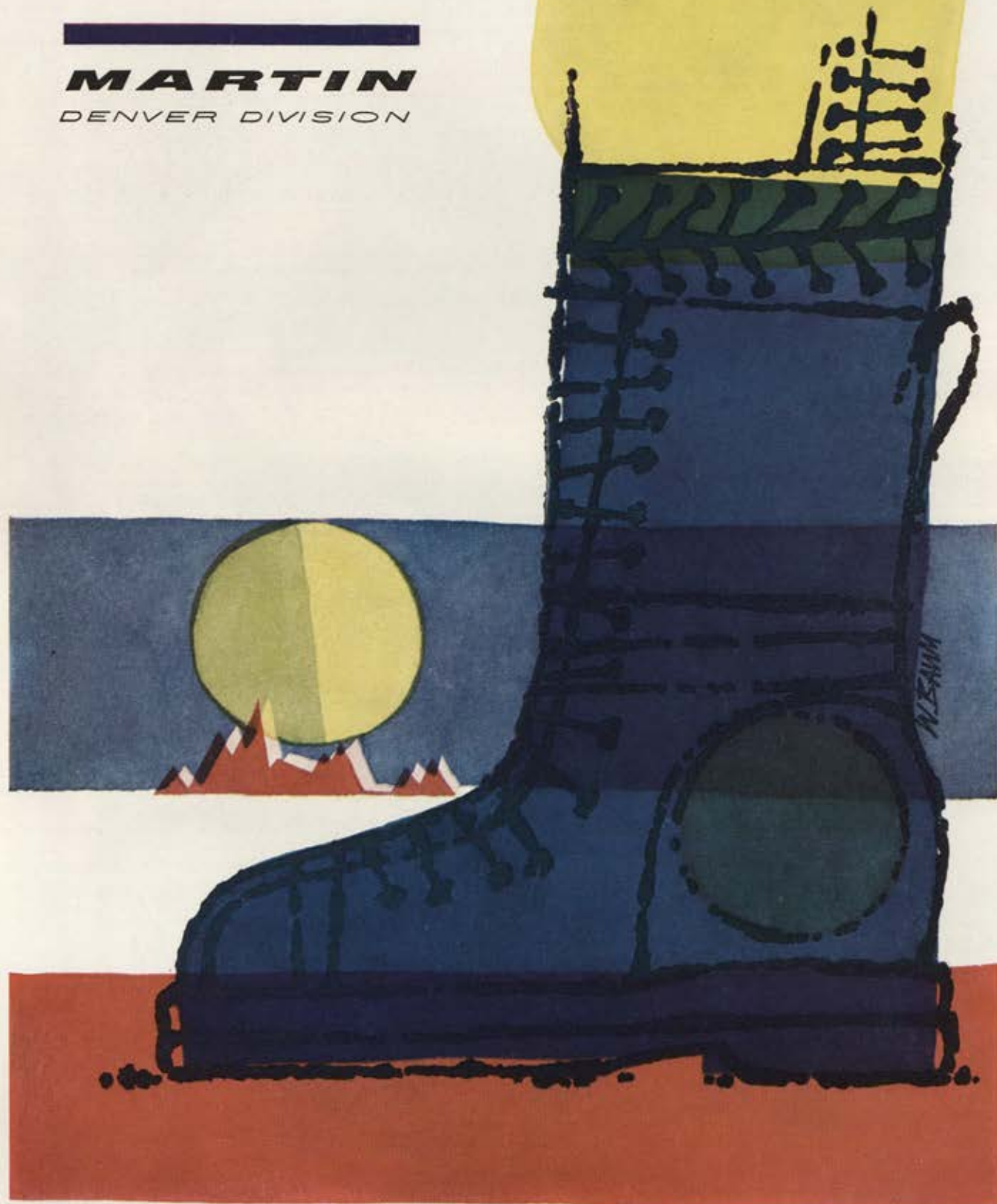
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look toward missile operations that I have presented.

Preliminary steps were taken in 1957 to convert the old Camp Cooke area into the ballistic missile complex that was later designated Vandenberg AFB. To meet the early schedules for IRBM and ICBM programs in 1958, we had trainees reporting for instruction by instructors who were still polishing off their own knowledge of missiles that were not quite ready for launch complexes.

The fact that these limited outcroppings of concurrency were kept within manageable limits at the critical point where crews, missiles, and support equipment were coming together for the first time proved the merit of the management approach pursued from the outset.

Unlike the neatly packaged plans that bring a manned aircraft base into being, our guidelines have recognized the uncertainties that are associated—at this stage—with missile operations. While some of these uncertainties are tied to the scientific and technical side of the effort, most of them stem from the requirement for establishing effective working relationships between 1st Missile Division and other agencies.

As the largest customer of the Pacific Missile Range, we are engaged in a continuous process of launch scheduling on a low-risk basis which—even with elaborate missile flight safety instrumentation—must take into consideration the minimum requirements for visual tracking, clearance of shipping near the impact areas, scheduled passenger trains, and unscheduled freight trains. Under the provisions of an agreement with the US Navy, we are moving toward an arrangement under which the missile destruct system will be controlled by the Air Force during ballistic missile launches, and by the Navy during R&D satellite launches. As the sponsoring agency for ballistic missile and satellite launches from the Vandenberg-PMR complex, the Air Force—under the terms of that agreement—has full responsibility for flight preparation of missiles, satellites, space vehicles, and launching devices; and for launching and controlling the flight through impact or last stage burnout.

Development of Vandenberg's technical facilities to support these operations is being carried out by the Ballistic Missile Division Field Office of the Air Research and Development Command which completes the designs and supervises the Corps of Engineers' construction work through the brick-and-mortar phase of each project. It then uses various missile contractors as its agents

for the installation and checkout of launch and guidance consoles, testing devices, and other ground-support equipment before the entire facility is turned over for use.

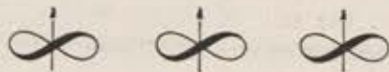
In addition to these PMR and ARDC contracts, we work closely with the Air Training Command to establish types and levels of requisite skills for trainees and to regulate the pipelines of trainee input to our program. We are also drawing extensively on missile contractors for technical assistance. As in the case of manned aircraft operations, this technical support is being substantially reduced as our experience grows.

To make these interservice, intercommand, and contractor relationships productive, we have entered into a complex series of joint tenancy agreements and cross-servicing arrangements that present some intricate problems.

In moving ahead within the framework of these arrangements, we have produced a box score of mission accomplishment that includes successful launches of two Atlases, twelve Thors, and ten Discoverers. All of our launches have been accomplished without mishap on the pad.

Additionally, we have trained more than 1,100 crew members for the Thor squadrons of the Royal Air Force and more than 475 Atlas crew members for our operational and training complexes at Vandenberg. We also have now in training 160 Atlas crew members who will man the 564th Strategic Missile Squadron at Francis E. Warren AFB, Cheyenne, Wyo. In related courses, we have given instruction to technicians in the maintenance management field and in the ballistic missile familiarization staff officers course.

In conjunction with both its training and operational program, Vandenberg is constantly developing methods for measuring missile reliability, reaction time, and accuracy. We are also helping to develop and refine the operational concepts and procedures that will ensure best results from the use of these weapons. By meshing the operational testing cycle for ICBMs with its crew-training program, Vandenberg is—in effect—serving as a ballistic missile operational proving ground.—END



A veteran airman and civil engineering graduate of Louisiana Polytechnic Institute, General Wade entered the Air Force in 1935. He was Chief of Staff, SAC, prior to assuming his present post.

It is reasonable to assume that the Air Force pilot of the space age will carry the big stick of deterrence into the arenas of space. . . .

In the 'Soaring Sixties' Man Is on His Way--Up

BRIG. GEN. CHARLES H. TERHUNE, JR., USAF
Vice Commander, Air Force Ballistic Missile Division

SINCE man first appeared on this planet he has capitalized progressively on his God-given advantages—physical dexterity, rational intellect, and the exercise of free will—to extend his horizons and broaden his capabilities. He has ventured into one frontier after another, and has conquered obstacle after obstacle. Immensely adaptable, he has used the forces of nature to his own benefit. Yet the wider his knowledge has become, the greater have been the challenges.

At this point in time, man is confronting his greatest challenge—the challenge of the vertical frontier. This decade already is being heralded as the “soaring sixties.” Man in on his way up.

In the emphasis that has been placed on technology, it is easy to lose sight of a fact that should be apparent. It is simply this: Man *does* have a place in space. He has a role to fulfill in the distant reaches beyond our atmosphere just as surely as he has pioneered in the exploration and exploitation of the land, the sea, and the air. Our ultimate objective in this sunset side of the twentieth century is not *man* in space, but *men* in space. As Lt. Gen. Bernard Schriever has said:

“Despite the talk of push-button technology, whether in industry or the military, it is the man who counts, and not the button. You just can’t build creative ability into a machine. You can’t design a circuit to take the place of courage. Above all, you can’t enclose dedication to freedom in a magic black box.”



As long as man and machine have toiled together, we have sought continually to get the most out of their relationship. In reaching upward, in attempting to rise above terrestrial limitations, we have pushed the machine virtually to the limit. A jet aircraft, for example, will accommodate man at altitudes up to 70,000 feet. But beyond that the operation of today's jet engines, as we know them, is marginal.

Yet while progressing from the Jenny to the jet, we have also gone from Kitty Hawk to Canaveral. And suddenly we have at our technical finger tips new machines—machines which carry their own atmosphere with them. Now we look once more to man, to train him to fit the capabilities of these machines.

We are doing a great deal to bridge the thin air between earth and space. It is a tribute to man's resourcefulness that he has learned to sample artificially the unknowns of new frontiers, without serious risk to his own well-being. Machines are expendable. No tears are shed over tubes and transistors.

If, in the past, we had decided to channel our resources—without regard for costs—toward the development of spacecraft (and by that I mean advanced man-carrying vehicles) we could eventually have done aerodynamically what we are more rapidly achieving through ballistic missile and satellite programs. Our sights are set on our goals. If we can attain them by quicker, more effective methods, then there is little justification



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

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

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

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

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for following the slower, more traditional patterns.

Let me illustrate. In the evolution of aircraft we have gradually achieved ever greater range, continually higher altitudes, increasingly faster speeds. We have perfected jet power, and we cracked the sound barrier.

But two major breakthroughs, occurring in recent years, suggested a reorientation of our efforts. We harnessed the power of the atom, and we aroused ourselves to the practical advantages of rocket engines. And because a potential enemy was turning great strides in the direction in which these developments pointed, it suddenly became not only expedient, but virtually essential, that we move in the same direction. As a result we have penetrated the gravity barrier. We have proved the feasibility of reentry; and we shall soon demonstrate that man, too, can pierce the heat barrier and survive. In addition, a fourth obstacle—the radiation barrier—is now recognized as a serious problem.

The facilities, weapons, and equipment we have put together in our mammoth ballistic missile program do indeed provide us with a base for space. It is a broad base, serving both as a deterrent and as a solid foundation for raising us step by step toward our goals in space. Studies being conducted now, at the Air Force School of Aviation Medicine and at other research centers, are aimed toward acclimating man to the peculiarities of space.

The men now being selected as the Air Force test pilots of the future are pioneers just as surely as Langley and Lindbergh and Mitchell and Doolittle were pioneers in their day. The fact that these illustrious names belong to our century makes me confident that we shall see—in *my lifetime*—man as firmly established in the medium of space as he is now in the medium of air.

Man tends to be pessimistic regarding things he knows little about. When the airplane was new, intelligent people conceded it might someday be practical for man to fly, but surely not more than a few miles and certainly not with any weight greater than a thousand pounds.

In 1943, when the first American jet aircraft took wing, few if any realized its true significance. That jet brought dramatic changes. New, broader characteristics of speed, of altitude, of endurance, of pilot techniques—all dictated fresh concepts and, consequently, new tactics. These breakthroughs required exploring, understanding, and learning.

Once accepted, however, jets came quickly into their own. Their dynamic impact as a deterrent

force and as an offensive instrument emerged out of the transitory thinking that marked the conversion from hot to cold war. Modifications in both technologies and tactics have led to jet bombers of intercontinental ranges, and these have flowered commercially into airliners of similar speeds, ranges, and carrying capacities.

Still another graphic example was the breakthrough achieved in nuclear energy. The atomic bomb was developed during World War II and finally employed as a means of resolving decisively the war with Japan. It was used initially in its most primitive fashion and peaceful applications which control of the atom would yield had not yet been given the consideration they were later to receive. Throughout history man has suffered from a shortage of power, and suddenly he was faced with an awe-inspiring source of new power. In a short fifteen years the fantastic energy derived from the atom has been used to fashion a new base for deterrent strength. It has been put to use in powerplants and in medicine. It has made possible submarines of great endurance. And the expansive commercial applications of nuclear energy still lie ahead. We never dreamed when we tackled the enigma of the atom that one of our problems was going to be an *excess* of power—a problem requiring discrimination and subtle employment in the exploitation of this new-found source.

Our thinking at this tender point in the aerospace age may be just as naive as these examples. Yet here we are, in 1960, with another newly developed technology at our command. We have built and demonstrated workable ballistic missile weapon systems. Even the experts who made up the Strategic Missiles Evaluation Committee in 1954—in their most optimistic moments—believed that an operational ICBM could not be produced in less than six years. Our Atlas, launched by a Strategic Air Command crew just five years and two months from the time the accelerated development effort began, not only exceeded this expectation, but it has attained performance, accuracy, and reliability standards far better than originally specified.

This is an era ripe for progress. It is ready *now*, not by accident but by intent. The lessons of the recent past should make it crystal clear that unparalleled opportunities are ours for the taking.

Now, why should man go into space . . . and how will he benefit himself and his country once he is there?

Man is already taking a big part in the overture to space. The trip begins at the beginning—



on the ground. The boosters, the space vehicles, the instruments they carry—all germinate in the minds of men. Men of many talents must create, develop, build, test, operate, and maintain them.

Already space has had a tremendous impact on long-accepted doctrines of military strategy. The potentials of robot military vehicles have been illustrated vividly in the Discoverer series, and future uses are clearly predictable. Past accomplishments and visible prospects are equally stimulating.

The ballistic missile and strategic space systems we are building today are intricate. But this does not mean that we are piling complexity upon complexity. Rather, in the interests of reliability and economy, we are continually seeking simplification. Our coming Minuteman ICBM, for instance, will be much easier—and cheaper—to build, maintain, and operate than the liquid-fueled Atlas and Titan.

The remarkable fact emerging from our current developments is not the conquest of challenging technologies alone. More significant is the fact that people accustomed to traditional patterns of development have been able to accept and react to drastic departures in technologies, methods, and procedures. We have been faced with an intense challenge to our learning processes—the necessity to expand hurriedly but productively into new sciences and new career fields.

Short years ago electronic brains were the province of a few. Today the use of giant computers is becoming common, and people who may not necessarily comprehend their complexities are proficient in this operation. A pilot not familiar with the cockpit of a B-52—or a 707—may be dismayed by the array of dials and instruments that surrounds him. Yet he soon discovers that these devices make his job easier, simpler, and safer.

I cannot imagine the Air Force operating without planes, or various forms of manned vehicles, at any time in the foreseeable future. I believe that the Air Force will come to depend upon a broad, flexible, well balanced "mix" of aircraft, ballistic missiles, satellite systems, and man-carrying spacecraft. And we should not be so short-sighted that we fail to recognize both the vistas of opportunity and the extension of responsibilities which this mix entails.

We are expanding the regions in which man can become militarily and commercially proficient. To succeed we must plan for advanced manned systems—systems which will enable us to perform in space the kinds of missions we have been conducting at the lower altitudes. This calls for versatile forces, both aloft and at ground level, which are capable of fulfilling a growing variety of exacting duties.

Those who think that the aircraft needs defending have pointed to certain operational requirements which can now be satisfied only by conventional manned vehicles. For example, aircraft can be launched when an attack appears imminent . . . and recalled if that attack fails to materialize. Aircraft, en route, can divert from one target to another. They can strike multiple targets and perform combined tasks on a single sortie. They have the ability to search out, locate, and attack targets of uncertain location. And aircraft are not expendable on a single mission.

Yet here is an important fact *not generally recognized*: In looking realistically to the future, we are laying technically practical plans to incorporate into the nation's force structure *manned or unmanned space systems* which can accomplish, or *improve on*, every one of these capabilities traditionally related to aircraft.

Through recoverable boosters and nonexpendable spacecraft, we will be able to inject man—safely and economically—into our space programs. Man's dexterity and judgment applied to these far-ranging systems will broaden this scope, reduce their costs, and enhance their practicality. In the true mastery of spaceflight, the personal



AN ACHIEVEMENT IN DEFENSE ELECTRONICS

WHAT'S BEHIND A BMEWS RADAR?

Years of experience—for as early as 1954, General Electric had conceived and developed radar equipment capable of detecting ballistic missiles at 1,000 miles. This was the forerunner of the AN/FPS-50 surveillance radar being provided by General Electric under subcontract to RCA for the Air Force Ballistic Missile Early Warning System (BMEWS).

The AN/FPS-50 radar equipment, with a range in excess of 2,000 miles, is a singular example of achievement in defense electronics. It is another milestone in General Electric's sustained engineering effort to develop and produce equipment to meet the unprecedented detection problems posed by ICBM's.

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MICRO-MODULE EQUIPMENT



The micro-module is a new dimension in military electronics. It offers answers to the urgent and growing need for equipment which is smaller, lighter, more reliable and easier to maintain. Large scale automatic assembly will bring down the high cost of complex, military electronic equipment. Looking into the immediate future, we see a tactical digital computer occupying a space of less than two cubic feet. It will be capable of translating range, wind

velocity, target position, barometric pressure, and other data into information for surface to surface missile firings. The soldier-technician monitoring the exchange of computer data will have modularized communications with the other elements of his tactical organization. RCA is the leader contractor of this important United States Army Signal Corps program and is working in close harmony with the electronic components industry.



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capabilities of man will replace complex and expensive equipment.

The rational ability which man can bring into play will be far better than the most intricate devices ever conceived. Man is still the best all-purpose computer servo-system known. His brain is equal to ten billion electron tubes. He is unsurpassed in evaluating, reasoning, interpreting, and reacting to complex situations.

Man's performance in space will complement and protect man's progress on earth. The crews of our Strategic Air Command fly long hours over great distances in the interests of national security. As human boundaries have receded, human responsibilities have increased. It is reasonable to assume that the Air Force pilot of the space age will carry the big stick of deterrence into the arenas of space.

Above the atmosphere, too, man can widen his knowledge and extend his abilities in the fields of communications, intelligence, navigation, and meteorology. He can perform in superior fashion the functions of reconnaissance and early warning soon to be carried out by our Samos and Midas satellite systems. He can raise his scientific and engineering capabilities to new heights, maintaining and utilizing the growing number of artificial satellites which will be joining the space-traffic pattern. He can look into the universe unhindered by the atmosphere.

As our ascent in the vertical dimension lengthens, characteristics change. But the pilot remains the essential link between aspiration and achievement.

Like our current earth satellite programs, any manned space system should begin, and end, in the lower atmosphere. We have determined that the best vehicle to carry man into space will be one which he can control and maneuver and land. The earliest such craft will undoubtedly be similar to the skip-glide kind of vehicle now envisioned in the Air Force Dyna-Soar program.

In the latter years of this century, the people who will support these manned spaceflights will probably be performing many of the same kinds of tasks now being done in support of aircraft and satellite systems.

Near Sunnyvale, Calif., the Air Force Satellite Test Center is already in operation. It is the nation's first organization set up exclusively to satisfy the launch, tracking, acquisition, and recovery requirements of a satellite program. A nerve center for an electronic network that extends around the world and into space itself, the Center is linked to instrumentation squadrons in Hawaii,

to tracking stations in California and Alaska, and to a launch squadron at Vandenberg AFB.

Already marked for expansion, this Satellite Test Center will take on increasing responsibilities in the months ahead. The staffs of NCOs who keep electronic fingers on the pulses of these systems will grow significantly as the systems increase in number and in complexity.

Similarly, men who service and maintain our fighters, bombers, and cargo planes will be matched by men technically trained to the demanding job of readying space vehicles for flight—work which requires the ultimate in quality and attention to detail. Others will be needed for ground support, control, and communications.

Already we can acquire, during a single pass of an instrumented satellite, enough scientific and performance data to keep processors and evaluators busy for weeks. More and more, skilled computers will be needed to extract vital information from the infinite mysteries of the universe.

Tracking, control, and communication with orbiting vehicles will demand manpower and brain power in hitherto unmatched quantities. During research and development, these are functions accomplished primarily by civilian technicians; but with operational systems, these jobs will belong to the men . . . and women . . . who wear Air Force blue.

Never let it be said that the flying Air Force is a dying Air Force. Nothing could be further from the truth. Man will go into space. The work which the Air Force does today and in the years just ahead will strengthen our national security and enhance the progress of our civilization. And men will be shaping, building, operating, and administering the aerospace force which is emerging today as our strong lifeline to peace.

Man has ranged the length and breadth of the land. He has descended to the depths of the sea; climbed to the heights of Everest. He has raised himself to the limits of the atmosphere. Man has been the instigator and the benefactor of every breakthrough against technical, social, and geographic frontiers. He will not stop short of the last great frontier.—END



A career officer with degrees in mechanical and aeronautical engineering, General Terhune was one of the first officers assigned to the Ballistic Missile Division of which he is now Vice Commander.

COMMAND AND CONTROL

for Missiles and Space

WITHOUT communications, all I command is my desk."

As dramatic as it is succinct, this comment by Gen. Thomas S. Power, SAC's Commander in Chief, puts in focus the utter helplessness of a commander who cannot find out what is going on nor convey his decisions to his subordinates. One cannot command without control, and one cannot control without instantaneous communications.

The military definition for command and control systems calls them "those major systems, usually electronic in character, which are used to collect, transmit, process, and display the data required for timely decisions needed for modern-day control of our weapons and to facilitate highly complex decisions."

What this means is that the Air Force needs eyes and ears (radar, infrared sensors, cameras, etc.) to seek out and collect information. It needs a nervous system to transmit the information to the brain and to translate the brain's decision into offensive or defensive action of the arms and legs (movement and strike action of weapons). This big Air Force nervous system is made up of command and control systems.

To cope with the requirement, increased immeasurably by the introduction of ocean-spanning ballistic missiles into the force and the promise of intricate space systems to come, the Air Force is riding the wave of what some call "the electronic revolution." Giant strides are being made in data acquisition, transmission, storage, and retrieval—made possible primarily by the development of more sophisticated computers.

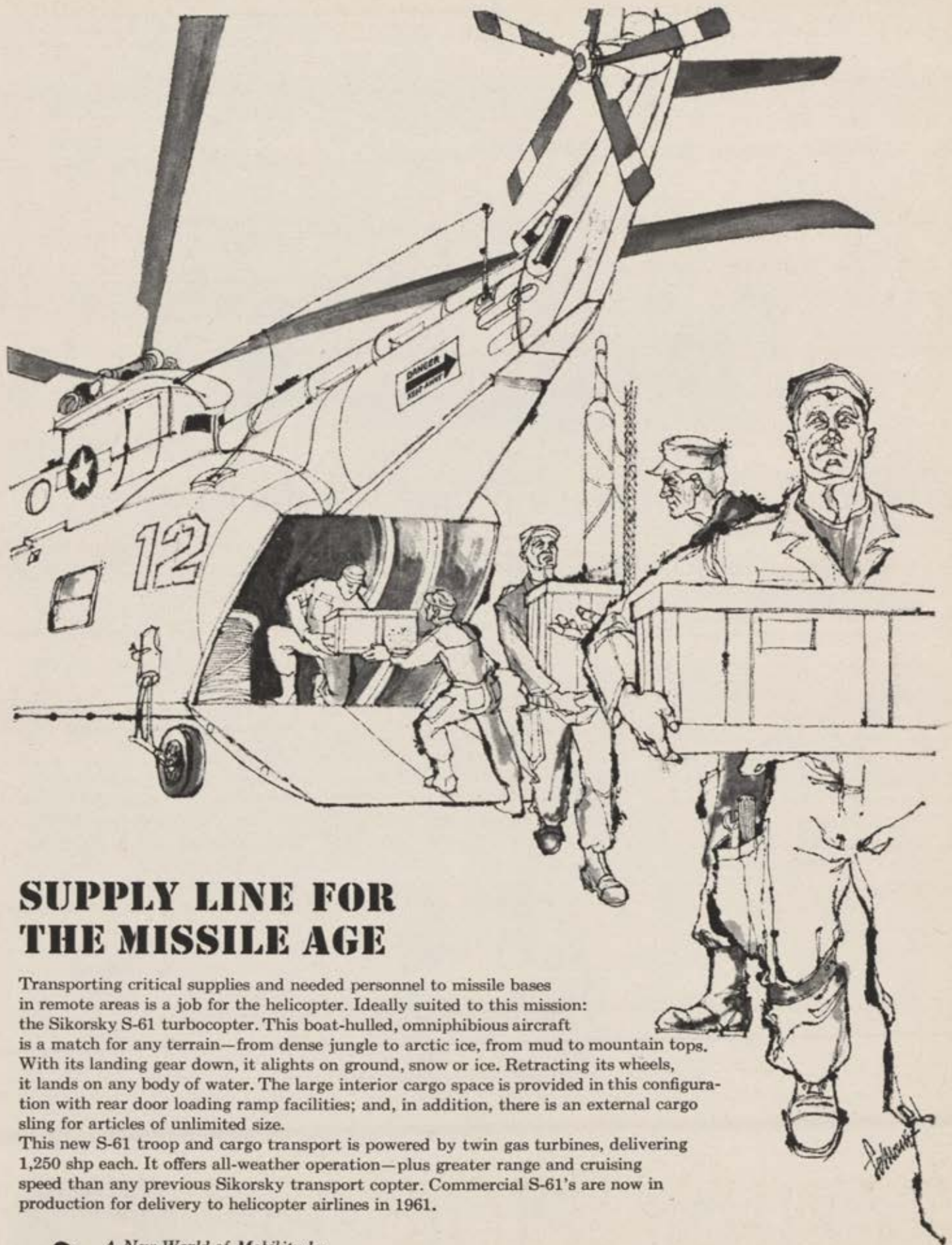


Computers are commonly, but erroneously, called "electronic brains." They are not quite that, yet, although scientists are looking to the day when computers will be able to "think" as well as store and process data. What they are able to do, if given the proper orders through a system called "programming," is to assimilate vast amounts of data, sort through them, and come up with a display of information, in some cases offering a number of different decision choices. But the commander still must command; the decision is his, not the computer's.

The lack of a clear understanding as to the strength and weakness of computers has, in some cases, given rise to unrealistic military requirements. Every commander wants all the information he can get that bears on the decision he has to make. This in turn can put a burden on communications and computers that is out of proportion to the benefit received—if, indeed, possible at all.

Hence, it is mandatory that command and control systems meet the standards of technical realism—what is really feasible within the state of the art, of cost, and, very important, of integration—the ability to talk with one another and to complement, rather than compete.

It is in recognition of this fact that the recent reorganization of the Air Research and Development Command set up, as one of four major divisions, a Command and Control Development Division (immediately dubbed C²D²—C square D square). To provide logistic support, following the precedent established in the ARDC-AMC relationship in air weapons and ballistic missiles



SUPPLY LINE FOR THE MISSILE AGE

Transporting critical supplies and needed personnel to missile bases in remote areas is a job for the helicopter. Ideally suited to this mission: the Sikorsky S-61 turbocopter. This boat-hulled, omniphibious aircraft is a match for any terrain—from dense jungle to arctic ice, from mud to mountain tops. With its landing gear down, it alights on ground, snow or ice. Retracting its wheels, it lands on any body of water. The large interior cargo space is provided in this configuration with rear door loading ramp facilities; and, in addition, there is an external cargo sling for articles of unlimited size.

This new S-61 troop and cargo transport is powered by twin gas turbines, delivering 1,250 shp each. It offers all-weather operation—plus greater range and cruising speed than any previous Sikorsky transport copter. Commercial S-61's are now in production for delivery to helicopter airlines in 1961.



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system in 90 minutes. It is a product of KNOWMANSHIP. So is the support equipment for the Inertial Guidance Stable Platform on the Army's Pershing missile. And it is KNOWMANSHIP that developed Air Data Computer support



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development and procurement, Air Materiel Command established a logistic opposite number for C²D². This has been named the Electronic Systems Center.

Location for the new headquarters has been placed at Laurence G. Hanscom Field, Bedford, Mass. The Hanscom area already houses ARDC's Cambridge Research Center, the Lincoln Laboratory of the Massachusetts Institute of Technology, and the Air Defense Systems Integration Division (ADSID). It also lies in the heart of the mushrooming electronic industry complex of the Greater Boston area. The entrance to Hanscom is just off Route 128, known as the "electronic horseshoe," which is lined with one new electronic installation after another.

Heading the Command and Control Development Division is Maj. Gen. Kenneth P. Bergquist, who has been Commander of ADSID since its inception in July 1958. His Air Materiel Command opposite number and Commander,

of the University of Detroit, is in his thirty-first year of commissioned service. His materiel experience dates back to 1942, when he was Chief of Fighter Aircraft Procurement at Wright Field, until after World War II. With minor exceptions, he has been in the logistics business ever since.

At this point, perhaps a word about ADSID will serve to illustrate the new role of C²D², since in effect the C²D² concept is a lineal descendant. ADSID was set up after the electronic computers had invaded the air defense field—its job to ensure that all air defense weapons and the electronic systems which controlled them were compatible one with another. Hence the important word "integration" in the title—Air Defense Systems Integration Division. Germane to the problem also was the need for positive control of the entire air battle—offensive as well as defensive.

As General LeMay once put the problem: "Our air offense and our air defense cannot be permitted to interfere with each other. This requires close



*Maj. Gen. Clyde H. Mitchell,
Commander, ESC.*



*C. W. Halligan, President,
The MITRE Corporation.*



*Maj. Gen. Kenneth P. Bergquist,
Commander, CCDD.*

Electronic Systems Center, is Maj. Gen. Clyde Mitchell, formerly Commander, Rome Air Materiel Area, Rome, N. Y.

General Bergquist, forty-seven, a 1935 West Point graduate, brings to his new job a wealth of operational experience, particularly in air defense where the need for an integrated electronic control system early became apparent, one result being the Lincoln Lab-developed SAGE (Semi-Automatic Ground Environment system) now in operation.

General Mitchell, fifty-four, a 1930 graduate

direction and control to assure protection of our offensive and defensive forces and the most effective destruction of enemy forces. To achieve the greatest effectiveness we cannot have confusion in orders, procedures, or identification. To fight any battle, the defensive and offensive forces must be interrelated and centrally controlled to get the best results. In fighting an air battle, this principle is even more of a requirement because of the great flexibility, high speeds, lethal weapons, and great ranges involved."

It would be hard to find a better statement of

work for ADSID and for its successors—Command and Control Development Division, ARDC, and Electronic Systems Center, AMC. In the vast and growing field of electronic control systems for aircraft, missiles, and exotic space systems yet unborn, their job is to develop and procure systems that will be technically compatible—"make it work"—and programmed to put the right component in the right place at the right time—"make it come out even."

To provide systems engineering and technical direction to C²D², the Air Force has expanded the area of interest of an organization originally set up to perform essentially the same functions for ADSID. This is a nonprofit corporation known as MITRE.

The MITRE Corporation is an outgrowth of the long association of the Air Force with the Massachusetts Institute of Technology in the air defense field. MIT's Lincoln Laboratory research in this area has spawned, among other developments, SAGE.

However, MIT felt that, while research quite properly fell in the province of the Institute, active technical direction and systems management clearly did not. Hence, a nonprofit corporation, MITRE, was set up under MIT sponsorship, with the core of its staff recruited from Lincoln. The name has a dual significance—from the word "mitre," to fit together, and Massachusetts Institute of Technology-Research Engineering.

MITRE's President, C. W. Halligan, is on leave from Bell Telephone Laboratories, where he was director of military engineering. He has been concerned with air defense matters for the past eight years. Vice President for Technical Operations is Robert R. Everett. Executive Vice President, who joined MITRE in January, is Peter J. Schenk, well known to AIR FORCE/SPACE DIGEST readers as immediate past president of the Air Force Association.

Unlike the Ballistic Missile Division, which was able to start operation with a clean slate, the job of C²D², ESC, and MITRE is complicated by the fact that they have inherited projects and organizations already in being and operating. And there is still a good deal of sorting out as to who is to do what to whom. To this end, the problem is currently being examined by an *ad hoc* organization known as the Winter Study Group, with representation from all interested parties, including Hq. USAF, ARDC, AMC, and the using commands. Technical Director of the Winter Study Group is Gordon Thayer, a Vice President of

American Telephone and Telegraph. Under Mr. Thayer, Lt. Col. John L. Lombardo of C²D² and J. F. Jacobs, Technical Director of MITRE, coordinate the work of panels of technical experts concerned with various phases of the command and control problem.

Winter Study Group panels include: Systems (including a NORAD subpanel), Data Processing Equipment, Data Processing Utilization, Display, Communications Equipment, Sending Equipment, Cost, Threat, Vulnerability, Design Methodology, People, Reliability, Weapons, and Logistics.

The Group is advised and directed by a steering group set up within the Office of the Secretary of the Air Force. The chairman of the steering group is Dr. A. G. Hill of MIT, who formerly headed Lincoln Laboratory. Serving with Dr. Hill are Dr. W. O. Baker, Vice President for Research, Bell Telephone Laboratory; Dr. Ivan Getting, Vice President of Engineering and Research, Raytheon; Mr. Halligan, President of MITRE; Dr. R. F. Mettler, Executive Vice President, Space Technology Laboratory; Dr. Carl Overhage, Director, Lincoln Laboratory; Dr. Emanuel Piore, Director of Research, IBM; Dr. Allen Puckett, Vice President, Hughes Aircraft; Dr. W. H. Radford, Associate Director, Lincoln; Dr. H. Guyford Stever and Dr. Jerome B. Wiesner of MIT.

A tentative deadline for the final report of the Winter Study Group has been set for July 1, but no one will be surprised if that schedule slips by a month or so. The report will be the basis for a detailed charter of Air Force interest and operations in the electronic systems field and as such will have deep implications for the Air Force and for the electronic industry which serves it.

Meanwhile, of course, the work in electronic systems cannot wait for the findings of the Winter Study Group. Work on them—the so-called "L" systems—proceeds apace. C²D², at this writing, is in the process of seeking ARDC and Air Force approval of its organization chart, but it should be approved, staffed, and in operation within a month or two.

Electronic Systems Center is firm as to organization and manning, with twelve ESPOs (Electronic Systems Program Office) for each of the systems currently within its jurisdiction. These are organized into three major directorates—Command and Control Communications, Intelligence and Warning, and Weapons Control. Total manning for the Center is 136 officers, five airmen, and 370 civilians.

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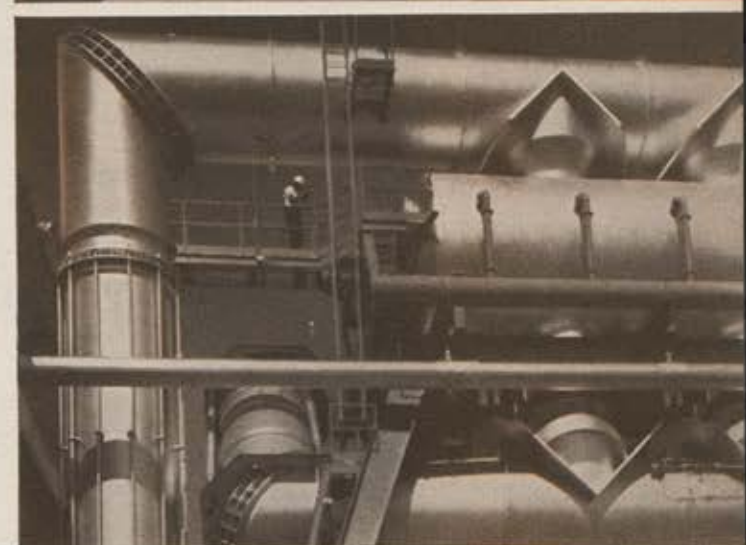
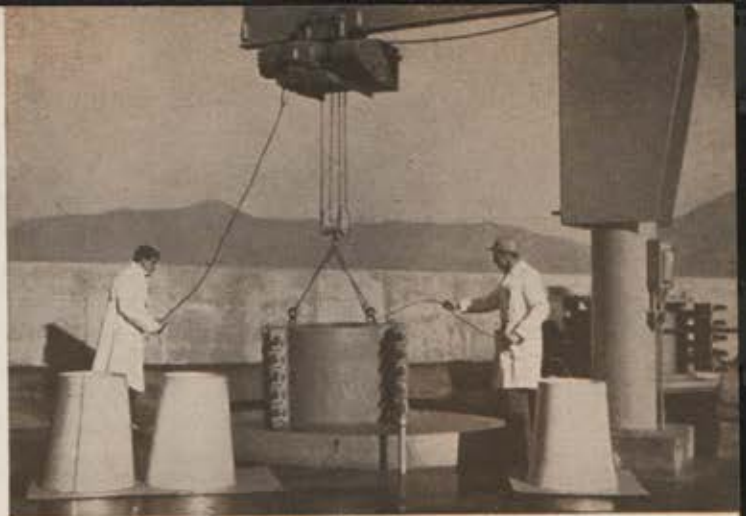
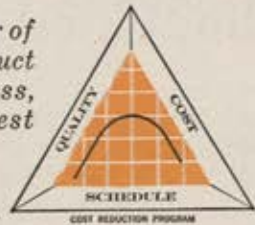
Recent expansion and additions further enhance Marquardt/Ogden's capability. In 1958 the plant doubled floor space to almost ¼ million square feet, with numbers of employees increasing 93%. 1959 marked Ogden Division's addition of a first-of-its-kind Spin Forge and completion of a new facility for explosive metal forming. Ogden's USAF-Marquardt acceptance test facility at Little Mountain gives the Division full-plant capability.

Marquardt/Ogden is now capable of producing space-age hardware in all of its basic configurations—cones, cylinders, rings, parabolic shapes—using the most sophisticated of space-age metals.

Responsible for Marquardt/Ogden's record are: a creatively cost-conscious management team headed by Mr. D. K. Tasker (pictured left); early application of industry's newest and most advanced production and metal working techniques; a facility cited by *Factory Magazine* as one of America's top ten; and the efforts of the Division's nearly 2,000 men and women workers. All combine to provide Department of Defense and Weapon Systems Managers with a unique capability for the on-time delivery of reliable space-age hardware at minimum cost.

For additional production capability specifics, you are invited to contact: Manager, Customer Relations Department, Ogden Division, The Marquardt Corporation, 1000 West 33rd Street, Ogden, Utah.

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CENTER. Marquardt/Ogden's massive Spin Forge is the most powerful of its type for cold-flow forming of space-age metals. It compliments the Division's new explosive metal forming facility and other specialized equipment.

BOTTOM. USAF-Marquardt Jet Laboratory-Ogden at Little Mountain, some 15 miles West of Ogden, acceptance-tests every production engine system produced by the Division; is capable of simulating flight at speeds in excess of Mach 3, altitudes above 100,000 feet.

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A dramatic new phase of the U.S. Navy's *Operation Deep Freeze 60* began with the recent landing of a ski-equipped Lockheed C-130 HERCULES at the South Pole — after a 770 mile flight from McMurdo Sound, Antarctica.

The huge 62-ton "Ski-130" which accomplished this historic "first" is one of seven U.S. Air Force Tactical Air Command prop-jet HERCULES transports — all ski-equipped — assigned to assist the U. S. Navy in support of the United States scientific effort in Antarctica. Recognizing the advantages of this go-anywhere, haul-anything airfreighter for *Operation Deep Freeze 60*, the Navy has ordered four "Ski-130s" of its own.

The Jet Age airlift provided by these C-130s will make possible the improvement of buildings to house the expedition's scientists

and equipment — thus expediting the entire program. It has been estimated that a full year in time may be saved. In addition, costly breakage of delicate equipment and supplies, previously dropped by parachute, will be eliminated — at an estimated saving of \$1 million.

Only a few months ago these same TAC "Ski-130" sky giants transported 26 million pounds of construction equipment and materials — and more than 1500 workers — to Distant Early Warning sites on the Greenland Icecap. This record-breaking Arctic airlift was completed well ahead of schedule.

Now in flight test: the new Boundary Layer Control version of the C-130 HERCULES, which will operate from extremely short, unimproved runways.

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Hundreds of thousands of words on the problems of survival in the nuclear-space age have been uttered. Here are some of the most thoughtful we have heard or read recently. In one way or another, they all address themselves to the acute problem of our times, the question of whether we are willing to face up to the challenges of a new world that is already upon us. They are not tranquilizers, but rather serious. . . .



Teller: Only with optimism can we create any worthwhile future in which to live.



Schriever: We must acknowledge the importance of space for national survival.

SPACE CAPSULES

"I think it is my duty and your duty to be optimistic in the atomic age, because only with optimism can we create out of all the uncertainty the kind of future in which it will be worthwhile to live."

Dr. Edward Teller, nuclear physicist and Director of the University of California's Lawrence Radiation Laboratory, Livermore, Calif., writing in the Lincoln, Neb., Sunday Journal and Star, November 1, 1959.



"I believe that our nation must acknowledge the predominant importance of space for national security and survival."

Lt. Gen. Bernard A. Schriever, Commander, Air Research and Development Command, testifying before the House Committee on Science and Astronautics, February 5, 1960.



"We could lose *all* by allowing an adversary to gain technical advantage in space weapons. We almost did when we allowed Stalin a nearly eight-year uncontested head start on rocket and missile development. . . .

"But to win the world for freedom takes much more than weaponry. It calls for the application of science and technology to human needs—making the deserts bloom with desalinized sea water, converting solar energy to power, unlocking the secrets of the living cell to achieve a longer, healthier life span, and . . . eventually develop-

ing better understanding and cooperation between peoples."

James H. Doolittle, on receiving the 1959 Silver Quill Award from National Business Publications, Washington, D. C., January 21, 1960.



"This command [SAC] has a vital interest in [weather, reconnaissance, and warning] satellites. . . . Weather satellites . . . can help us expand what is already the world's largest and most complete weather service. The value of reconnaissance satellites is obvious. Without question, they would add tremendously to our intelligence capability. The vital need for warning satellites also requires no embellishment. SAC, as the free world's greatest retaliatory force, urgently needs every moment of warning it can get to unleash a counter-blow. . . .

"Although missiles will become a major portion of [our] inventory, the manned aircraft will still be necessary to maintain a flexible . . . force. . . . There will always be a requirement for man's brain in the weapon system. According to our plans, manned and unmanned systems will develop on a parallel until we reach the point of placing the human being in a system that operates in space. This is the goal. To achieve it, we cannot neglect the development of either system."

Gen. Thomas S. Power, Commander, Strategic Air Command, in an interview with this magazine, March, 1960.



"One reason [Congress does not increase the defense budget] I am sure is that not enough congressmen are really interested in this subject. There are a number of them who really do their homework, and a growing number, but the great majority of them pay very little attention to [the defense problem] until their mail forces them to. . . ."

Thomas G. Lanphier, Jr., on NBC's "Meet the Press," March 13, 1960.



"Today, the question is often asked: 'How far do we plan to send manned vehicles into space?' The answer, as I see it, is—as far as they need to go in regular operations. . . ."



Doolittle: Winning the world will take even more than supremacy in space weaponry.



Power: SAC has a vital interest in space technology; man in space is our goal.

Gen. Thomas D. White, Air Force Chief of Staff, testifying before the House Committee on Science and Astronautics, February 4, 1960.



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White: How far into space? The answer is as far as we need to go for operations.



Glennan: And there is this matter of competition with the Soviet Union.

machines of war, we have a situation for the first time in history where the opening event by which a great nation enters a war—an event which must reflect the preparations it has made or failed to make beforehand—can decide irretrievably whether or not it will continue to exist. . . .”

Bernard Brodie, in Strategy in the Missile Age. Princeton University Press, 1959.

“ . . . There is this matter of competition with the Soviet Union. While space research is only one of the many areas of scientific, economic, and political rivalry between our two great nations, it is the most exciting, difficult, and glamorous of all. For decades, the world at large had regarded this country . . . as preeminent in most scientific, technological, and industrial fields. They have known us by our works and judged them good.

“The Soviets have managed to convince many, even in the relatively sophisticated Western nations, and certainly in the less industrially developed nations, that Russian accomplishments in space—and they are considerable—are the true measure of scientific and technological development, and thus the measure of the strength of a society and a form of government.”

T. Keith Glennan, Administrator, National Aeronautics and Space Administration, to the Worcester, Mass., Economic Club, February 15, 1960.



“Space accomplishments have captured the imagination of the world and we must recognize that we cannot be second best in space for very long and still command respect and hold world leadership. In a very real sense, we are in a war of scientific development, as well as a war of production. We must have firsts—firsts in space and firsts elsewhere, if we are to continue to be leaders.”

Thomas J. Watson, Jr., President, International Business Machines Corporation, testifying before the Senate Subcommittee on National Policy Machinery, February 25, 1960.



“If we are not prepared . . . to admit that we are in a struggle for survival involving military power, economic productivity, and influence on the minds of men in political, scientific, and moral fields, then we have truly succumbed to the hard sell of the soft attitude.

“For whether we like it or not, we are in the early stages of a ruthless and lengthy period of competition between our system of free men governed by their consent, in a society of reasonably free enterprise, and the Communistic system with the so-called advantages derived by a dictatorship endowed with cold-blooded patience, continuity of determined effort, and openly declared single-

ness of purpose directed toward world domination."

Robert A. Lovett, former Secretary of Defense, testifying before the Senate Subcommittee on National Policy Machinery on February 23, 1960.



"... I wish to emphasize six major points: First, the nation faces a clear and eminent threat to its survival, but we have not yet fully awakened to this very unpleasant fact. Second, the nation can and should do much more to put its back into the job of meeting the threat. We certainly have the resources to do those things required for our survival, provided we allocate them wisely. Third, key officials concerned with our national security frequently do not have all the facts they need to make many important decisions, or they have the wrong facts. Fourth, I believe our key officials, particularly the Secretary of Defense, need better staff assistance for securing objective military advice. Fifth, the Congress should, by appropriate legislation, give the President and the Secretary of Defense more flexibility in assigning roles and missions to the three services and the Marines. Sixth, the Congress could and should play a more active role in stiffening our response to the Communist challenge."

Robert C. Sprague, Chairman of the Board, Sprague Electric Co., testifying before the same subcommittee, February 24, 1960.



"... We are not moving ahead rapidly enough, nor with enough, to ensure victory in the space war. . . . Perhaps the main reason we are not moving fast enough is because our populace seems to be divided into two camps—the complacent and the foolhardy; those who just don't care—there are far too many of these—and those who would spend money on any stunt. We don't, in effect, have the polarization of effort required to fight a war and I honestly believe that in this day and age the space race is war. It may cost lots of money, and maybe we might all have to work a bit harder, but if we don't start running fast, the consequence is defeat. There is simply no alternative."

Dr. Rex C. Mack, Manager of Space Program Development, Hughes Aircraft Company, to the Institute of Radio Engineers, Pasadena, Calif., February 18, 1960.



Lovett: Have Americans succumbed to the hard sell of the soft attitude?



Khrushchev: We will bury you.

"... Let us not delude ourselves. Would we rather see our taxes go to efforts to solve the problems of space today, or would we prefer to wait and see them go to a foreign power in payment for the exports from that country's newest territory—the moon?"

Thomas R. A. Davis, M. D., Director of Environmental Medicine, US Army Medical Research Laboratory, writing on "Man Alive in Outer Space," in the Atlantic Monthly, March, 1960.

That's your missile warhead in terminal dive, or your aircraft approaching a heavily defended target... the enemy has detected you. They're jamming your radar or confusing the terminal guidance. Decoys are between you and the target. Enemy radar is "locked on." Nuclear tipped anti-missiles are energized for intercept.

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to get
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"I don't see that there has been any change in the long-run Communist goals of world domination. Whether you deem that the Communist aims are those of world subjection by military force or whether you consider that their aims are longer-run aims of world domination simply by doing a better job and producing more and being smarter than we are, still I say that it is a competitive world and we have to figure out how to meet that competition."

Malcolm P. McNair, Lincoln Filene Professor of Retailing, Harvard Graduate School of Business Administration, in the General Electric Defense Quarterly, January-March, 1960.



"If the true aim of space projects is to be spectacular, to impress the world with bigness, power, and the unspoken threat of missile weapons, the Soviets are more successful than the US. If it is to serve peace and scientific knowledge, then our Pioneer V is performing very well indeed. It is unfortunate that the US has not succeeded better in making this contrast in American and Soviet space efforts plainer to the world."

From an editorial in the Philadelphia Inquirer, March 15, 1960.



"This new age of rapid change is not one we can ignore or one from which we can turn away to more tranquil and predictable times. For the revolution in ideas and science and technology are virtually worldwide. Failure to meet this challenge with our best efforts would be tantamount to surrender to forces we could control with the abilities and wisdom God has given us. . . ."

Rep. Bernard F. Sisk, Democrat of California and member of the House Committee on Science and Astronautics, speaking at the dedication of Avco's Research Center, Wilmington, Mass., in May, 1959.



"Soviet supremacy in the production and use of missiles and space vehicles will give them a two-fold advantage. One, the US will and ability to combat Communist moves of aggression will be paralyzed by the threat of mass destruction, and two, the world will be told the Communist system is best suited to the new era of civilization in

which man has escaped his earthly confines. It takes little imagination or foresight to anticipate our plights were such advantages to reside in the hands of the masters of the Kremlin. Our eventual submission . . . would be assured."

Ralph Becker, vice chairman of the American Rocket Society's Space Law and Sociology Committee, at the 1959 annual meeting of ARS at Washington, D. C., December, 1959.



"In all of Washington, there appears to be only one man who does not believe it is crucially important to catch up with and surpass the Russians as soon as possible. He is the boss, President Eisenhower.

"He alone does not concede we are in a race with the Russians. He alone has expressed doubts that American prestige and influence in the world have suffered because the Communists have [made] a greater national effort to master space."

Leverett Chapin, associate editor, the Denver Post, in the last of a series of articles on "The Great Debate," published March 10, 1960, in that newspaper.



"We will bury you."

Soviet Premier Nikita Khrushchev, between cocktails, 1959.

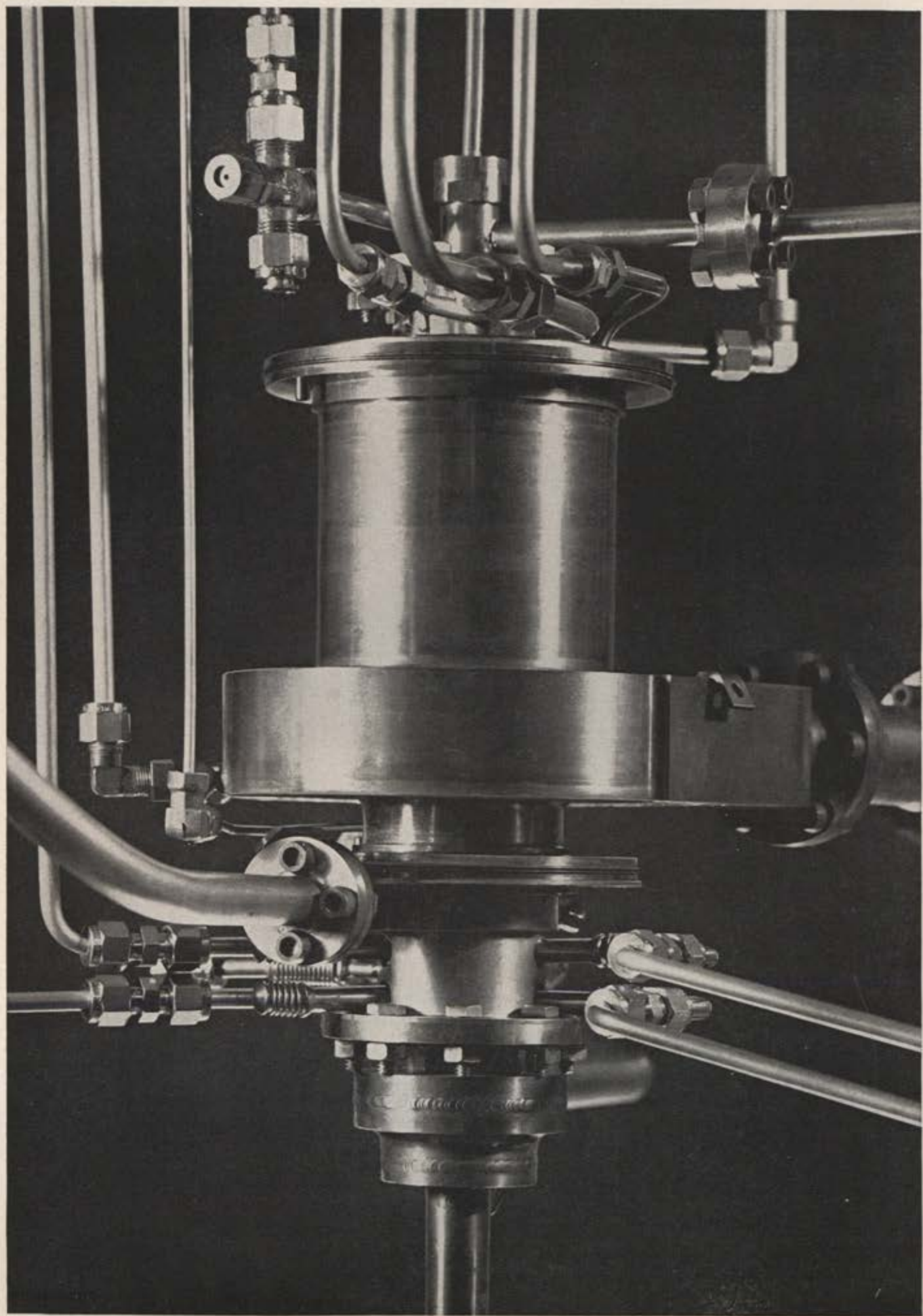


The first and last statements quoted above, the hopeful remark of Dr. Teller and the cold threat of Mr. Khrushchev, stand in interesting contrast. They symbolize the two possible roads the world may travel as it enters the new age.

In one sense or another, the rest of the statements, ranging from Jimmy Doolittle's call for a technological triumph over poverty and disease to Tom Lanphier's plea for earnest congressional interest in defense matters, are commentaries on national attitudes in this business of road choosing.

It is a plain fact that the world is entering a new epoch of history. Like all plastic things, history must be shaped—by men.

If anyone is willing, in Year Four of the space age, to do that shaping—for the rest of us—it is Mr. Khrushchev. He could win that right by default if not enough of us heed the warnings quoted above.—END





TRW's power conversion system, shown here in relative position in a typical space satellite, was developed as part of the AEC's SNAP II project under prime contract to the Atomic International Div. of North American Aviation, Inc.

from a miniature turbo-generator...

ELECTRICAL POWER FOR A YEAR IN SPACE

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The SNAP II turbo-generator achievement will help make possible long-lived satellites, world-wide television communications, deep space information transmission and interplanetary travel. It is only one result of the continuing program of basic and applied research by TRW scientists and engineers into new materials, techniques, and devices to meet the stringent operational and environmental requirements of the space age.

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With a background of many years of advanced scientific and engineering effort in infrared, Baird-Atomic has developed and delivered a number of ground-based and airborne systems for special government requirements. B/A's backlog in this field has risen sharply, with major new commitments for the Missiles and Space Division of Lockheed Aircraft Corporation. Baird-Atomic's responsibilities include the development and delivery of specialized systems for important new applications in space programs. Other programs for infrared system development for the government show continued growth.

The expansion of infrared projects at B/A and the continued growth of national and world markets have created new openings for scientists, designers and production engineers. Unusual opportunities are yours, if you qualify. For details, write to: Personnel, Baird-Atomic, Department Y.



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*As the stakes in the technological
war have increased, NASA and
USAF have emerged as the two
dominant agencies in . . .*

The National Space Effort—1960

Less 'Alphabet Soup,' But Far From Spelled Out

WILLIAM LEAVITT

Associate Editor

THE Russians announce another spectacular. . . . We announce another management reorganization." This was the head-scratching comment of a well known military reporter one afternoon not long ago as he emerged from a Pentagon press conference. He was speaking less as a veteran newsman accustomed to the ways of government than as a citizen trying to keep up with the zigzag pattern of our national space organization.

Some things have changed since we last attempted on these pages to present a graphic picture of the complex of agencies and offices involved in the US space effort. That picture, drawn as a molecular structure (because it seemed to tell so much more than the conventional organizational chart), was given in February 1959. That was two Luniks and much recrimination ago, but the principal point made then still holds true: In our national space effort, there is no central focus, outside the White House, of *both* decision and authority. This fact has become only more disturbing in the fourteen months since February 1959.

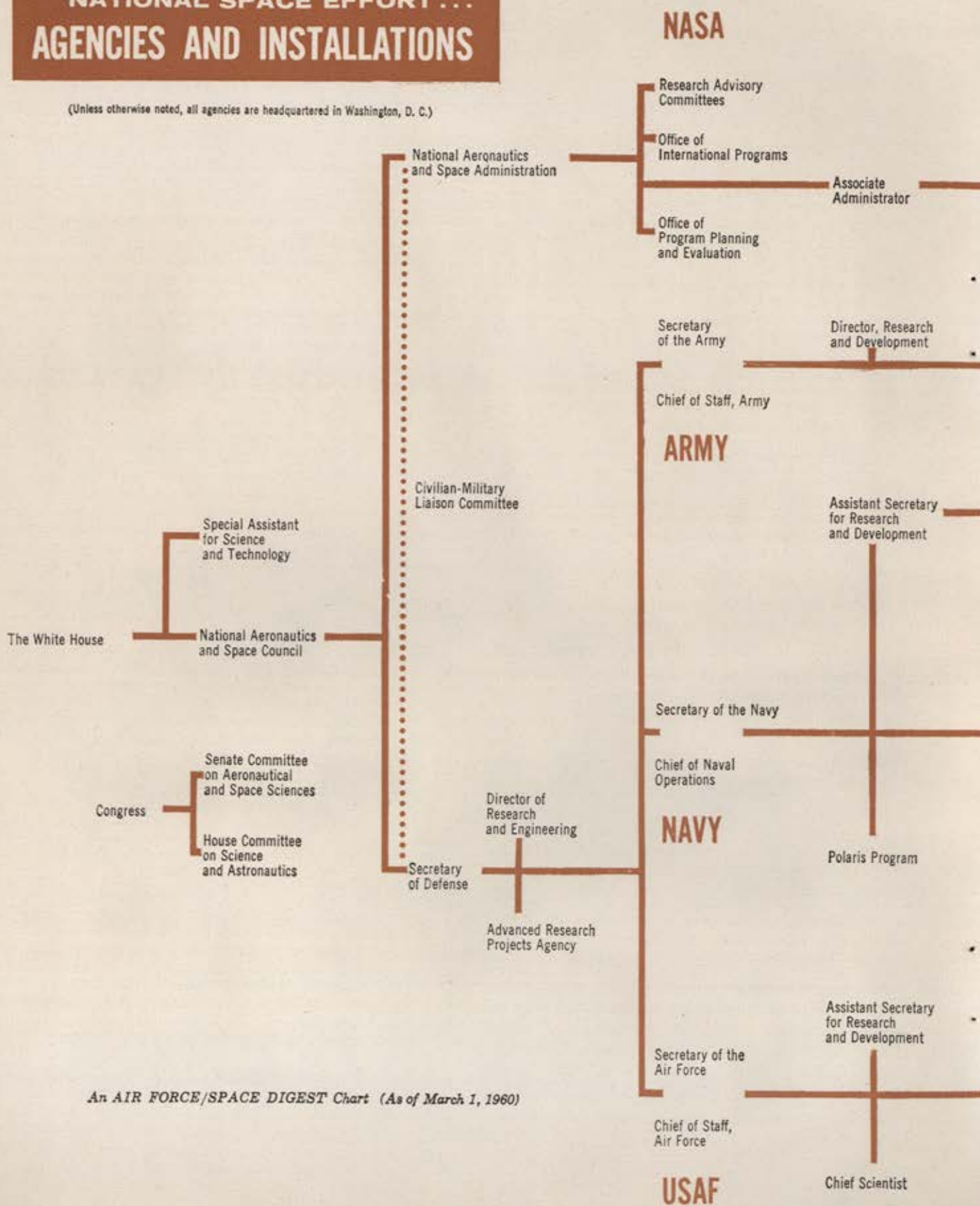
A year ago, the country was getting used to headlines describing such new operations as the President's Special Assistant for Science and Technology, the National Aeronautics and Space Council, the Director of Defense Research and Engineering, the Advanced Research Projects Agency, the Civilian-Military Liaison Committee, and the National Aeronautics and Space Administration. One by one, since Sputnik, these offices had been created by the Executive and the Congress, almost as if the planners had a sort of spiritual faith that with the appropriate name on the appropriate door, the "science" of management would come to our rescue.

But, as in all other struggles, the fittest and most functional survived. The Advanced Research Projects Agency, created in the wake of Sputnik as a supermanagement agency within the Depart-

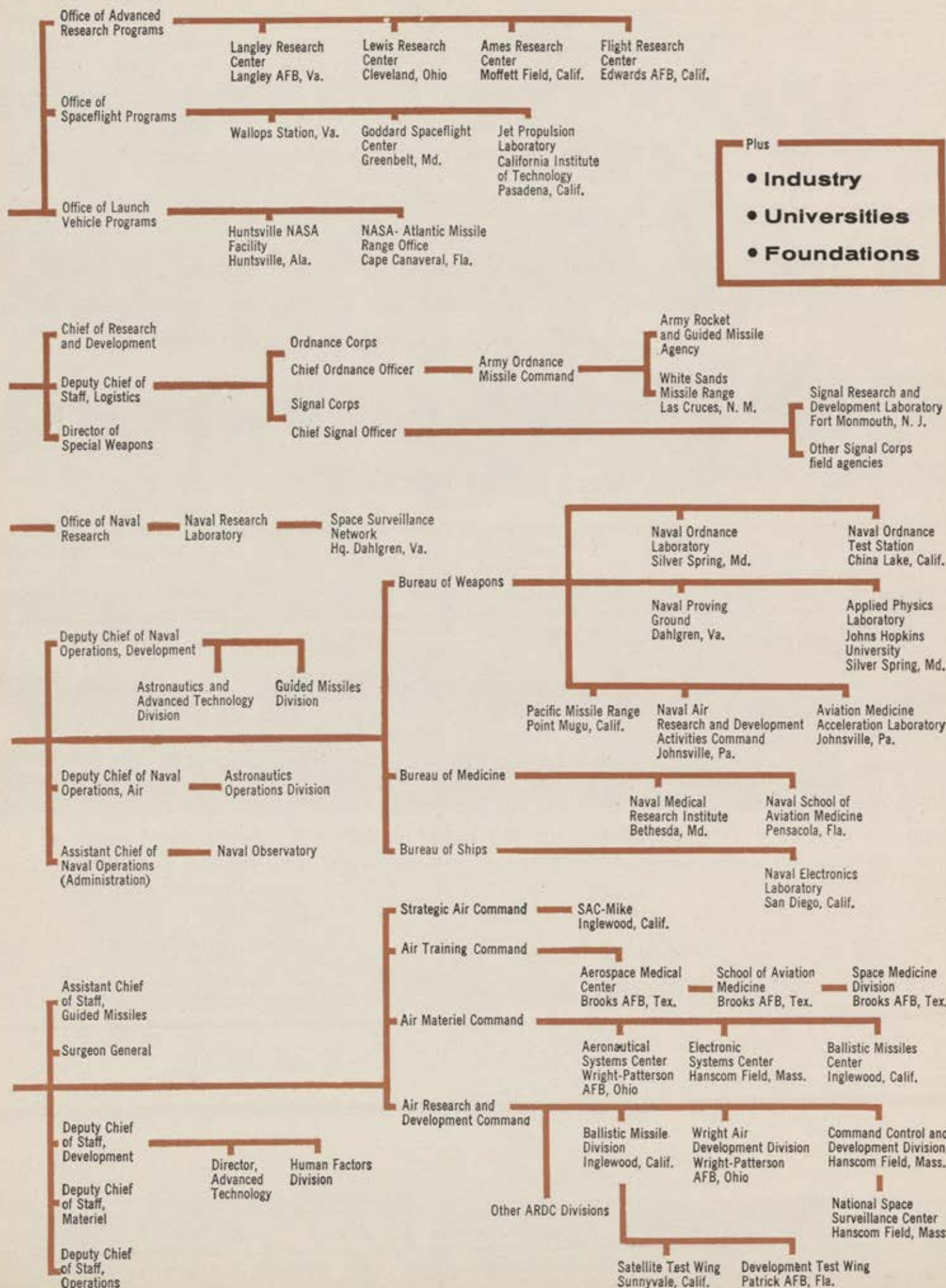


NATIONAL SPACE EFFORT ... AGENCIES AND INSTALLATIONS

(Unless otherwise noted, all agencies are headquartered in Washington, D. C.)



An AIR FORCE/SPACE DIGEST Chart (As of March 1, 1960)



—or our Representatives.

ment of Defense, described as the Pentagon's space agency, has shrunk to a ghost of its former self. For a time, until the organization of the National Aeronautics and Space Administration, ARPA held sway over the three military services, funding space projects. Today, ARPA still shows up on the chart, but devoid of its former glory, funding a few programs—important ones, to be sure—in materials research, fuel studies, antimissile defense, and communication satellites. And although many observers have credited ARPA during its brief ascendancy with having served the good purpose of “koshering” military space projects for funding (an ARPA tag was highly prized for a while by the services), most of them also agree that it has long since ceased to be highly significant. The final denuding of ARPA occurred last year when the Air Force received the military space booster mission.

Another example of an exciting opener and a rather unexciting road-show run has been the office (created in 1957, shortly after Sputnik, and announced by President Eisenhower in his “chins-up” speech in October 1957) of Special Assistant for Science and Technology. The nation was given the impression that the then newly designated James R. Killian was to be, as this magazine put it, a “science chief of staff” to the President, with real power. As matters turned out, this was not the case at all. Instead, the new office rapidly became more decorative than functional, its main contribution to the space effort being the delivery of frequent speeches stressing the need for higher educational standards and more attention to science in the educational system. Dr. George Kistiaowsky, the present Special Assistant, has spoken out much more strongly on the challenge of Soviet science. But the power that *might* have resided in the office is, if anywhere, focused in the office of Director of Defense Research and Engineering, Department of Defense, the post held by Dr. Herbert F. York.

There are two other items that still show on the chart but probably won't the next time our artist executes one. These are: (1) The National Aeronautics and Space Council, and (2) The Civilian-Military Liaison Committee. The President has asked Congress to abolish both functions.

The Space Council, with the President as chairman, created by the Space Act of 1958 which set up NASA, was to be a National Security Council sort of operation to make high-level policy on astronautical matters. It has met infrequently during its brief history, and there seems to be little regret anywhere at its approaching

demise. Also, the President, in his requested amendments to the Space Act, asks to be relieved of both the duties of formulating a national space program and of submitting an annual “space report” to Congress.

The Liaison Committee, headed by one-time Pentagon Director of Guided Missiles, William M. Holaday, was, under the Act, to have been the pipeline of adjudication of differences between the military, represented by the Department of Defense, and the civilian space organizations, represented by NASA. The committee has, by the admission of Mr. Holaday, had practically nothing to do since its inception. There was late last year, after Senate testimony by Mr. Holaday, a flurry of feeling that the Committee ought to be eliminated. It is on its way out.

What is the organization of the space effort as of today? Essentially, it has resolved down to two main organizations—NASA and the Department of Defense, for which it is accurate to read United States Air Force. This is not to say that the other military services have lost their interest in space. Both Army and Navy still retain some capability and a good deal of interest, but the exigencies of budget and the pressure of logic has placed the Air Force in the dominant position so far as military space operations are concerned.

With the presidential transfer of the Von Braun team from the Army Ballistic Missile Agency to NASA, the Army, for all practical purposes, is today out of the military space business, although by no means out of the missile business per se. Also, the Army has high hopes for a space mission involving communications satellites.

The Navy, with a considerable aeromedical capability, a Polaris program, plans for a navigation satellite, and its Pacific Missile Range responsibilities, is hanging on more tightly. Both Army and Navy are presently, but apparently separately, supporting proposals for a tri-service military space command, an idea that is doubtless being looked at somewhere in the Pentagon.

The Air Force and NASA. These are the two halves of today's space organization. Between them is divided the difficult-to-divide national space effort. There is much interchange, especially on the working level and notably in the Project Mercury program of NASA to put an American into orbit. Mercury itself is largely a descendant of what were originally Air Force proposals to do the same job. The Astronauts are benefiting from the notable aeromedical know-how of the Air Force (also that of the Navy); their flight surgeon, Maj. William Douglas, is an Air Force doc-

tor. Three of the Astronauts are Air Force test pilots. The one who takes the big ride into orbit will be boosted out of this world by a USAF-Convair-developed modified Atlas missile.

Incidentally, it is worth noting at this point that as of March 2 (one day after the cutoff date of our chart on pages 94 and 95) NASA established its own Office of Life Sciences, designed to develop an in-house space-medicine capability. The new office will be directed by Dr. Clark Randt, a well known neurologist who joined NASA in 1959. The creation of the new human factors division in NASA was recommended by a committee under the chairmanship of Dr. Seymour Kety of the National Institute of Health. It is too early to judge the validity of NASA's setting up such a new division, in view of the large existing capability in the Air Force and Navy, but it is fair to say that at least some people will wonder if this new departure isn't a duplication of effort.

The new NASA division, regardless of its merits or demerits, is perhaps as handy a symbol as any other of the current dualism.

Boosters—our admitted great shortage in the competition with the Soviet Union—are similarly divided primarily between the Air Force and NASA. In this case, there is even a flesh-and-blood bridge between the two agencies in the person of Maj. Gen. Don Ostrander, USAF, on loan to NASA as Director of Launch Vehicle Programs. In this capacity, General Ostrander bosses Dr. Wernher von Braun and his team, formerly with the Army Ballistic Missile Agency and now being transferred to NASA, who are developing the superthrust Saturn engine cluster now billed as the great hope for substantial payload-carrying space missions. Meanwhile, the Air Force is handling, with industry, a big share of NASA's Centaur program to develop a liquid-hydrogen high-thrust engine, part of NASA's over-all "family of space vehicles" (see page 102), many of which utilize the well known Atlas and Thor.

Although the organizational situation has changed in the direction of simplicity in the past year, the analysis and discussion on official and unofficial levels has continued unabated.

In recent weeks, for example, various observers, ranging from Dr. William Pickering, Director of the Jet Propulsion Laboratory of California Institute of Technology, to retired Maj. Gen. John B. Medaris, former commander of the Army Ordnance Missile Command, have declared publicly that the present organization, divided as it is,

is ineffective and somehow has to be changed.

Dr. Pickering, representing one extreme, believes that practically all authority should be focused in NASA, while General Medaris believes that the space effort must be rolled into one package run by the military.

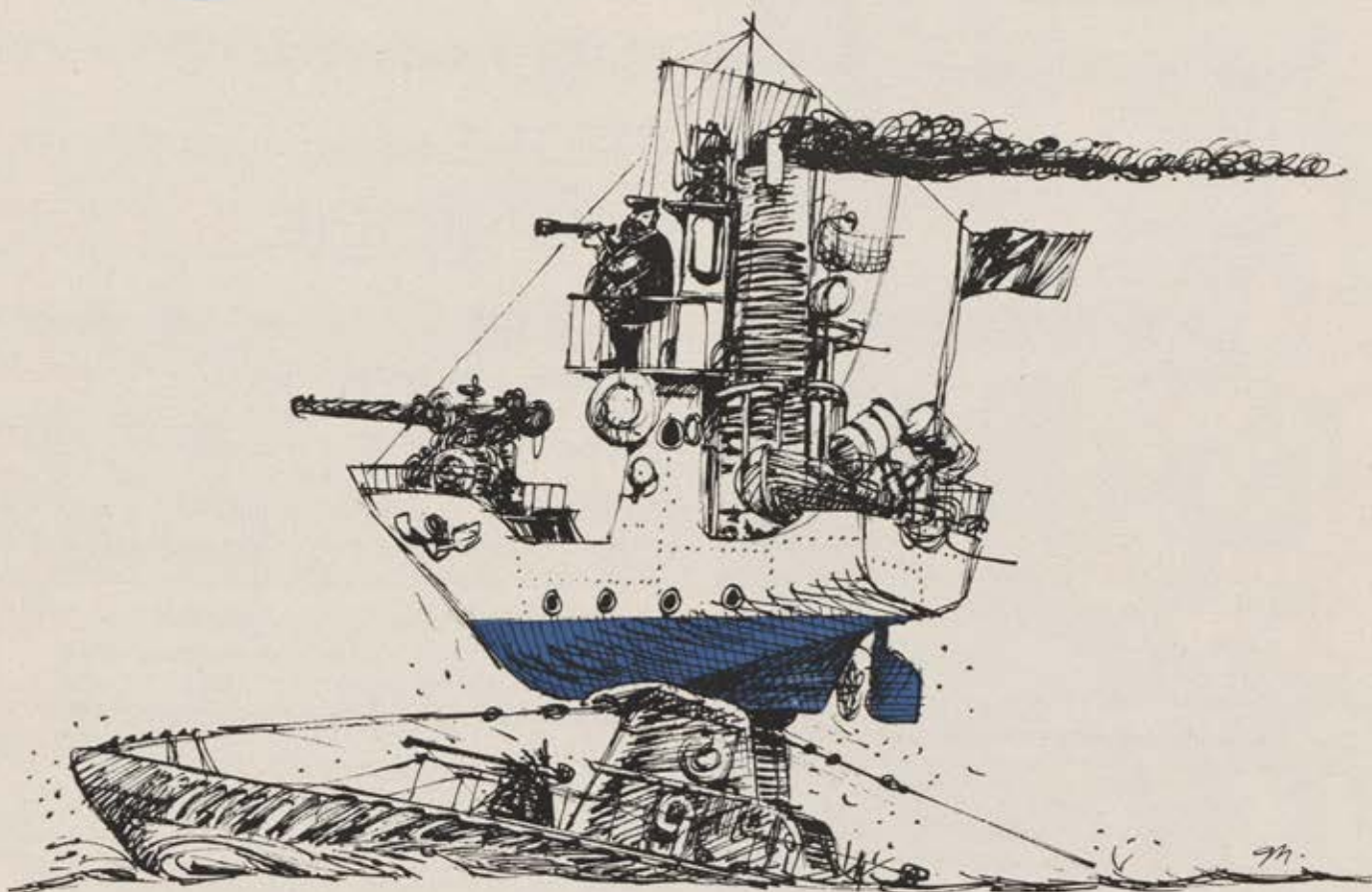
Between these extremes are views, some in the Air Force, notably the Air Research and Development Command, that NASA in itself is a fine and valuable organization but that it could be much more valuable if, in a heavily expanded way, it performed in the manner of the old NACA—that is, research for customers—and did not operate as a vast contracting agency as it is empowered to do now under the Space Act of 1958.

Also, there is sentiment in some quarters and there will probably be study in Congress of the possibility of creating a military applications division with NASA, analagous to the one in the Atomic Energy Commission. This idea has great appeal for some, but it has to be pointed out that such an arrangement would be a hopeless duplication of such existing operations as the Air Force's Ballistic Missile Division and its relative counterparts in the other services. It has to be remembered that when AEC was established, it was born of the Army's Manhattan District and was the only repository of nuclear capability in the country. There is no real analogy between nuclear capability and astronautics.

Which brings the writer, the reader, and the numerous congressmen following the vagaries of US space organization back to the same old question: Can the country devise an organization which provides for the over-all civilian control that is traditional to our society while paying sufficient attention to the increasingly obvious military needs for space capabilities?

On the chart on pages 94 and 95 we have tried to include all the principal agencies, both military and civilian, that are contributing to the space effort. They range from White House and Capitol Hill to the field installations of NASA and the three services. Not cited because of space limitations—although they too play important roles—are such agencies as the AEC, which is exploring nuclear propulsion and auxiliary power systems, some of the other committees of Congress which are involved importantly with appropriations and investigations, or such items as the Space Science Board of the National Academy of Sciences, which does project-suggesting for NASA.

One agency in particular is not cited but is very active in writing the guidelines—the Bureau of the Budget.—END



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USAF-NASA's X-15

1960-1970 will be a busy space decade. Here are the space vehicles and projects that will be taking the US up and out. . . .

SPACEPOWER

... Today and Tomorrow

Manned Aerospace Flight Programs

- **MERCURY**

NASA top-priority program to place US Astronaut in low (some 120 miles) orbit, for an expected three passes around the earth, followed by parachuted capsule reentry and recovery at sea. Seven veteran military test pilots—three Air Force, three Navy, one Marine—now in training; one will be chosen for actual first mission. Project headquarters at NASA Langley Research Center, Langley AFB, Va. Preliminary manned 200-mile ballistic trajectory flight in a McDonnell-built capsule mounted on an Army Redstone missile, scheduled for 1960, followed by orbital rehearsal flight using a primate. Actual mission possible in 1961. Mercury capsule by McDonnell Aircraft Corp., orbital boost by USAF-Convair Atlas ICBM. Human factors support by Air Force, Navy, Army.

- **X-15**

Air Force-NASA program, with naval funding

and pilot support—first conceived in 1952. Air launch of North American Aviation-built rocket craft from under wing of Boeing B-52; to attain altitudes of 50 to 100 miles at speeds which some estimates have placed as high as 3,600 mph. From maximum altitude, X-15 will glide home to a dead-stick landing, obtaining data on aerodynamic heating at hypersonic flight speeds, pilot capabilities under high accelerative stresses. Pilot expected to experience several minutes of weightlessness. Some 80,000 feet altitude already attained in powered flights from air launch. First of three vehicles accepted by USAF, March 1960. Propulsion: 50,000-pound-plus liquid-fueled engine by Reaction Motors Div. of Thiokol. Actual mission expected in late 1960, early 1961.

- **DYNA-SOAR**

Air Force follow-on program to X-15. Manned hypersonic glider, to be launched from earth by rocket, possibly a modified Martin Titan ICBM, to near-orbital velocity and altitude, followed by skip-glide reentry at low angle through upper

atmosphere and landing at preselected point. Mission: to test feasibility of manned orbital glider system. Boeing and Martin companies head industrial teams, with Boeing handling vehicle and Martin propulsion. Air Force's Wright Air Development Division initially acting as prime contractor. Glider flight and crew training in Air Force planning stage. Actual mission expected in late 1960s.

Vehicles, Vehicle Programs, Vehicle Studies

The family of vehicle combinations contemplated for scientific and military uses during the present decade falls into three general categories: those now available, those under development, those under study.

Into the first category fall such items as the Army-developed Redstone missile, which will be phased out of space project use by NASA after 1960-1961 service as a booster in manned ballistic trajectory flights in support of Project Mercury; the Juno II Army-developed vehicle which has been used in NASA space probes and will be phased out by NASA by the end of 1961; the Thor-Able, Air Force-developed vehicle also used in space probes, which will be phased out of NASA service probably in 1960; and the Air Force-developed Atlas-Able, expected to be phased out by NASA in 1961.

The second and third categories—combinations under development or study—are expected to carry the main burden of scientific and military space missions through 1969. They, in turn, break down into two categories.

The first is a family of vehicles using the Air Force Atlas and Thor, respectively, as first stages.

The second includes the Saturn project of NASA, now in development, to create a million-pound-thrust, first-stage liquid-fueled engine cluster; and the NASA Nova project (still not firm) to create a first-stage liquid-fueled engine cluster with more than 6,000,000 pounds of thrust.

For purposes of clarification, it is noted that the Atlas designation in the following listing refers to the USAF Convair-built Atlas-D model ICBM, powered by three North American Rocketdyne liquid-fueled engines (two boosters and one sustainer) developing some 360,000 pounds of thrust. The Thor designation refers to the USAF Douglas-built IRBM, powered by a single Rocketdyne liquid-fueled engine developing some 150,000 pounds of thrust.

Also significant are such studies as the current

USAF Project 3059—looking toward million-pound-thrust solid-fueled systems—and numerous other studies of exotic propulsion methods such as nuclear, ionic, and photon propulsion—under study by NASA, the AEC, the military services, and in industrial laboratories.

● SATURN

NASA program, under way at NASA, Huntsville Facility, Ala., under direction of former ABMA team headed by Dr. Wernher von Braun, to develop superthrust multistage vehicle with a first-stage thrust of 1,500,000 pounds. First stage a cluster of eight H-1 North American Rocketdyne liquid-fueled engines (modifications of those used in Thor and Jupiter IRBMs). Up to four additional stages contemplated, all fueled by liquid oxygen and liquid hydrogen. Total vehicle expected to supply thrust surpassing *present* USSR capabilities. Test launches scheduled 1962.

● ATLAS-ABLE

USAF-NASA four-stage vehicle with lunar mission capability, was used in unsuccessful Thanksgiving Day 1959 attempt to orbit moon. First stage, Atlas. Second, powered by Aerojet-General liquid-fueled engine. Third, powered by Allegany Ballistics Laboratory solid-fueled engine. Fourth, a solid-fueled retrorocket by Space Technology Laboratories. Airframes by Convair. Prime contractor, STL. Thrust: Atlas first stage's 360,000 pounds, plus second-stage thrust of 7,500 pounds, and third stage's 2,500 pounds, totaling 370,000 pounds. Expected to be phased out by NASA in 1961.

● ATLAS-AGENA-B

USAF-NASA two-stage vehicle adaptable for both military and scientific purposes, including Air Force Midas and Samos polar-orbit satellite systems (*see below*). Combines first-stage Atlas with second-stage Agena-B, powered by Bell Aircraft "Hustler" liquid-fueled engine. Agena-B is modified version of the Agena vehicle which, boosted by Thor, has been sent into orbit in USAF Discoverer program at Vandenberg AFB, Calif. First-stage airframe by Convair, second-stage airframe by Lockheed. Prime contractor, Lockheed.

● ATLAS-CENTAUR

USAF-NASA program to develop two-stage general-purpose space vehicle. Combines first-stage Atlas with projected Centaur second stage, engines to be powered by liquid oxygen and

Anticipated NASA Major Space Launching Schedule by Vehicle

(as submitted to the House Committee on Science and Astronautics, 1960)

Fiscal Year	1960*		1961				'62	'63	'64	'65	'66	'67	'68	'69	Total
Redstone		1	2	3	2										8
Atlas		1	2	1	2	1	6	1							14
Juno II	1		1	3											5
Thor-Able	2														2
Atlas-Able		1	1												2
Scout		4	2		2		6	6	6	6	6	6	6	6	56
Thor-Delta	1	1	1	2	1	1	5								12
Thor-Agena-B							1	6	6	6	6	6	6	6	43
Atlas-Agena-B					1		3	4	5	6	3				
Atlas-Centaur						1	5	4	5	6	9	12	12	12	88
Saturn							2	2	3	4	4	4	4	4	27
Nova Type													1	2	3
Total		12		29			28	23	25	28	28	28	29	30	260

*Last two quarters only

liquid hydrogen under development by Pratt & Whitney. Airframes by prime contractor, Convair. Some 390,000 pounds of thrust, comprised of Atlas' 360,000-pound thrust and second-stage's 30,000 pounds of thrust.

● THOR-ABLE

USAF-NASA four-stage vehicle used in space-probe attempts. First stage, Thor. Second stage, modification of old Vanguard, liquid-fueled by Aerojet-General. Third stage, solid-fueled by Allegany Ballistics Laboratory. Fourth stage, when applicable, solid-fueled retrorocket by Thiokol. Airframes by Douglas. Prime contractor, Space Technology Laboratories. First-stage thrust, 150,000 pounds. Second stage, 7,500 pounds. Third stage, 2,500 pounds. Thor-Able was carrier for Pioneer II lunar probe and for Pioneer V sub-orbital deep-space probe. Will be used for NASA Tiros I meteorological satellite (*see below*). Expected to be phased out by NASA by the end of 1960.

● THOR-DELTA

NASA configuration of Thor-Able with guidance in the second stage. Will be used for NASA Tiros II meteorological satellite (*see below*).

● THOR-AGENA-B

USAF two-stage vehicle used in Discoverer program, expected to be used by NASA for NASA Project Nimbus polar-orbiting meteorological satellite (*see below*). First stage Thor. Second stage, which contains payload and goes into orbit, powered by Bell "Hustler" liquid-fueled engine. First-stage airframe by Douglas. Second-stage airframe by Lockheed. Prime contractor,

Lockheed. First-stage thrust, 150,000 pounds. Second-stage provides some 15,000 pounds thrust.

● JUNO II

Army-developed four-stage vehicle used in space-probe attempts. First stage, a modified Jupiter IRBM. Second, third, and fourth stages, modified Army Sergeant solid-fueled rockets. Airframe by Chrysler. First-stage propulsion by Rocketdyne. Upper-stage propulsion by Thiokol. Used for Pioneer II lunar-probe attempt, Pioneer IV solar satellite. Expected to be phased out by NASA in 1961.

● SCOUT

NASA four-stage "economy" all solid-fueled vehicle with basic mission of placing 150-pound payload in 300-mile orbit. First stage by Aerojet-General; second by Thiokol; third and fourth by Allegany Ballistics Laboratory. First-stage thrust, some 100,000 pounds.

● LITTLE JOE

NASA solid-fueled vehicle, using eight solid-fueled modified Army-developed Sergeant rockets, fired sequentially. Used for testing Mercury capsule. Airframe by North American. Propulsion by Thiokol. Combined thrust, some 370,000 pounds.

● NOVA

NASA program for superthrust multistage vehicle (up to five stages) with first-stage thrust exceeding 6,000,000 pounds. First stage, a cluster of Rocketdyne F-1 liquid-fueled engines. Second stage, a single F-1 liquid-fueled engine. Third and fourth stages (configuration and contractors un-



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certain at this writing) expected to be fueled by liquid oxygen and liquid hydrogen. Fifth stage, if used, would probably be fueled by storable liquid.

- **PROJECT 3059**

USAF studies of million-pound-thrust solid-fueled systems now under way.

- **ROVER**

Atomic Energy Commission-NASA project to develop nuclear rocket system, with AEC providing nuclear reactor and NASA the nonnuclear components and liquid-hydrogen propellant.

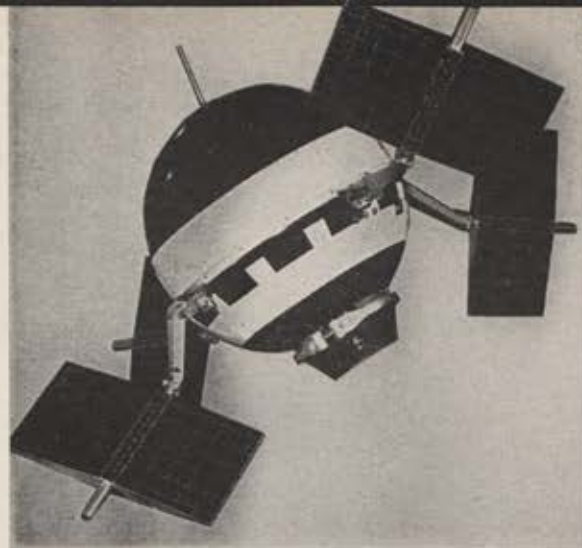
Specific Mission Space Projects

Following is a listing of current civilian and military projects geared to specific missions or in feasibility study stages. Under present rulings, all responsibility for development and launchings of boosters for military space projects is assigned to the Air Force, specifically the Air Force Ballistic Missile Division. Payload development may rest with any interested service. Nonmilitary space projects are the responsibility of the National Aeronautics and Space Administration, with large-scale launchings (beyond the research-rocket category) usually handled by the Air Force Ballistic Missile Division. A number of space and space-oriented projects are sponsored also by the Advanced Research Projects Agency of the Department of Defense, with the military services and industry contributing, with the expectation that the project will be turned over to the using service as it enters advanced developmental stage.

SCIENTIFIC PROJECTS

- **PIONEER**

Over-all project name for series of space-probe missions under direction of NASA, including lunar and deep-space probes, latest of which is Pioneer V, launched March 11, 1960, into a solar orbit between earth and Venus, and carrying a 94.8-pound "paddlewheel" satellite designed to obtain data on radiation, magnetism, and micro-meteorites, and extremely long-distance radio communications. Pioneer series began in 1958. Launchings have been by the Army and Air Force for NASA, have employed Army-developed Jupiter-C and follow-on Juno II vehicle in Army firings, and Thor-Able vehicle in Air Force firings, including Pioneer V, and Atlas-Able. Launches from Air Force Missile Test Center, Cape Canaveral. Space vehicles involving polar orbits are expected to be launched from Vandenberg AFB.



Pioneer V—94 pounds in solar orbit

- **ECHO**

NASA passive communications satellite project to place 100-foot inflatable plastic sphere in estimated 1,000-mile orbit for reflection of radio signals. Langley NASA Research Center directs program. Launch vehicle: Thor-Delta. Test launches expected in 1960. Preliminary balloon launches to 250-mile altitudes already achieved to test inflation techniques.

- **TIROS I**

NASA meteorological satellite project using two television cameras to photograph cloud covers of the earth from an orbit inclined to the equator by some fifty degrees, some 440 miles out. Launch vehicle, Thor-Able. Payload, 270 pounds. Transmitting lifetime, ninety days. Payload development managed by Army Signal Corps, with Radio Corp. of America. Expected launch in 1960.

- **TIROS II**

NASA follow-on program to Tiros I, using infrared scanning and nonscanning devices to obtain meteorological data, also from equatorial orbit. Launch expected in 1960, using Thor-Delta vehicle.

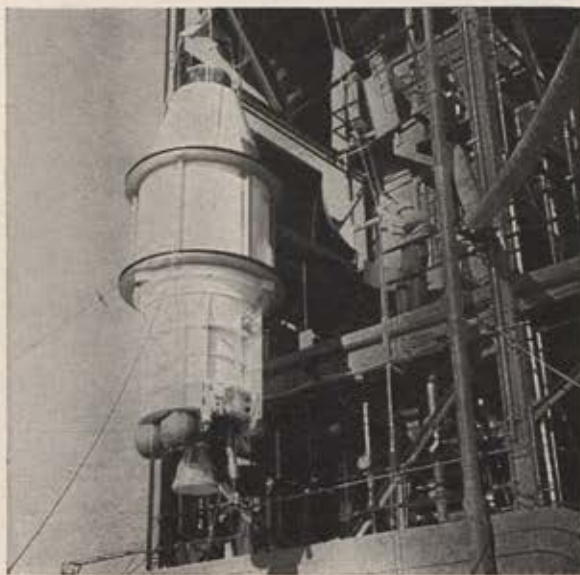
- **NIMBUS**

NASA follow-on to Tiros I and II. Meteorological satellite to be fired into 690-mile polar orbit, using Thor-Agena-B vehicle. Payload, 650 pounds, containing both television cameras and scanning and nonscanning infrared devices. Stabilized always to face the earth. Useful lifetime, six months. Possible launch, 1961 or 1962 from Vandenberg AFB, Calif.

- **NERV**

NASA program to launch recoverable probes to altitudes of at least 1,800 miles to obtain

further measurements of Van Allen radiation, using radiation-sensitive emulsion materials. General Electric developing payload; launchings, possibly in 1960, expected from Vandenberg AFB, using Argo D-4 rocket as booster.



Agena on the test stand

MILITARY PROJECTS

● DISCOVERER

USAF series of polar-orbital launchings by Ballistic Missile Division from Vandenberg AFB, Calif., to gather data on vehicle attitude-stabilization, environmental information for biomedical studies, and payload recoverability. Vehicles used: first stage, Thor; second stage, Agena, which in entirety goes into orbit, developed by Lockheed, powered by Bell "Hustler" liquid-fueled engine. Six out of ten launchings to date have attained orbit. Data fed into Midas and Samos programs (*see below*) and NASA Project Mercury man-in-space program. Lockheed, prime contractor.

● MIDAS

Missile Defense Alarm System—USAF program to place series of satellites in polar orbit to detect aggressive missile launches by use of infrared sensing devices. First stage, Atlas; second stage, Agena, modified to contain specific payload. One test launch from Air Force Missile Test Center, Cape Canaveral, Fla., has failed (February 1960). Additional launches expected this year. Lockheed, prime contractor.

● SAMOS

Formerly known as Sentry—USAF program to

place reconnaissance satellite system in polar orbit. First stage, probably Atlas; second, probably Agena (*see above*). Lockheed, prime contractor. Test launches possible in 1960.

● TRANSIT

Navy program to develop navigational satellite, employing Doppler principle. First test launch failed in 1960. Thor-Able used as booster. Johns Hopkins Applied Physics Laboratory developing payload.

● NOTUS

ARPA programs to develop a family of communications satellite systems:

First phase, called *Courier*, is a delayed repeater communications satellite payload development under Army Signal Corps direction, with Philco developing communications package; International Telephone and Telegraph developing ground-based communications stations systems; Radiation, Inc., developing ground-based antenna system.

Another phase called *Steer*, is a polar-orbiting instantaneous two-way repeater satellite system. General Electric and Bendix are contractors.

Advanced phase of Notus is called *Decree*, an ARPA study of placing a communications satellite system in 22,300-mile-out orbits, with instantaneous relay capability.

● PONTUS

ARPA advanced-material studies.

● DEFENDER

ARPA antimissile studies.

● SHEPHERD

ARPA managed systems for detection and cataloguing of all orbiting vehicles. System includes Air Force's Space Surveillance and Control Center, Navy's SPASUR, Army's Doploc.

● PRINCIPIA

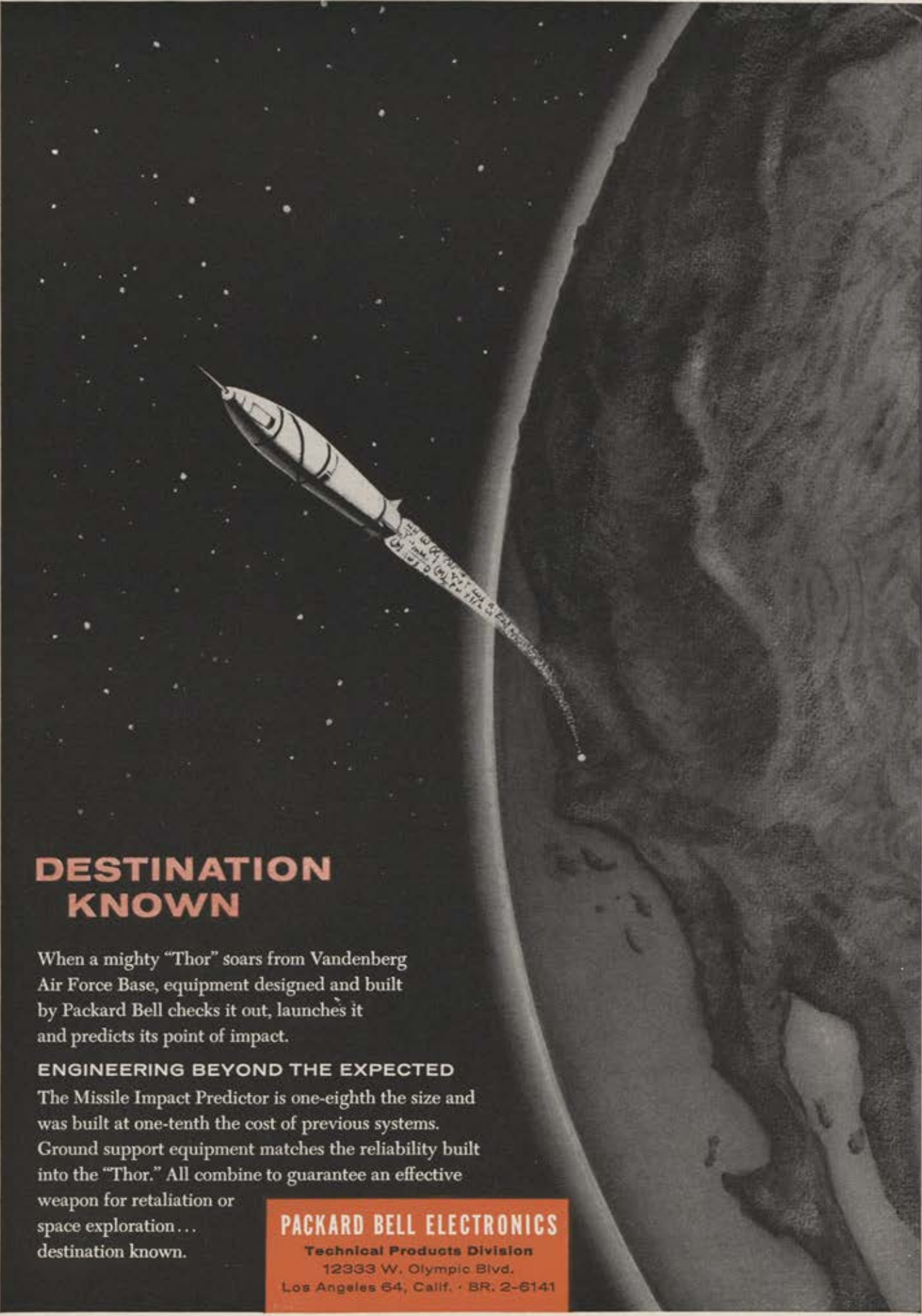
ARPA solid-fuel studies.

● ORION

Former ARPA study, expected to be transferred to Air Force, of space platform or vehicle maneuverable by controlled nuclear explosions. General Atomics, prime contractor.

● Yo Yo

Navy study of vehicle to make orbital pass for quick reconnaissance. —WILLIAM LEAVITT



DESTINATION KNOWN

When a mighty "Thor" soars from Vandenberg Air Force Base, equipment designed and built by Packard Bell checks it out, launches it and predicts its point of impact.

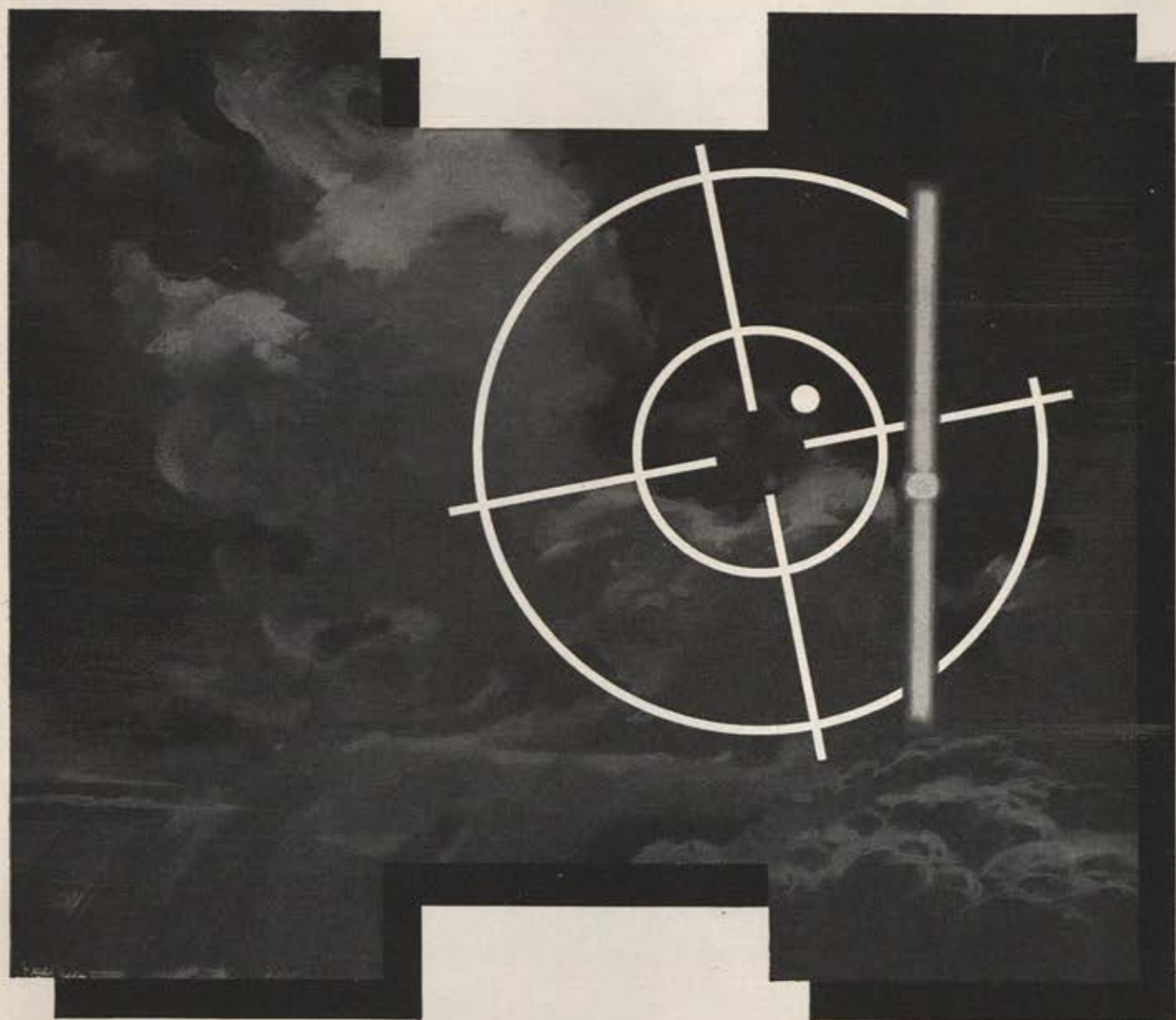
ENGINEERING BEYOND THE EXPECTED

The Missile Impact Predictor is one-eighth the size and was built at one-tenth the cost of previous systems. Ground support equipment matches the reliability built into the "Thor." All combine to guarantee an effective weapon for retaliation or space exploration... destination known.

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How to take a longer look

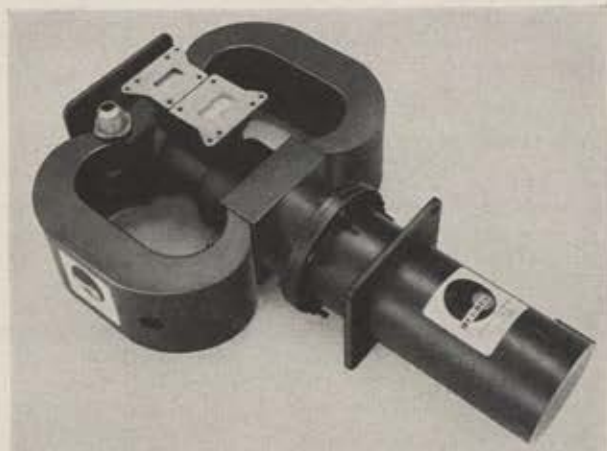


at air space

Tomorrow's manned interceptor aircraft—and even faster ones of the future—require radar navigation, target acquisition, armament control and electronic counter-measures systems of vastly greater scope and dimension than ever before.

To fulfill this critical requirement Hughes has developed a new advanced radar system which embodies many significant state-of-the-art advances. One of the most significant is a unique and highly advanced Traveling Wave Tube developed in the Hughes Laboratories. This tube's two outstanding advantages: 1) higher power to provide greater range; 2) broader frequency band width for operational flexibility.

In addition, this new Hughes radar system will discriminate against ground return and will detect targets at extreme ranges. Designed to operate in a "hard" counter-measures environment, the system is radar augmented by infrared detection and tracking.



Heart of the new Hughes radar system is this Traveling Wave Tube which provides greater power and a broader band width.

One of the vital "innards" of the new Hughes system is this miniaturized (1.3 cu. ft.) Hughes memory drum which can store over 1 million bits of information.



This radar system is the latest of a series of pace-setting Hughes systems. The Hughes E-1 was the first all-weather interceptor radar system ever developed. The Hughes E-4 system first made possible the rocket lead-collision attack. The Hughes E-9 and MG series systems were first to automatically stage and fire advanced air-to-air guided missiles. And the Hughes MA-1 system first provided complete control of aircraft from take-off to touch down.

Although over 16,000 all-weather interceptor systems have been produced to date, Hughes' radar experience is not limited to interceptor systems. For the Army and Navy, Hughes is producing surface-based 3-dimensional radar systems which utilize electronic, rather than mechanical scanning methods. And the Hughes TARAN system utilizes a high-resolution radar which makes it possible for pilots to fly tactical missions at low altitudes, in any kind of weather!

Foreseeing the needs of the future—and being the first to provide for them—is a deeply ingrained tradition at Hughes. Perhaps we can help you solve some of your radar system problems. Please write: Hughes Advanced Program Development, Marketing Department, Hughes Airborne Systems, Culver City, California.

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GALLERY OF AMERICAN MILITARY

MISSILES AND SPACE WEAPONS

Air Force

ATLAS SM-65

Type—SAC intercontinental ballistic missile (ICBM); prime contractor—Convair; maximum speed—Mach 20; ceiling—600 to 900 mi. at peak trajectory; range—over 6,000 nautical mi.; length—82 ft. 6 in.; diameter—10 ft. for tank section, 16 ft. at base; weight—over 260,000 lb.; power system—liquid rocket engines, two boosters each 150,000-lb. thrust, one sustainer 60,000-lb. thrust, and two vernier engines; guidance—radio-inertial or all-inertial; warhead—nuclear; status—operational at Vandenberg AFB; 13 squadrons to be at 11 bases (*see map, page 135*), each squadron equipped with 10 missiles; bases to be hardened; other contractors—airframe, Convair; powerplant, North American Rocketdyne; guidance, (radio-inertial) General Electric and Burroughs, (all-inertial) Arma; systems engineering, Space Technology Laboratories; nose cone, General Electric.

TITAN SM-68

Type—SAC two-stage ICBM; prime contractor—Martin Co.; maximum speed—Mach 15 to 20; range—over 6,000 nautical mi.; length—about 92 ft., first stage 52 ft.; diameter—first stage, 10 ft., second stage, 8 ft.; weight—222,000 lb.; power system—liquid rockets in both stages; first stage, 300,000-lb. thrust, second stage, 80,000-lb. thrust; guidance—radio-inertial or all-inertial; warhead—nuclear; status—testing, expected to be operational in 1961, will be launched from underground silos or hardened sites, 5 sites announced (*see map, page 135*), plans call for 14 squadrons, each with 10 missiles; other contractors—airframe, Martin; powerplant, Aerojet-General; nose cone, Avco; guidance, Bell Telephone Laboratories, Arma, Sperry Rand; systems engineering, Space Technology Laboratories.



ATLAS

THOR SM-75

Type—SAC intermediate-range ballistic missile (IRBM); prime contractor—Douglas Aircraft Co.; maximum speed—Mach 10 to 15; ceiling—several hundred mi.; range—1,500 nautical mi.; length—65 ft.; diameter—8 ft.; weight—110,000 lb.; power system—single-stage liquid rocket engine, 150,000-lb. thrust, and two verniers; guidance—all-inertial; warhead—nuclear; status—operational, deployed to United Kingdom, will also go to Turkey; other contractors—airframe, Douglas; powerplant, North American Rocketdyne; guidance, AC Spark Plug; nose cone, General Electric; systems engineering, Space Technology Laboratories.

JUPITER SM-78

See listing in Army section, below.

SNARK SM-62

Type—SAC air-breathing intercontinental cruise missile; prime contractor—Norair Division of Northrop Corp.; cruise speed—600 mph; ceiling—above 60,000 ft.; range—at 60,000 ft., 6,300 nautical mi.; at sea level, 2,000 mi.; length—67 ft. 11 in.; span—42 ft.; diameter—about 5 ft.; weight—59,936 lb. with 2 boosters; power system—J57-P-17 turbojet for cruise; two solid-propellant booster rockets; guidance—self-contained, stellar-monitored inertial guidance; warhead—nuclear; status—operational, deployed at Presque Isle AFB, Me.; other contractors—airframe, Northrop; powerplant, Pratt & Whitney, Allegany Ballistics Laboratory; guidance, Northrop.

MINUTEMAN XSM-80

Type—SAC solid-propellant ICBM; prime contractor—Boeing Airplane Co.; maximum speed—Mach 20; design range—6,500

nautical mi.; length—55 ft.; diameter—7 ft.; weight—80,000 lb., smaller, lighter than Atlas and Titan; power system—three-stage solid-propellant rocket engines; guidance—all-inertial; warhead—nuclear; status—in development, currently undergoing tethered tests, expected to be operational in 1962 or 1963; Minuteman, with comparatively small size and ease of handling, will lend itself to mobile dispersal and hardened underground sites; other contractors—guidance, North American Autonetics; first-stage propulsion, Thiokol; second- and third-stage propulsion, Aerojet-General; propellant, Hercules Powder Co.; nose cone, Avco; missile transporters, Beech; assembly and test, Boeing; systems engineering, Space Technology Laboratories.

SKY BOLT GAM-87A

Type—SAC air-launched ballistic missile (ALBM); prime contractor—Douglas Aircraft Co.; speed—hypersonic; range—about 1,000 mi. after launching from bombers, at present probably B-52s or B-58s; power system—two-stage, solid-propellant; warhead—nuclear; status—developmental; other contractors—airframe, Douglas; propulsion, Aerojet-General; nose cone, General Electric; guidance, Nortronics Division of Northrop, General Electric, Boeing.

(Prior to USAF announcement of Sky Bolt program, Lockheed, Convair, Martin, and McDonnell also were proceeding with ALBM design programs. The Lockheed-Martin program was known as Bold Orion. The McDonnell program was called Alpha Draco.)

HOUND DOG GAM-77

Type—SAC air-breathing air-to-ground guided stand-off missile; prime contractor—North American Aviation; speed—Mach 1.6 to 2.2; range—over 500 mi.; altitude capability—over 50,000 ft.; length—42 ft. 6 in.; diameter—28 in.; power system—J52 turbojet; guidance—inertial; warhead—nuclear; status—operational, launched from B-52G and H aircraft; other contractors—airframe, North American; powerplant, Pratt & Whitney; guidance, North American Autonetics.

MATADOR TM-61

Type—TAC air-breathing surface-to-surface guided missile; prime contractor—Martin Co.; speed—about 650 mph; ceiling—over 35,000 ft.; range—latest version, over 500 mi.; length—39 ft. 6 in.; span—28 ft. 7 in.; diameter—4 ft. 6 in.; weight—about 10,000 lb.; power system—J33-A-37 turbojet, with Aerojet-General solid-propellant booster for launching; guidance—radar-command; warhead—nuclear or conventional; status—operational, deployed throughout the world and being turned over to West German forces; other contractors—airframe, Martin; powerplant, Allison, Aerojet-General; guidance, Martin.

MACE TM-76 (A and B)

Type—TAC air-breathing surface-to-surface guided missile (improved version of Matador); prime contractor—Martin Co.; speed—650-plus mph; operating altitude—1,000 to 40,000 ft.; range—A model over 650 mi., B model 1,000 mi.; length—44 ft.; span—22 ft. 11 in.; diameter—4 ft. 6 in.; weight—about 14,000 lb.; power system—J33-A-41 turbojet with Thiokol solid-propellant booster for launching; guidance—ATRAN map-matching in A model, inertial in B; warhead—conventional or nuclear; status—A model operational, replacing Matador, being deployed to West Germany; B is developmental; other contractors—airframe, Martin; powerplant, Allison, Thiokol; guidance, Goodyear, AC Spark Plug; transport vehicles, Goodyear, Ford Motor.

BULLPUP GAM-83A

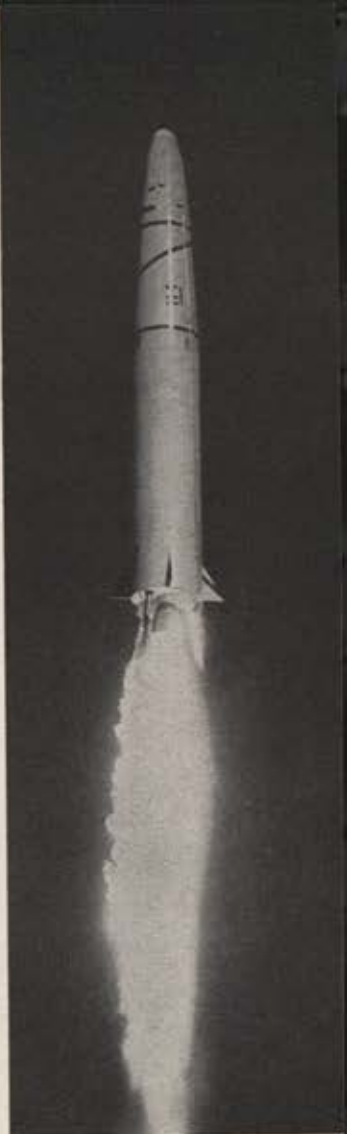
See listing in Navy section, below.

BOMARC IM-99 (A and Super Bomarc, B)

Type—ADC ramjet surface-to-air interceptor missile; prime contractor—Boeing Airplane Co.; speed—A, Mach 2.8; B, up to Mach 4; ceiling—A, 68,000 ft., B, up to 100,000 ft.; range—A, 200 mi., B, over 400 mi.; length—47 ft. 4 in.; span—18 ft. 2 in.; diameter—35 in.; weight—about 15,000 lb.; power system—A, launched by Aerojet-General liquid rocket with two Marquardt RJ43-MA-3 ramjets for cruise; B, launched by Thiokol solid rocket with two advanced Marquardt RJ43-MA-9 ramjets for cruise; guidance—radar-command, linked to SAGE air-defense system during midcourse; homing system in missile



TITAN



THOR



SNARK

as terminal guidance system; warhead—nuclear or conventional; status—A, first squadron operational at McGuire AFB, N. J., 18 other sites programmed; B, developmental; other contractors—airframe, Boeing; powerplant, Marquardt, Aerojet-General, Thiokol; guidance, Westinghouse.

FALCON GAR-1, -1D, -2, -2A

Type—ADC, TAC air-to-air guided missile; prime contractor—Hughes Aircraft Co.; speed—above Mach 2; range—five mi.; length—6 ft. 6 in.; span—1 ft. 8 in.; diameter—6.5 in.; weight—GAR-1D, 110 lb., GAR-2A, 122 lb.; power system—solid-propellant; guidance—GAR-1 and -1D, radar-homing, GAR-2 and -2A, infrared-homing; fired from aircraft electronically in each instance; warhead—conventional; status—operational, carried

(Continued on following page)



MINUTEMAN



HOUND DOG



MATADOR



MACE

MISSILES & SPACE WEAPONS

by F-89, F-101, F-102, F-106, and other aircraft; other contractors—airframe, Hughes; powerplant, Thiokol; guidance, Hughes.

SUPER FALCON GAR-3, -4, -9, -11

ADC, TAC GAR-3 Super Falcon was developed from the earlier Hughes Falcon air-to-air missile; has new Thiokol solid-propellant motor, modified nose cone, greater length; guidance—radar-homing; status—currently operational; in research and development, based on Super Falcon, are GAR-4 with infrared-homing, GAR-9 with nuclear warhead, and GAR-11.

GENIE MB-1 (Known variously during development as Ding-Dong, Bird Dog, and High Card)

Type—ADC air-to-air unguided interceptor rocket; prime contractor—Douglas Aircraft Co.; speed—supersonic; range—1.5 mi.; length—8 ft.; diameter—1 ft. 3 in.; power system—solid-propellant; guidance—none; warhead—nuclear, about 1.5 kilotons; status—operational, carried by F-89J, F-101, F-102, F-106; training version in production under name Ting-a-Ling; under development is a more advanced model with built-in guidance, greater thrust and range; other contractors—airframe, Douglas; powerplant, Aerojet-General; fire control, Hughes.

SIDEWINDER GAR-8

See listing in Navy section, below.

QUAIL GAM-72

Type—SAC air-launched diversionary bomber-defense missile; prime contractor—McDonnell Aircraft Co.; speed—subsonic; range—200 mi.; length—12 ft. 10 in.; tail span—5 ft. 4 in.; diameter—2 ft. 1 in.; power system—J85 turbojet; weight—1,100 lb.; warhead—none; status—has been successfully flight tested from B-47s and B-52s; other contractors—airframe, McDonnell; propulsion, General Electric; guidance, McDonnell, Summers Gyroscope; countermeasures gear, Thompson Ramo Wooldridge Inc.

Longbow WS-121-B

Type—air-launched missile, believed designed for antiradar mission; prime contractor—Radioplane Division of Northrop Corp.; speed—supersonic; guidance—designed to home on enemy sites as defense measure for incoming US bombers; status—in development; no details known. Longbow has supplanted Crossbow, GAM-67, as a developmental antiradar missile. These details were known on Crossbow, a less advanced vehicle in the testing stage of its development by Northrop's Radioplane Division at the time it was terminated: speed—subsonic; range—about 200 mi.; weight—2,000 lb.; power system—turbojet; guidance—radar-homing; other contractors—test instrumentation, Bendix-Pacific.

WAGTAIL

Type—air-to-surface tactical-support missile; prime contractor—Minneapolis-Honeywell Regulator Co.; power system—solid-propellant; guidance—understood highly sophisticated gyro-reference able to elude obstacles en route to target; no details known; status—developmental, reported to be aimed at low-altitude launch and low velocity; other contractors—airframe and guidance, Minneapolis-Honeywell; propulsion, Thiokol.

SLAM (Supersonic Low-Altitude Missile)

Type—nuclear-powered, low-altitude intercontinental missile; prime contractor—Chance Vought Aircraft Co.; speed—supersonic; range—over 6,000 mi.; power system—nuclear ramjet being developed under study program designated Pluto by AEC's Lawrence Radiation Laboratory, North American's Atomic International Division, and Marquardt; guidance—command or inertial; warhead—nuclear; status—in development; design studies under way by North American and Convair (in the study phase at the same time is a closely related project, Clam, a chemical ramjet missile with roughly the same design concept).

Additional USAF missiles canceled in the recent past:

Goose (SM-73), a diversionary missile under development

by Fairchild Engine & Airplane Corp.; was to be ground launched and powered by turbojet; cancellation announced December 12, 1958.

Rascal (GAM-63), supersonic, air-to-ground, rocket-powered guided missile developed and manufactured by Bell Aircraft Co. Had nuclear capability, range of 75 mi.; overtaken by rapid technological developments in air-launched missile field; canceled September 9, 1958.

Navaho (SM-64), long-range surface-to-surface missile developed by North American Aviation; air-breathing, rocket-launched, comparatively large payload; cancellation came in June 1957, but information gained during the decade of development of the Navaho has been used in later missiles.

Army

JUPITER SM-78

Type—SAC IRBM; prime contractor—Chrysler Corp., designed by Army Ballistic Missile Agency; now under operational control of US Air Force; maximum speed—Mach 15; range—over 1,500 nautical mi.; maximum height of trajectory—300 mi.; length—60 ft. 4 in.; diameter—9 ft.; weight—110,000 lb.; power system—liquid-propellant, single-stage, 150,000-lb. thrust; guidance—all-inertial; warhead—nuclear; status—operational, to be deployed in Italy and Turkey, 15 missiles per squadron; other contractors—airframe, Chrysler; powerplant, North American Rocketdyne; nose cone, Goodyear; guidance, Ford Instrument.

PERSHING

Type—two-stage surface-to-surface ballistic missile; prime contractor—Martin Co.; speed—6,800 mph; range—up to 700 mi.; length—about 50 ft.; diameter—over 2 ft.; power system—solid propellant; guidance—inertial, with built-in "selectivity" feature; warhead—nuclear; status—in development, tactical testing expected in late 1960; other contractors—airframe, Martin; powerplant, Thiokol; guidance, Bendix; warhead fuzing and arming, Bulova.

REDSTONE SSM-A-14

Type—surface-to-surface, basically improved V-2 missile; prime contractor—Chrysler Corp., designed by Army Ballistic Missile Agency; maximum speed—Mach 5; range—200 mi.; length—69 ft. 4 in.; diameter—70 in.; span of fins—12 ft. 9 in.; weight—61,000 lb.; power system—liquid-propellant, 78,000-lb. thrust; guidance—self-contained all-inertial; warhead—nuclear or conventional; status—operational, deployed in Europe; other contractors—airframe, Chrysler; powerplant, North American Rocketdyne; guidance, Ford Instrument.

CORPORAL SSM-A-17

Type—surface-to-surface, short-range guided bombardment weapon; prime contractor—Firestone Tire and Rubber Co., Gilfillan Bros.; maximum speed—Mach 3; range—75 to 100 mi.; length—46 ft.; diameter—30 in.; weight—12,000 lb.; power system—liquid-propellant; guidance—preset and radio command; warhead—nuclear or conventional; status—operational, deployed abroad with US Army, also used by British Army; other contractors—airframe, Firestone; powerplant, Ryan; guidance, Gilfillan; warhead arming and fuzing, General Electric.

SERGEANT SSM-A-27

Type—medium-range, surface-to-surface ballistic missile; prime contractor—Sperry Utah Engineering Lab and Jet Propulsion Laboratory; speed—2,300 mph; range—over 100 miles; length—34 ft.; diameter—31 in.; span—7 ft. 8 in.; weight—11,000 lb.; power system—solid-propellant, 50,000-lb. thrust; guidance—inertial; warhead—nuclear or conventional; status—in production, replacement for earlier Corporal missile, going to West German forces; other contractors—airframe, Sperry; powerplant, Thiokol; guidance, Sperry, Minneapolis-Honeywell.

LITTLE JOHN XM-51

Type—surface-to-surface tactical rocket; prime contractor—
(Continued on page 117)



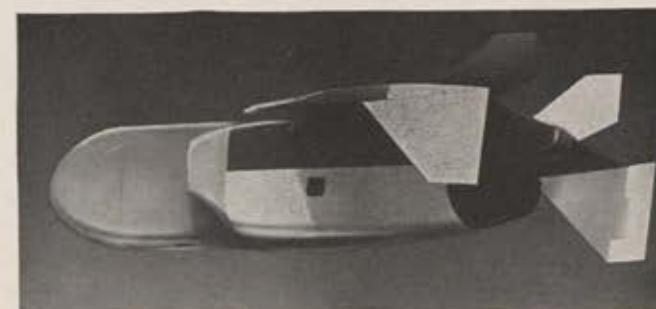
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MISSILES & SPACE WEAPONS—CONTINUED



GOOSE

Emerson Electric Co.; speed—supersonic; range—10 mi.; length—14 ft. 6 in.; diameter—12.5 in.; weight—980 lb.; power system—solid-propellant; guidance—none; warhead—nuclear or conventional; status—operational, in training units; other contractors—airframe, Emerson Electric; powerplant, Allegany Ballistics; warhead arming and fuzing, General Electric; Consolidated Western Steel, Minneapolis-Honeywell.

HONEST JOHN M-31A1C XM-50 (Advanced)

Type—surface-to-surface, unguided field artillery rocket for 1,500-lb. warhead; prime contractor—Douglas Aircraft Co., Emerson Electric Co.; speed—Mach 1.5; range—15.8 mi.; length—27 ft. 3 in.; diameter—30 in.; weight—5,800 lb.; power system—solid-propellant; guidance—none; warhead—nuclear or conventional; status—initial version operational, deployed in Europe and Japan, supplied to NATO forces; advanced version in production; other contractors—airframe, Emerson Electric and Douglas; powerplant, Allegany Ballistics.

LACROSSE SSM-A-12

Type—surface-to-surface, close-support missile; prime contractor—Martin Co.; speed—transonic; range—20 mi.; length—19 ft. 2.5 in.; span—9 ft.; diameter—20.5 in.; weight—3,500 lb.; power system—solid-propellant; guidance—radar-command; warhead—nuclear or conventional; status—operational; other contractors—development, Cornell Aeronautical Laboratories; airframe, Martin; powerplant, Stewart Warner, Thiokol; guidance, Federal Telecommunications Laboratories, Martin; warhead, Minneapolis-Honeywell; fuzing, General Electric.

MISSILE A

Type—surface-to-surface; prime contractor—Army Rocket and Guided Missile Agency; range—65 to 70 mi.; power system—solid-propellant; warhead—expected to have nuclear capability; status—in development.

NIKE-AJAX SAM-A-7

Type—surface-to-air guided weapon; prime contractor—Western Electric Co.; maximum speed—Mach 2.3; range—25 mi.; ceiling—60,000 ft.; length—34 ft. 10 in.; without booster 21 ft.; span—52 in.; diameter—12 in.; weight—2,300 lb.; power system—liquid-sustainer, solid-propellant booster; guidance—radar-command; warhead—conventional; status—operational, was first US surface-to-air missile deployed in US and overseas; other contractors—airframe, Douglas; powerplant, Bell, Hercules, Goodyear; guidance, Bell; warhead fuzing, Elgin.

NIKE-HERCULES SAM-A-25 (Formerly known as NIKE-B)

Type—surface-to-air guided weapon; prime contractor—Western Electric Co.; maximum speed—Mach 3.3; range—75 to 100 mi.; ceiling—over 100,000 ft.; length—with booster, 41 ft., without, 27 ft.; span—74 in.; diameter—31.5 in.; weight—missile and booster, 10,000 lb.; power system—solid-propellant sustainer and booster; guidance—radar-command; warhead—nuclear or conventional; status—operational, superseding Nike-Ajax in production, deployed overseas; other contractors—airframe, Douglas; powerplant, Thiokol, Hercules; guidance, Bell; warhead, General Electric and W. C. Maxson.

NIKE-ZEUS

Type—automated antimissile missile system; prime contractor
(Continued on following page)



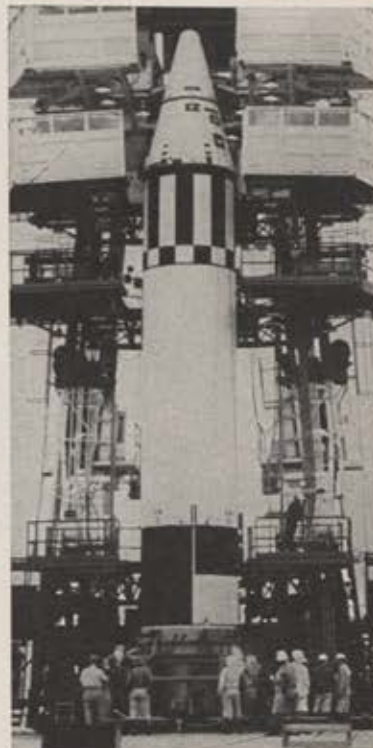
RASCAL



NAVAHO



PERSHING



JUPITER



REDSTONE



CORPORAL

MISSILES & SPACE WEAPONS—CONTINUED



SERGEANT



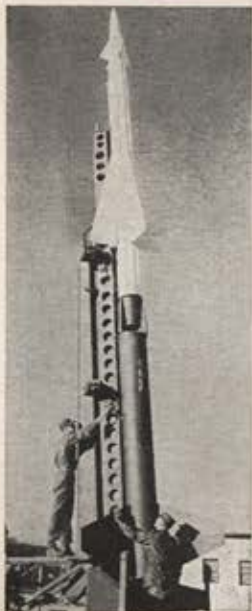
LITTLE JOHN



HONEST JOHN



LACROSSE



NIKE-AJAX



NIKE-HERCULES

—Western Electric Co.; maximum speed—about Mach 7; range—about 200 mi.; power system—solid-propellant booster and sustainer; guidance—radar-command (also reported to include electro-acoustical detection system); warhead—nuclear; status—in development; other contractors—airframe, Douglas; research and development, Bell; propulsion, Thiokol, Grand Central; guidance, Bell, Sanders Associates.

HAWK SAM-A-18

Type—surface-to-air, for use against low-flying airplanes; prime contractor—Raytheon Co.; speed—Mach 2.8; range—22 mi.; ceiling—less than 100 ft. to over 38,000 ft.; length—16 ft. 4 in.; span—4 ft.; diameter—14 in.; weight—1,275 lb.; power system—two stage solid-propellant; guidance—radar-homing; warhead—conventional; status—operational, slated for overseas deployment by Army, Marine Corps, to be supplied to allies; other contractors—airframe, Northrop, Raytheon; powerplant, Aerojet-General, Thiokol; guidance, Raytheon.

LOBBER

Type—solid-propellant ballistic missile able to deliver supplies, equipment, food, and ammunition to front-line troops, can also be adapted to carry napalm, nuclear or conventional warheads; prime contractor—Convair; cruise speed—1,500 mph; range—15 to 20 mi.; length—9 ft.; power system—solid-propellant; payload—over 50 lb.; recovery—assisted by use of parachute, shock-absorbing nose cone to prevent damage to cargo (about 70 percent of most missiles can be recovered and used again); status—in development, more advanced models also being studied.

SS-10, SS-11

Type—antitank guided missiles for firing from ground launcher, vehicle, helicopter, or airplane; prime contractor—Nord Aviation, Paris, France; range—1,600 to 3,800 yd.; weight—SS-10, 33 lb., SS-11, 63 lb.; power system—solid-propellant; guidance—wire guided; warhead—conventional; status—SS-10, operational with NATO, US troops; SS-11, operational, undergoing US Army evaluation.

SHILLELAGH

Type—lightweight surface-to-surface close-support missile, for vehicle-mounted use against armor, troops, fortifications; prime contractor—Ford Aeronutronics Co.; weight—about 40 lb.; caliber—90 mm.; guidance—fired from guide tube, guided to target by microwave beam; status—in development; other contractors—electronic system, Raytheon.

REDEYE

Type—surface-to-air shoulder-fired bazooka-type rocket weapon for use by combat troops against low-flying aircraft; prime contractor—Convair; altitude and range—commensurate with Army and Marine Corps field requirements; length—4 ft. 3 in.; diameter—4 in.; weight—20 lb.; power system—solid-propellant; guidance—electronic, reported to be of infrared-homing type; warhead—conventional; status—in development; other contractors—guidance, Philco, Convair. Also in development by Convair is the lightweight Mauler infrared-guided surface-to-air missile for front-line use; no details available.

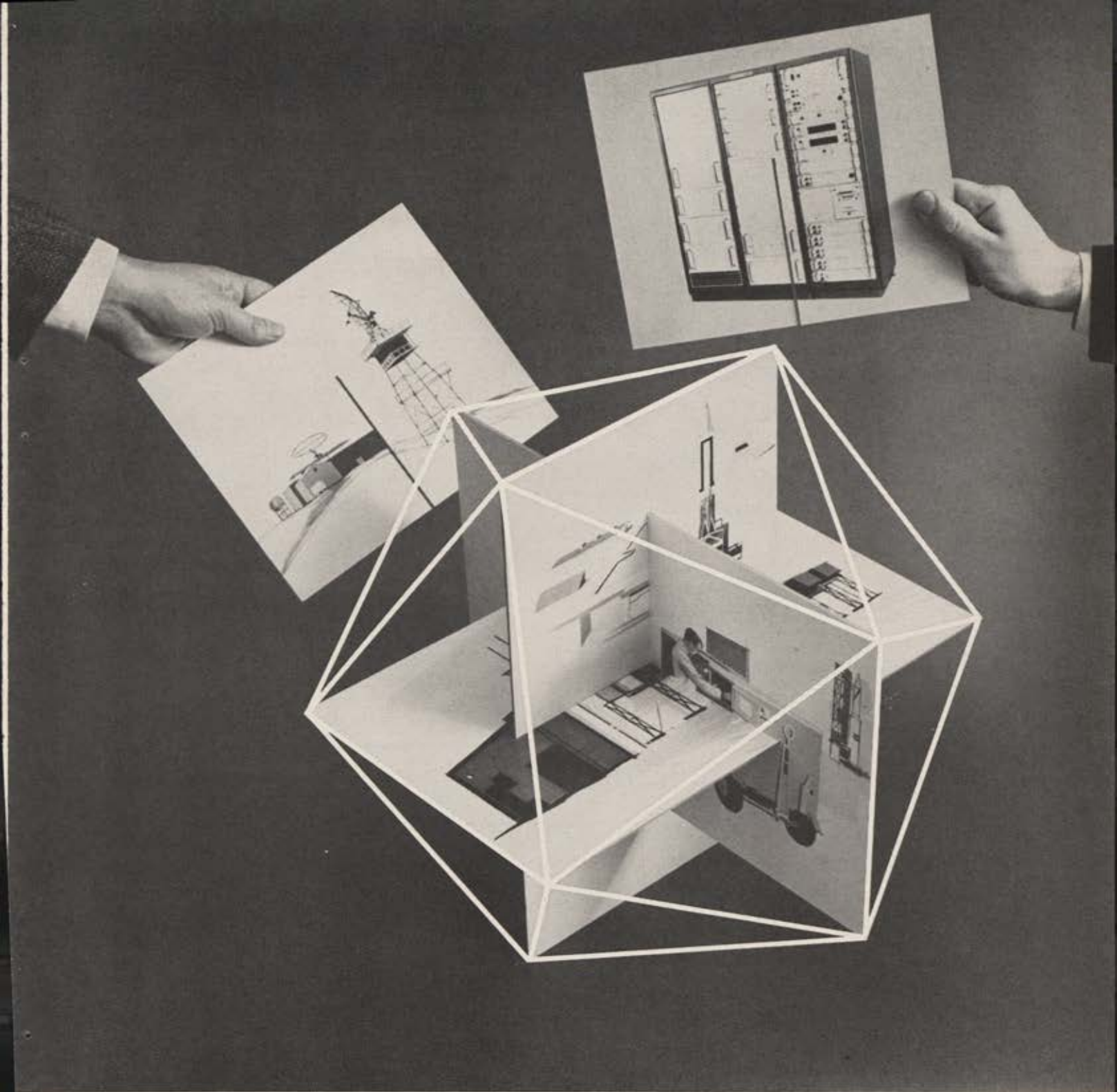
DAVY CROCKETT

Type—light surface-to-surface infantry weapon under development for Army, expected to be of the bazooka launching-tube type, to be fired in field by one or two men; range—5,500 to 8,800 yd.; prime contractor—Martin Co.; power system—solid-propellant; warhead—probably nuclear, in sub-kiloton range; status—development.

Additional Army missiles canceled in the recent past include: Plato, a research and development program for an antimissile missile that was phased out in 1958. Prime contractor was Sylvania Electric Products Co.

Dart, antitank missile terminated in September 1958, when weapons judged superior for the purpose appeared; prime contractor was Utica-Bend Corp., Utica, Mich.

(Continued on page 123)



The Matrix of Site Instrumentation

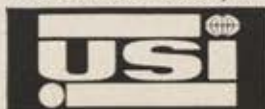


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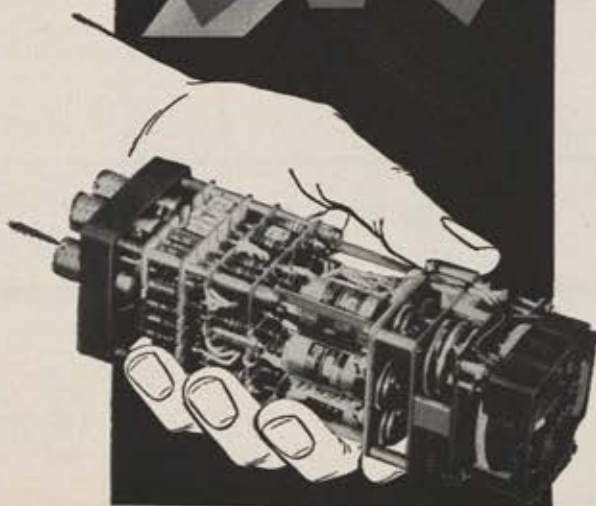
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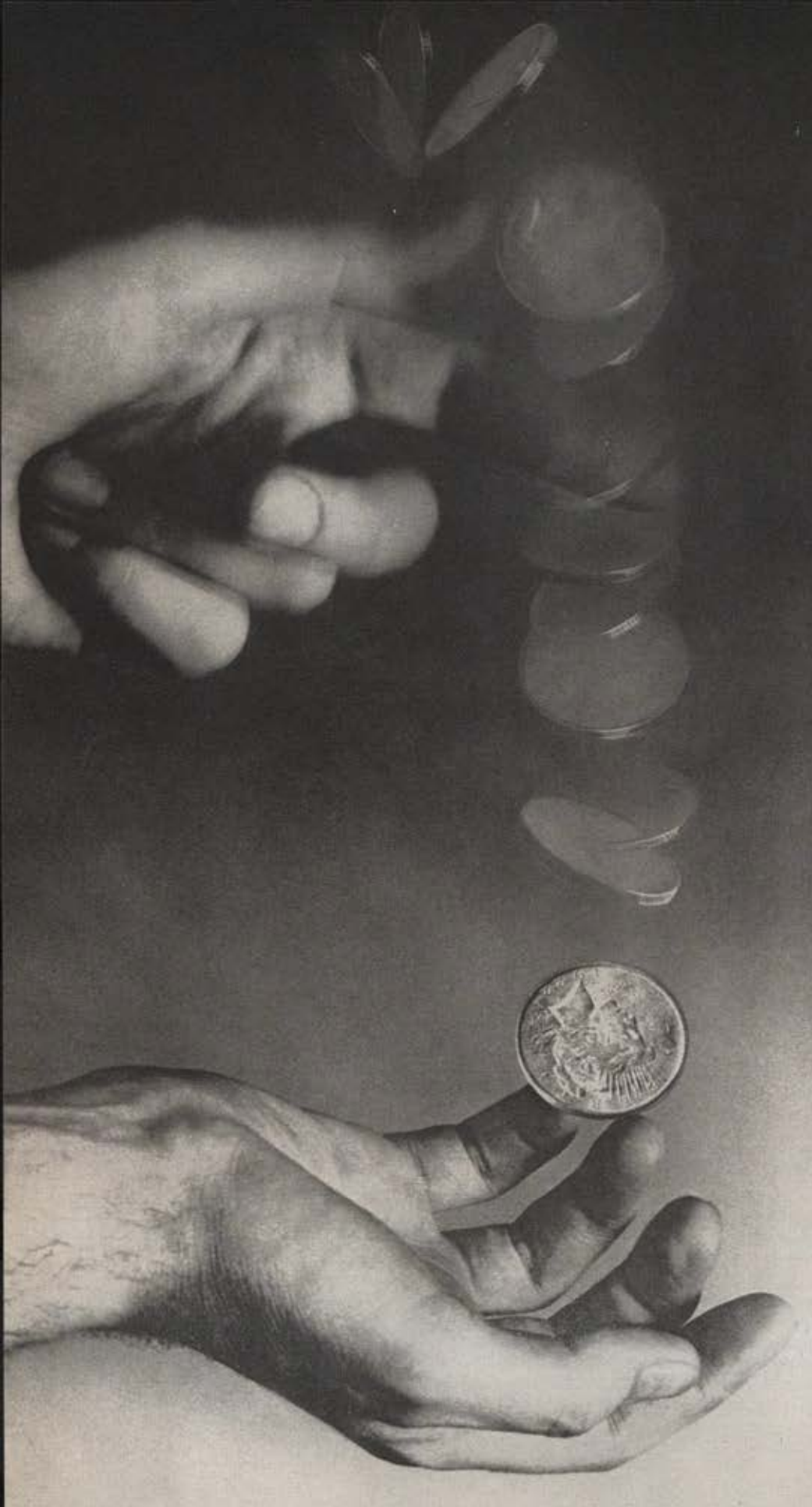
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NIKE-ZEUS



HAWK

Navy

POLARIS FBMS

Type—underwater-to-surface or surface-to-surface Fleet Ballistic Missile System (FBMS); prime contractor—Lockheed Aircraft Corp.; maximum speed—Mach 10; range—1,200 mi.; length—28 ft.; diameter—4 ft. 6 in.; weight—28,000 lb.; power system—two-stage, solid-propellant rocket, thrust about 100,000 lb.; guidance—inertial; warhead—nuclear; status—in development, for use aboard US Navy nuclear-powered submarines and possibly surface vessels and with land-based launchers; other contractors—nose cone and airframe, Lockheed; powerplant, Aerojet-General; guidance, General Electric.

SIDEWINDER Navy: AAM-N-7. Air Force: GAR-8 (ADC, TAC)

Type—air-to-air guided weapon; prime contractor—Philco Corp., General Electric Co.; maximum speed—Mach 2.5; range—at sea level, 3,500 ft.; at 50,000 ft., 11,000 ft.; ceiling—over 50,000 ft.; length—9 ft. 5 in.; diameter—5 in.; finspan—1 ft. 7 in.; weight—155 lb.; power system—solid-propellant rocket; guidance—infrared heat-seeking device; warhead—conventional; status—operational, supplied to several allied air forces, advanced 1C model, formerly called Diamondback or Sarah, under development; other contractors—guidance, Philco, General Electric; propulsion, Naval Powder Plant, Allegany Ballistics; warhead Eastman Kodak, Minneapolis-Honeywell, Baldwin Piano.

SPARROW III AAM-N-6

Type—air-to-air guided missile; prime contractor—Raytheon Co.; speed—Mach 2.5 to 3; range—8 mi.; ceiling—over 50,000 ft.; length—about 12 ft.; diameter—9 in.; span—3 ft. 3 in.; weight—380 lb.; power system—solid-propellant rocket or prepackaged liquid; guidance—semiautomatic radar-homing; warhead—conventional; status—operational, superseding now-obsolete Sparrow I; Sparrow II was experimental, not intended for operation; other contractors—airframe, Raytheon; powerplant, Aerojet-General; guidance, Raytheon.

ZUNI

Type—air-to-surface or air-to-air rocket; developed by Naval Ordnance Test Station, produced by Bridgeport Brass Co.; speed—Mach 3; length—9 ft.; diameter—5 in.; weight—107 lb.; power system—solid-propellant; guidance—none; warhead—conventional explosive rocket, can be armed with flares, fragmentation, armor piercing, etc.; status—operational.

HVAR (High-Velocity Aircraft Rocket, nickname Holy Moses)

Type—air-to-air rocket; speed—1,023 mph; length—6 ft.; diameter—5 in.; weight—about 140 lb.; power system—solid-propellant; guidance—none; warhead—conventional; status—operational.

MIGHTY MOUSE

Type—air-to-air or air-to-surface rocket; diameter—2.75 in.; warhead—conventional; status—in service, no longer in production; contractors—propellant, Aerojet-General; frame, Hunter Douglas Aluminum; warhead, Heintz Mfg.

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LOBBER



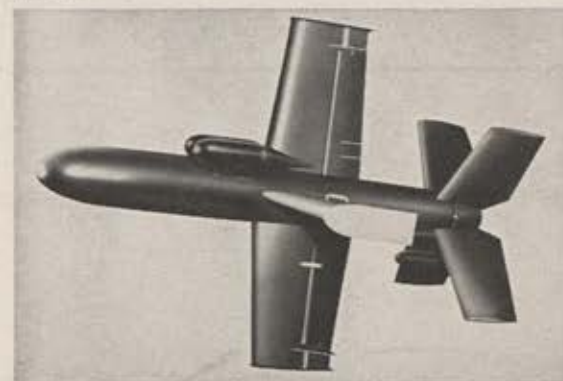
SS-10



SS-11



REDEYE



DART



POLARIS



SIDEWINDER



SPARROW III



ZUNI



TERRIER

MISSILES & SPACE WEAPONS—CONTINUED

EAGLE XAAM-N-10

Type—long-range air-to-air; prime contractor—Bendix Aviation Corp.; range—over 100 mi.; power system—solid-propellant; guidance—active radar-homing; warhead—nuclear; status—in development; represents new departure in that it could be launched from large, slow, patrol-type aircraft; other contractors—airframe, Grumman; propulsion, Aerojet-General; target-seeking equipment, Sanders Associates; tactical computer, Litton; airborne intercept radar, Westinghouse; guidance, Bendix.

TERRIER SAM-N-7

Type—solid-propellant surface-to-air, for firing from cruisers and US Marine mobile launchers ashore; prime contractor—Convair; maximum speed—Mach 2.5; ceiling—over 50,000 ft.; range—about 10 mi.; length—15 ft., 27 ft. with booster; diameter—14 in.; span—4 ft.; power system—solid-fuel rocket; guidance—radar beam-riding; warhead—conventional; status—operational, advanced version with greater range in production; other contractors—airframe, Convair; powerplant, Allegany Ballistics; guidance, Sperry, Convair, Motorola.

TALOS SAM-N-6

Type—shipboard surface-to-air or surface-to-surface; prime contractor—Bendix Aviation Corp.; speed—Mach 2.5; ceiling—extremely high altitudes; range—over 65 mi.; length—31 ft. 3 in.; diameter—30 in.; span—9 ft. 6 in.; weight—about 3,000 lb., 7,000 lb. including booster; power system—solid-fuel rocket motor for first few seconds, then ramjet engine; guidance—radar beam-riding, semiactive homing; warhead—nuclear or conventional; status—operational, advanced version known as Typhon Long Range, formerly Super Talos, in development; other contractors—airframe, McDonnell; powerplant, McDonnell, Allegany Ballistics, Bendix; guidance, Farnsworth Electric; "homing-head" radar, Sperry; development, Applied Physics Laboratory, Johns Hopkins University.

TARTAR

Type—solid-propellant surface-to-air, for use aboard destroyers and cruisers; prime contractor—Convair; speed—supersonic; range—about 10 mi.; length—15 ft.; diameter—over 1 ft.; power system—dual-thrust solid-propellant rocket; guidance—radar beam-riding; warhead—conventional; status—in development, expected to be operational shortly; advanced version known as Typhon Medium Range, formerly Super Tartar, in development; other contractors—airframe, Convair; powerplant, Aerojet-General, Allegany Ballistics; guidance, Raytheon.

BULLPUP Navy: ASM-N-7A Air Force: GAM-83A (Sometimes called White Lance in USAF)

Type—air-to-surface guided weapon; prime contractor—Martin Co.; cruise speed—Mach 1.8; range—over 15,000 ft.; length—11 ft.; diameter—1 ft.; span—3 ft. 1 in.; weight—571 lb.; power system—solid or liquid rocket; guidance—command (radio signals from launch plane pilot); warhead—conventional; status—operational, used by TAC in USAF; advanced version, one known as Bulldog, in development, one being developed for USAF will have nuclear capability; other contractors—airframe, Martin; powerplant, Allegany Ballistics, Aerojet-General, Thiokol; guidance, Martin.

CORVUS XASM-N-8

Type—stand-off air-to-surface missile; prime contractor—Temco Aircraft Corp.; speed—supersonic; range—greater than 100 mi.; power system—prepackaged liquid-propellant; guidance—radar-homing; status—in development; other contractors—airframe, Temco; powerplant, Thiokol; guidance, W. L. Maxson, Texas Instruments.

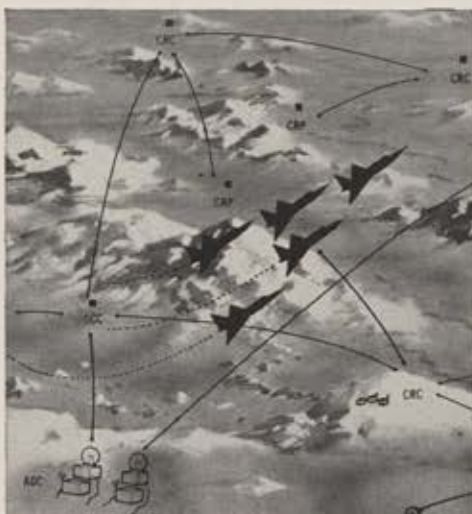
WEAPON ABLE

Type—antisubmarine surface-to-underwater rocket; prime contractor—Avco Corp.; range—variable; length—8 ft. 6 in.; diameter—12.75 in.; weight—500 lb.; power system—solid rocket; guidance—fired from turretlike launcher by advanced fire-control system; warhead—conventional explosive charge; status—operational.

(Continued on page 128)



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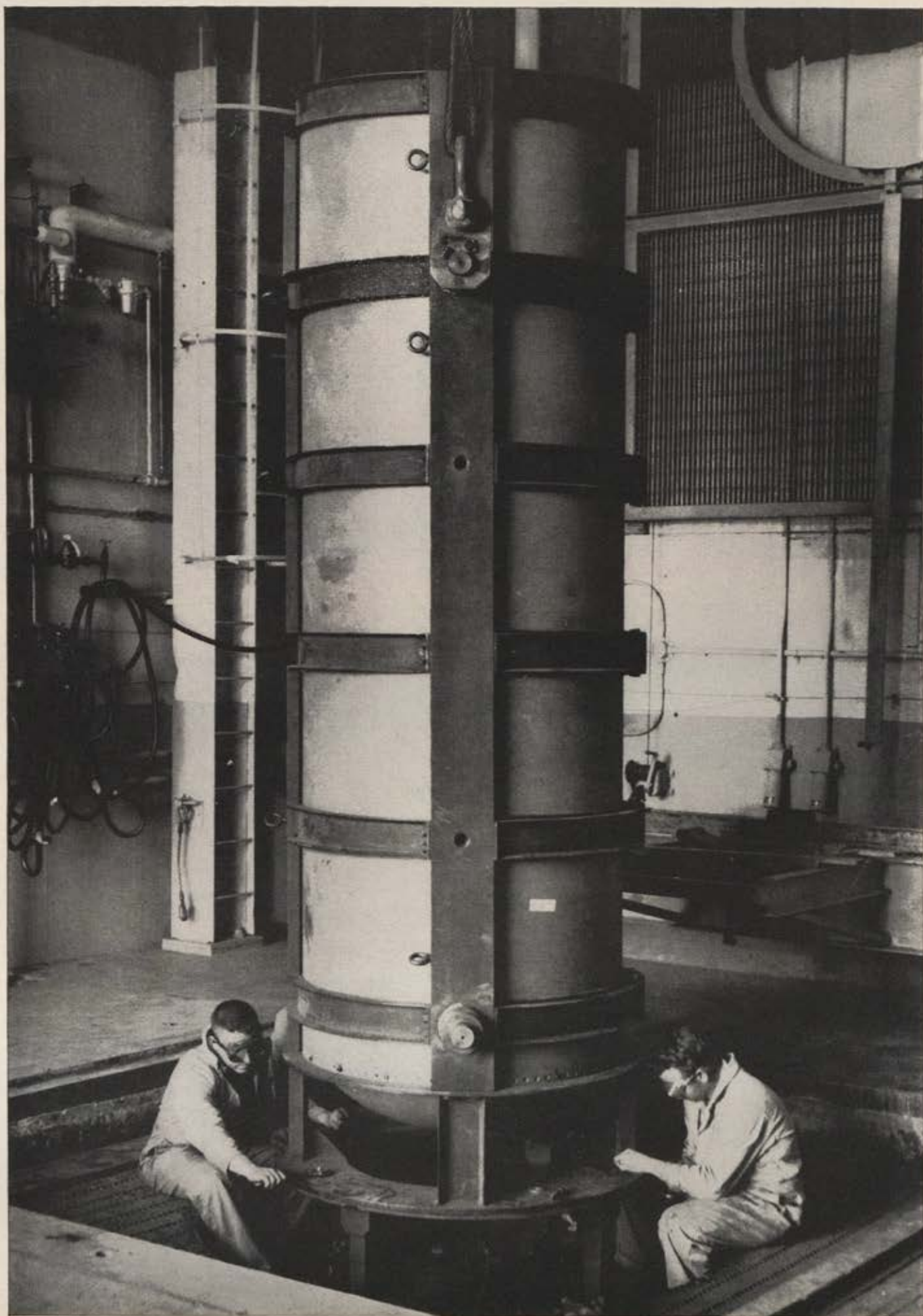
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In the development of powerplants for ballistic missiles like Minute-man, Nike-Zeus, Subroc, and for research vehicles like Little Joe and X-17 . . . THIOKOL draws on its own vast propulsion know-how plus the advanced technological background of scores of industrial organizations.

The Allison Division of General Motors, Radiation, Inc., Goodyear, General Electric, Douglas, Boeing, Curtiss-Wright, RCA, Solar Aircraft . . . these are but a few of the many companies, large and small, to whom THIOKOL has subcontracted in producing dependable propulsion systems.

We have called upon the aircraft industry to whom metals for flight are second nature to obtain rocket casings combining lightness of

weight and high tensile strength.

We have called upon the electronics industry whose art is instrumentation for the delicate devices required for precise testing and production controls.

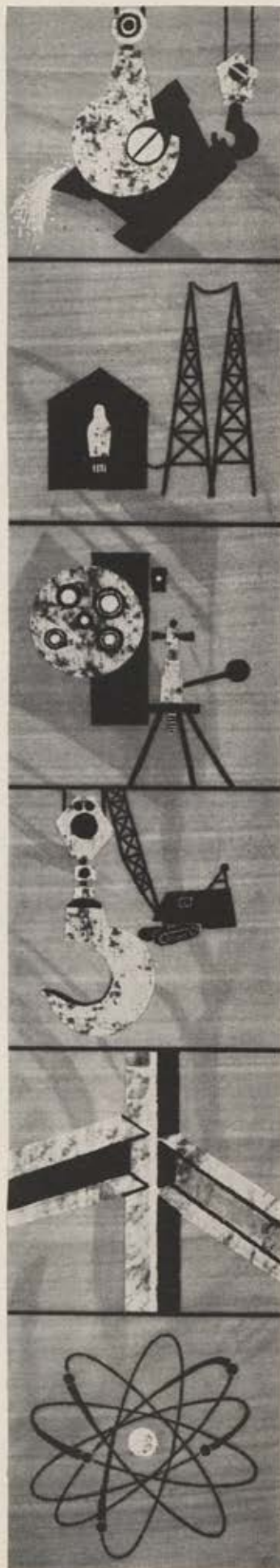
We have turned to the transportation and construction industries for development of specialized equipment such as monorail systems and movable cranes needed to process giant rocket motors with unfailing precision on an assembly line basis.

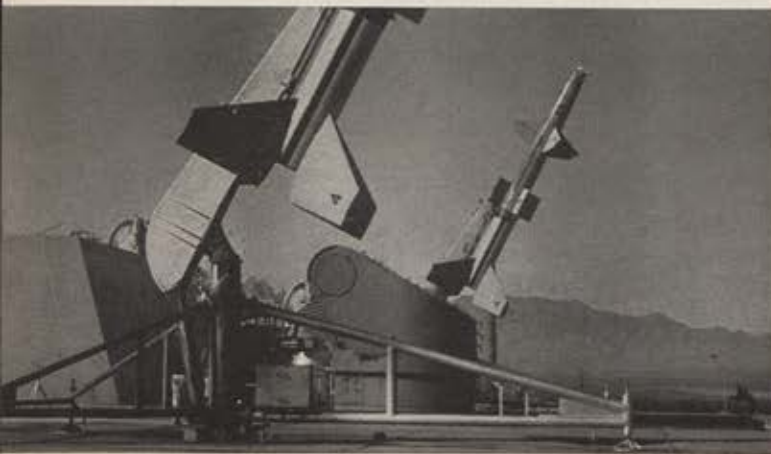
Many industrial technologies are met in a rocket propulsion system. Recognizing this, THIOKOL calls on specialists to achieve highest reliability, to meet the critical rocket power requirements of national defense and space research.

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®Registered trademark of the Thiokol Chemical Corporation for its liquid polymers, rocket propellants, plasticizers, and other chemical products.





TALOS



TARTAR



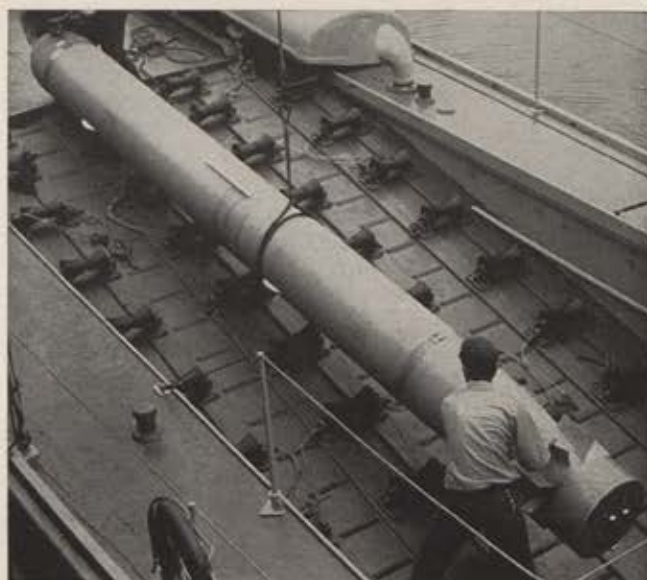
BULLPUP



CORVUS



WEAPON ABLE



ASTOR

SUBROC (Submarine Rocket)

Type—surface or underwater-to-underwater, for firing primarily by submerged submarines against other subs or surface craft; prime contractor—Goodyear Aircraft Corp.; power system—solid-propellant; warhead—nuclear or conventional; status—in development, final system will include equipment to compute target course and speed and fire the weapon; other contractors—propulsion, Thiokol; guidance, Librascope, Kearfott.

ASROC (Antisubmarine Rocket)

Type—rocket-assisted surface-to-underwater antisubmarine rocket; prime contractor—Minneapolis-Honeywell Regulator Co.; power system—solid-propellant; guidance—fired to the target area as an airborne missile, then becomes an acoustic homing torpedo after entering the water; warhead—nuclear; status—in development; cruisers and destroyers will carry ASROC; few details are available.

ASTOR (Antisubmarine Torpedo Ordnance Rocket)

Type—antisubmarine device to be launched from submerged submarines; prime contractor—Westinghouse Electric Corp.; length—20 ft.; underwater speed—20 kt.; power system—electric; range—20,000 yd.; guidance—electrically propelled and wire-guided; warhead—nuclear; status—in developmental testing stage; few details available.

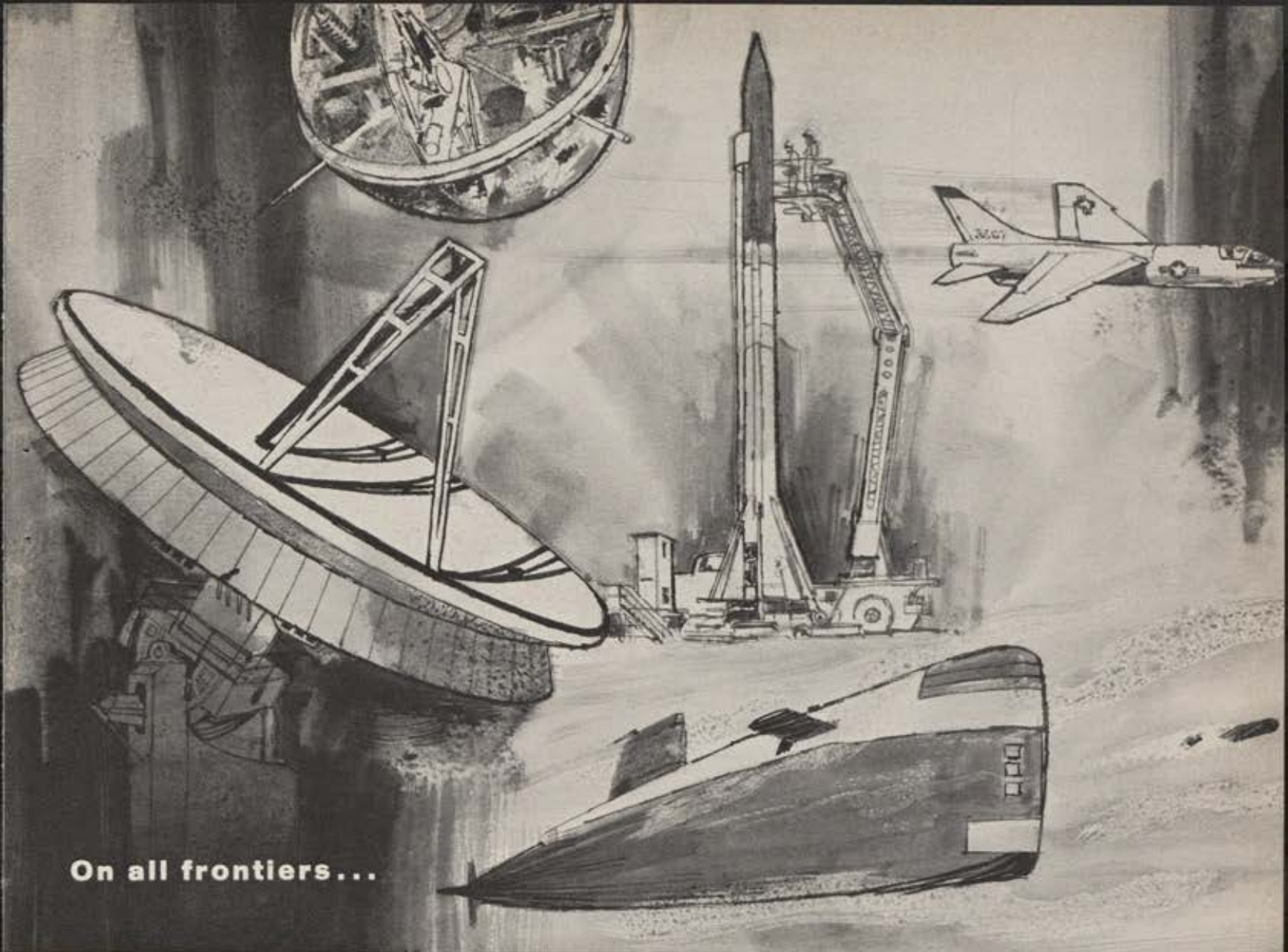
REGULUS I SSM-N-8

Type—air-breathing surface-to-surface "flying bomb" (KDU-1 is drone version); prime contractor—Chance Vought Aircraft; cruise speed—650 mph; terminal dive speed—transonic, Mach 0.9; range—575 mi.; length—33 ft.; span—21 ft.; diameter—4 ft. 6 in.; weight—14,522 lb.; power system—J33-A-18 turbojet with 2 solid-propellant boosters; guidance—command; warhead—nuclear; status—operational, production halted after 514th missile delivered in January 1959; installed on aircraft carriers, cruisers, and submarines; supersonic Regulus II project terminated in December 1958; other contractors—airframe, Chance Vought; powerplant, Allison, Aerojet-General; guidance, Motorola, Vance Industries.

COBRA

Type—US Marine Corps antitank missile; prime contractor—developed by Boelkow Entwicklungen of West Germany; Daystrom of US, distributor; speed—about 200 mph; range—500 to 1,760 yd.; length—30 in.; diameter—4 in.; weight—20 lb. overall, warhead 5.5 lb.; power system—solid-propellant; guidance—wire-transmitted electronic signals; warhead—conventional; status—undergoing tests here, operational with West German forces.

(Continued on page 131)



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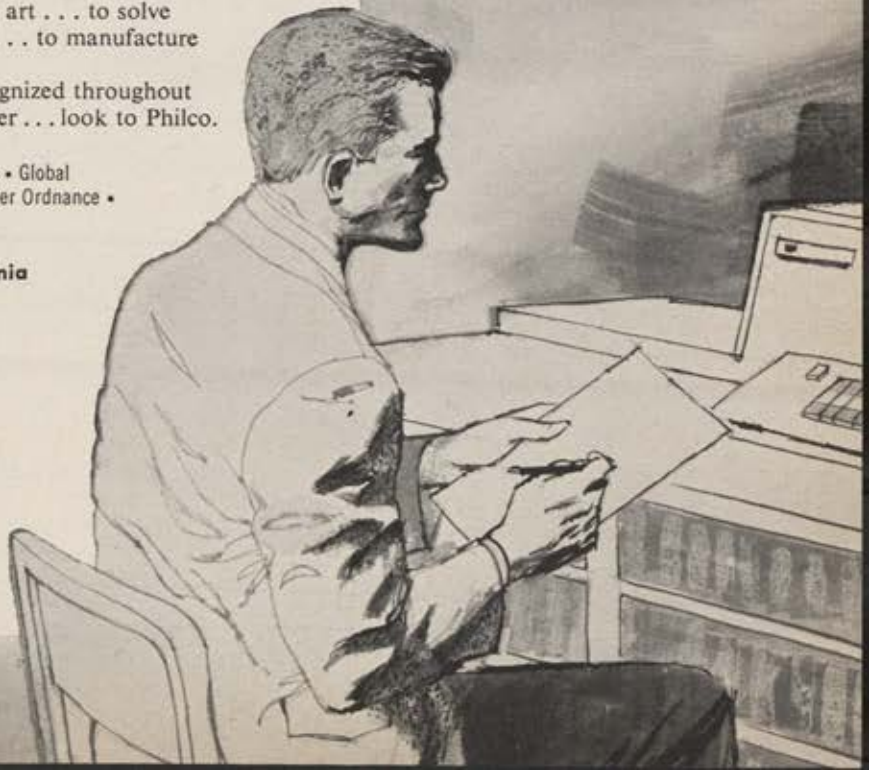
Weapons Systems • Satellites • Space Instrumentation • Guided Missiles • Global Communications • Radar • Data Links • Fire Control Systems • Underwater Ordnance • Air Traffic Control • Data Processing Systems • Closed Circuit TV

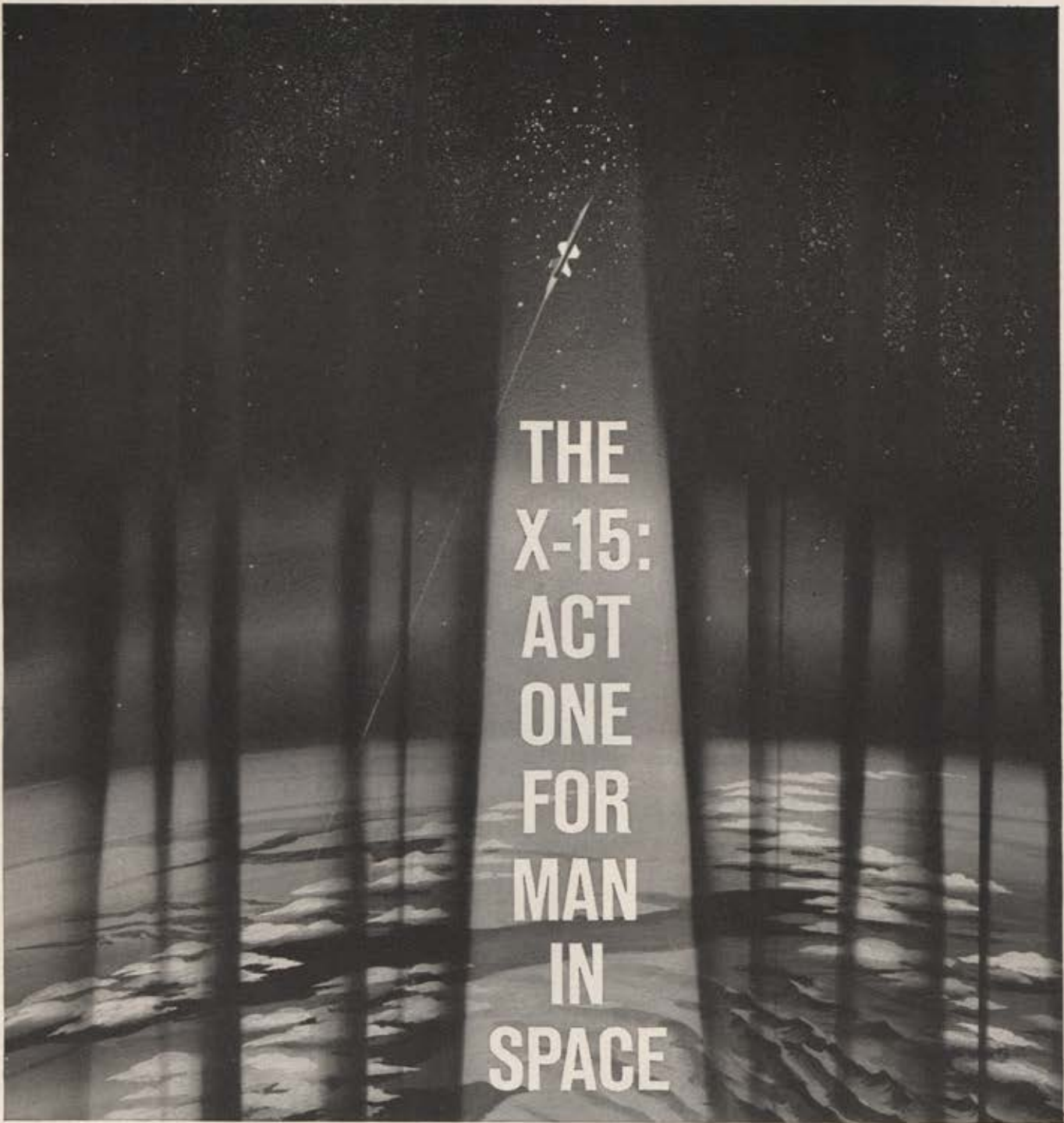
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THE X-15: ACT ONE FOR MAN IN SPACE

As North American's X-15 — world's most advanced manned research craft—parts the curtain of earth's atmosphere, the arts of guidance and direction must play a critical role. Sperry's Air Armament Division, assigned the Flight Data System responsibility for the X-15, is meeting the challenge with inertial guidance gear of advanced design, precision and dependability.

But the problems of inertial guidance are not new to Sperry. During the past ten years, over 25-million Sperry man-hours have been employed to develop and produce successful inertial guidance. As a result, the nation has in the Convair B-58 Hustler the most thoroughly studied, ana-

lyzed, tested, evaluated and understood inertial guidance system in being — plus the advanced guidance equipment for the X-15 and for other future applications.

And in addition to work on government sponsored space guidance systems and techniques, Sperry scientists and engineers are exploring new and exotic techniques for gyros, advanced miniaturized digital computers, acceleration sensors, zero gravity environment systems—in many cases involving radical departures from current technology—with the aim of developing concepts, systems and hardware that are *ahead* of the challenges of man in space.

SPERRY

MISSILES & SPACE WEAPONS—CONTINUED

GIMLET

Type—air-launched rocket; guidance—none; status—in development; no other details available.

Additional Navy missiles canceled in the recent past include: **Triton**, surface-to-surface missile under development by the Applied Physics Laboratory, Johns Hopkins University, when canceled in September 1957.

Rat, Naval Ordnance Test Station surface-to-underwater rocket-thrown torpedo canceled in January 1959 because superior antisubmarine weapons moved into advanced development.

Petrel, air-to-surface missile designed for use against submarines and surface ships, phased out of production in 1958



REGULUS I

after service with the fleet from April 1956. Prime contractor was Fairchild's Guided Missile Division.

As part of their rocket and missile programs, all three services are engaged in continuing hardware testing and basic research. A vast family of vehicles has taken part in this work in the past several years. Some have been used for a variety of purposes by more than one service as well as NASA. Among them:

- **Air Force**—Cajun atmospheric sounding rocket; **Astrobee** and **Aerobee** upper-atmosphere sounding rockets (in conjunction with both other services); **HTV** medium-altitude hypersonic test vehicle; **Rockaire** air-launched sounding rocket; **X-7** ramjet engine test pod; **X-10** test vehicle; **Arcas Robin** sounding rocket; **Cherokee** ejection-seat test rocket vehicle; **Cree** rocket for high-altitude testing of parachutes for manned aerospace craft escape systems, missiles, and drones; **Skokie I** and **II** air-launched parachute test vehicles; **Jaguar** air- and ground-launched high-altitude radiation-measuring rocket.



COBRA

- **Army**—Pogo-Hi solid-propelled missile target which can reach an altitude of 250,000 ft. at a speed of Mach 4; **Deacon** atmospheric sounding rocket also used by NASA; **Argo** research rocket; **Aerosound**, a variation on **Aerobee** atmospheric research.

- **Navy**—**Arcas** meteorological sounding and research rocket; **Arcon** upper-atmosphere research rocket; **Asp** series of high-altitude sounding rockets, used in NASA-Navy tests, Nike-Asp research shots to regions 50 to 100 mi. up; **Aspan** ultrahigh-altitude research rocket; **Hasp** upper-altitude research rocket; **Iris** two-stage research vehicle with a capability of carrying a payload of 100 lb. to a 200-mi. altitude; **Viking** sounding vehicle; **Wasp** ionosphere research rocket; **Rockair** instrumented sounding rocket; **Dan** two-stage sounding rocket.

—FREDERIC M. PHILIPS



HTV



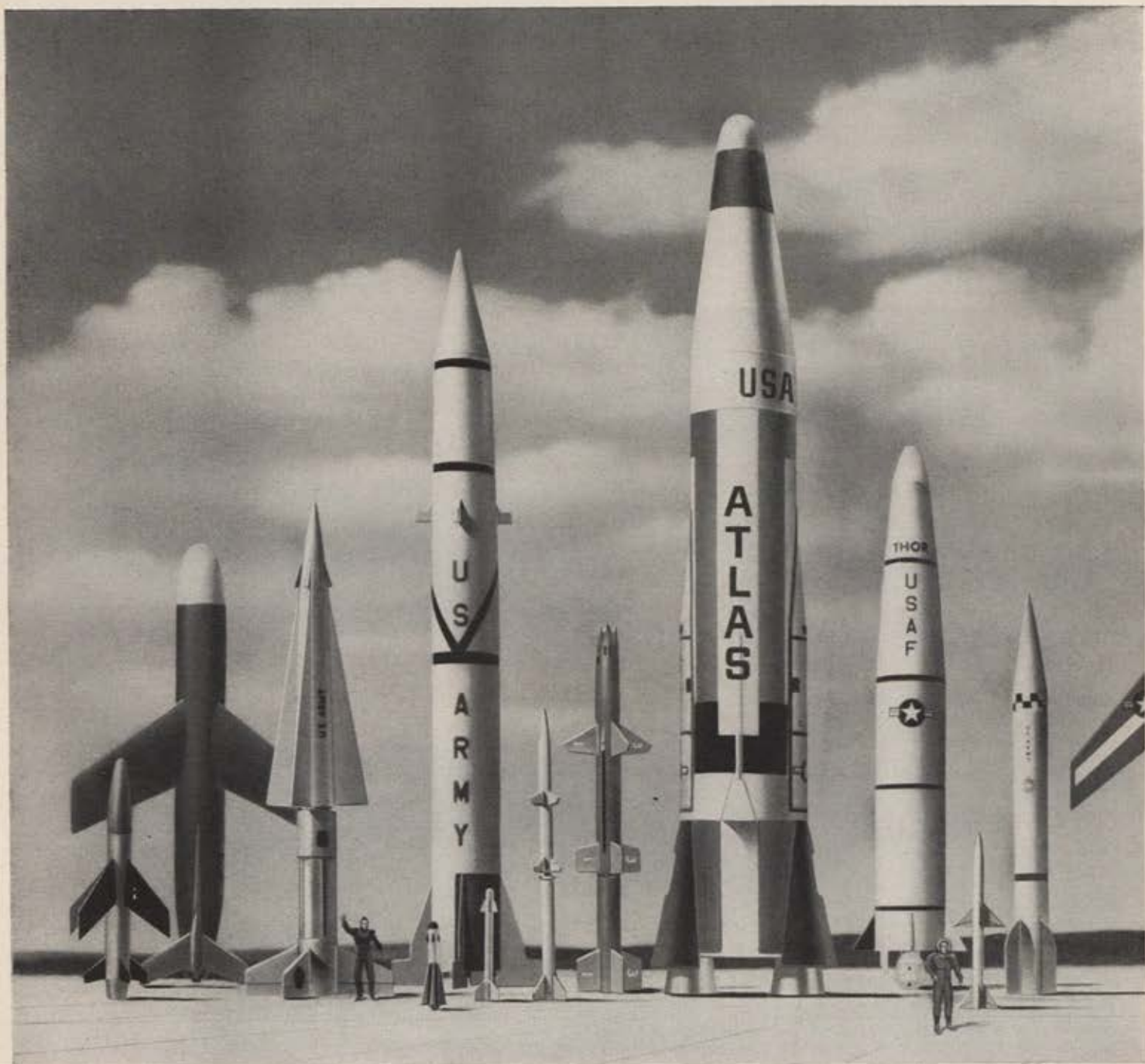
CREE



JAGUAR



VIKING

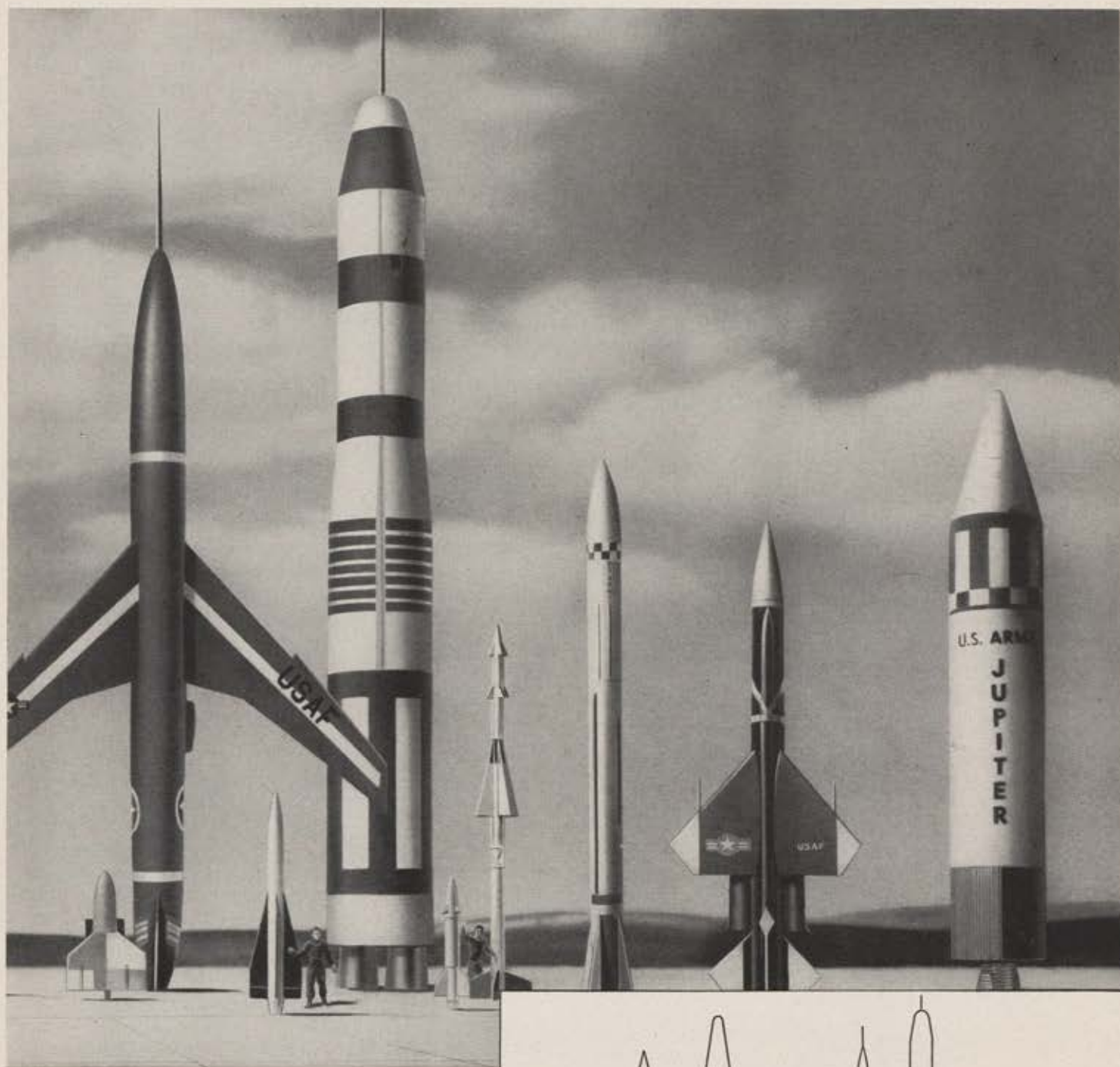


21 U.S. missiles rely on Raytheon electron tubes

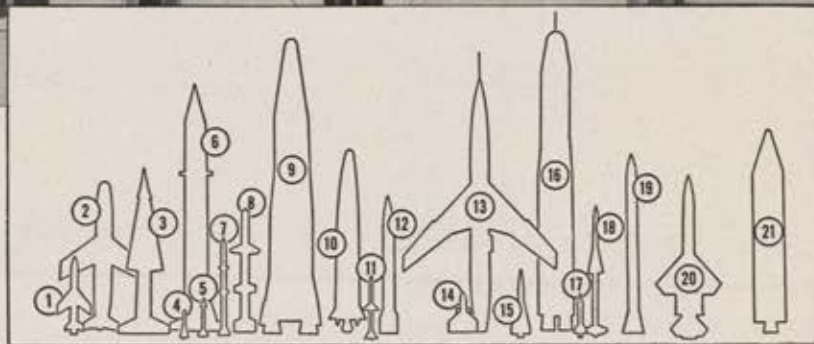
RAYTHEON COMPANY, WALTHAM, MASS.



EXCELLENCE IN ELECTRONICS



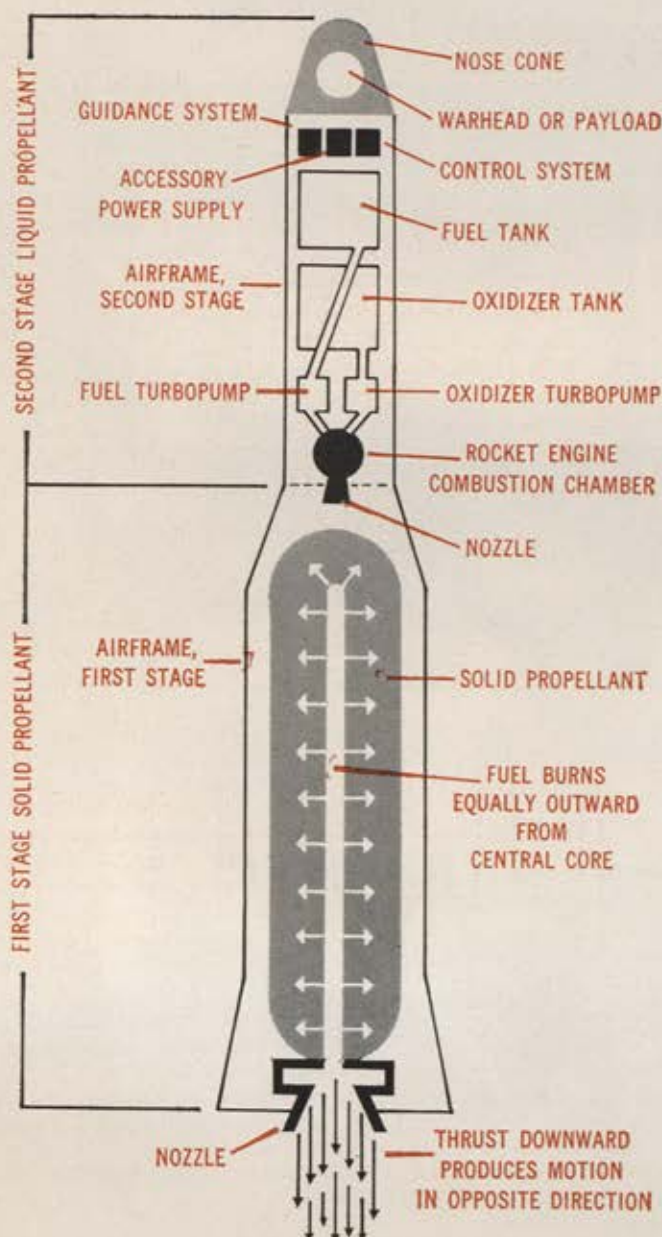
1. Lacrosse. Army. Ground-to-ground. Prime contractor: Martin.
2. Mace. Air Force. Ground-to-ground. Prime contractor: Martin.
3. Nike Hercules. Army. Ground-to-air. Prime contractor: Western Electric.
4. Falcon. Air Force. Air-to-air. Prime contractor: Hughes.
5. Sidewinder (GAR-8). Navy/Air Force. Air-to-air. Prime contractors: Philco; General Electric.
6. Redstone. Army. Ground-to-ground. Prime contractor: Chrysler Corp.
7. Terrier. Navy. Surface-to-air. Prime contractor: Convair.
8. Talos. Navy. Surface-to-air. Prime contractor: Bendix Aviation.
9. Atlas. Air Force. Ground-to-ground. Prime contractor: Convair.



10. Thor. Air Force. Ground-to-ground. Prime contractor: Douglas.
11. Sparrow III. Navy. Air-to-air. Prime contractor: Raytheon.
12. Sergeant. Army. Ground-to-ground. Prime contractor: Sperry Rand.
13. Snark. Air Force. Ground-to-ground. Prime contractor: Northrop.
14. Quail. Air Force. Air-to-ground. Prime contractor: McDonnell.
15. Hawk. Army. Ground-to-air. Prime contractor: Raytheon.
16. Titan. Air Force. Ground-to-ground. Prime contractor: Martin.
17. Bullpup. Navy. Air-to-ground. Prime contractor: Martin.
18. Nike Ajax. Army. Ground-to-air. Prime contractor: Western Electric.
19. Corporal. Army. Ground-to-ground. Prime contractors: Firestone; Gilfillan.
20. Bomarc. Air Force. Ground-to-air. Prime contractor: Boeing.
21. Jupiter. Army. Ground-to-ground. Prime contractor: Chrysler Corp.

SOME HOW'S, WHY'S, and WHERE'S OF MISSILES AND SPACE

INSIDE THE BALLISTIC MISSILE



Cutaway diagram of a hypothetical two-stage, ballistic-type missile, showing the major components. First stage is propelled by solid fuel; second is liquid propelled.

IN THE airless void of space, only a reaction engine—a rocket carrying its own supply of an oxidizer to enable a fuel to burn in a vacuum—can supply propulsion. In the future, atomic powerplants and even more exotic systems may be devised to heat fuels and provide the exhaust particles that push the ship forward, but today only chemical fuels—liquid or solid—are available for the job.

A rocket develops push or "thrust" when the hot gases caused by the burning of the propellants push outward equally against the walls of the combustion chamber. Since these gases can escape only through a nozzle at the bottom of the chamber, the resulting imbalance puts pressure on the combustion chamber wall opposite the nozzle and produces forward or upward movement.

The process is not unlike the behavior of a toy balloon set free after being blown up, and it illustrates Sir Isaac Newton's third law of motion: "To every action there is an equal and opposite reaction."

Some confusion exists between *missiles* and *rockets*. A *missile* is any object thrown at a target. A *guided missile* is one whose direction can be changed during flight. A *ballistic missile* is a particular form of guided missile in that it is powered and guided only during the first part of its flight and thereafter follows a "ballistic trajectory" like that of a thrown rock or an artillery shell, honoring the laws of physics.

Rocket refers to the type of propulsion. Some, but not all, missiles are rocket powered, though the tendency is to refer to them all as "rockets."

What are the components of a ballistic missile?

Inside the ICBM

Ballistic missiles—including intermediate-range (IRBM), approximately 1,500 miles, or intercontinental-range (ICBM), approximately 5,000 miles—consist of a number of interconnected and interacting systems and subsystems that perform distinct functions. The major components which are all packed into the airframe are:

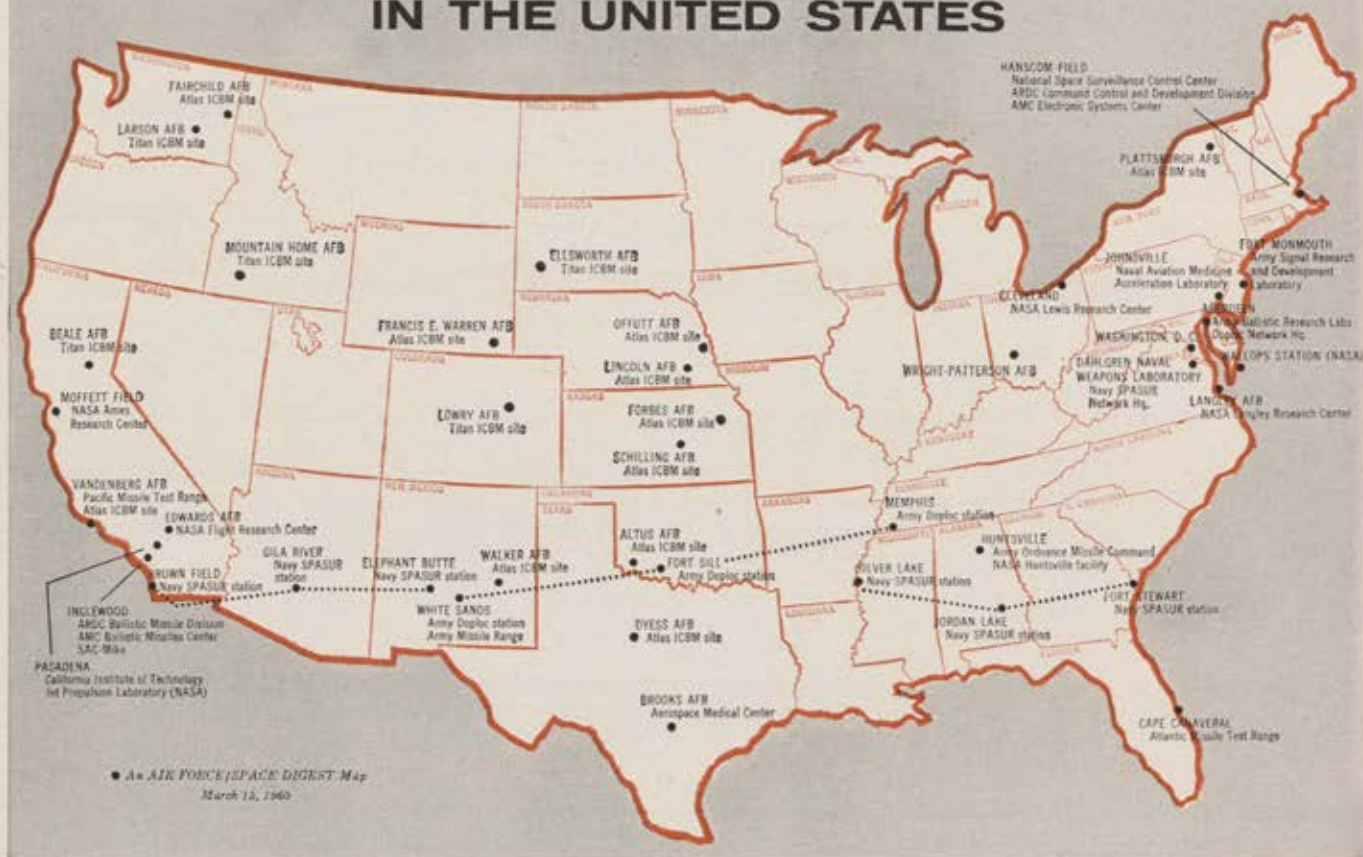
- The **nose cone**—the cone-shaped protective covering that enables the warhead to reenter earth's atmosphere.

- The **warhead**—may be high explosive, atomic, or thermonuclear, complete with fuzing and arming systems. In nonmilitary missions, the warhead becomes *payload* and may consist of instruments, a satellite, space probe, or an inhabited capsule.

- **Guidance system**—regulates the position and velocity of the missile during powered flight to establish a satisfactory trajectory before thrust cutoff. There are two main types of guidance in ballistic missiles:

1. In **radio-inertial** or **radar-command** guidance, one or more ground radars measure the position and velocity of the missile; corrective maneuvers are computed and trans-

MISSILE AND SPACE SITES IN THE UNITED STATES



Map shows principal installations of the National Aeronautics and Space Administration (NASA), the Army, Navy, and the Air Force; announced ICBM (Atlas and Titan) launch sites; the stations of the Navy's Space Surveillance network and Army's Doploc fence, both part of ARPA's Project Shepherd, a program for detecting "dark" or silent satellites; and the National Space Surveillance Control Center, where all information on satellites is gathered and interpreted.

mitted to the missile as "commands." Inertial elements such as gyroscopes may be included, but precision guidance is obtained primarily from the ground. This system uses two main types of radars—*pulse radar*, in which pulses of microwave energy are radiated from the ground, and the time lapses for the return of signals are measured to provide line-of-sight distance to the missile; and *Doppler radar*, which makes use of the fact that the return signal is shifted in carrier frequency by an amount proportional to the velocity of the missile.

2. *Inertial guidance* operates independently of information received from outside the missile. An onboard computer and sensing instruments (a set of mutually perpendicular accelerometers mounted on a gyro-stabilized platform) furnish signals to the control system based on data preset into the control system. Such guidance can be interfered with only by destroying the missile.

Other types of guidance for nonballistic missiles include: *Beam-rider guidance*—using a beam directed into space so the center of the beam axis forms a line along which it is desired to direct the missile.

Celestial guidance—guidance by reference to celestial bodies.

Celestial-inertial guidance—basic inertial guidance corrected by information from celestial observations.

Homing guidance—the missile steers itself toward a target by means of a self-contained mechanism (infrared detectors, radar, etc.), activated by some distinguishing characteristic of the target. Homing guidance may be *active*, *passive*, or *semiactive*.

Map-matching guidance—the missile guides itself by comparing a previously obtained radarscope film with echoes received from the terrain below during flight.

Preset guidance—the missile is sent on a predetermined path and cannot be adjusted after launching.

Terrestrial-reference guidance—the predetermined path of the missile can be followed by a device in the missile which reacts to some property of the earth such as magnetic or gravitational fields.

Track-command guidance—both target and missile are tracked by separate radars, and corrective commands are sent to the missile.

- **Control system**—maintains attitude stability of the missile during powered flight to prevent undesirable responses when overriding guidance signals are introduced and to correct any possible deflections.

- **Accessory power supply**—furnishes electric power for the guidance and control systems and any necessary hydraulic or pneumatic power.

- **Propulsion system**—consists of the rocket engine with nozzle, combustion chamber, ignition circuitry, fuel, and—in liquid-fuel systems—turbopumps to force fuel into the combustion chamber. There are two main chemical fuel systems—liquid and solid:

1. In *liquid-propellant systems* liquid fuel and a liquid oxidizer are fed under pressure from tanks into the combustion chamber. Different combinations produce various *specific impulses* (the thrust in pounds divided by the propulsion consumption rate in pounds per second).

(Continued on following page)

Here are some typical liquid-fuel systems:

Fuel	Oxidizer	Specific Impulse
Ammonia	Nitric acid	237
Kerosene	Oxygen	249
Hydrazine	Nitrogen tetroxide	249
Ammonia	Oxygen	250
Hydrazine	Chlorine trifluoride	251
Hydrazine	Oxygen	263
Hydrazine	Nitrogen tetroxide	279
Hydrazine	Fluorine	316
Hydrogen	Oxygen	364
Hydrogen	Fluorine	371

2. In *solid-propellant systems* the propellant, a single substance containing all the elements for complete combustion (the oxidizer is built in), burns at a nearly constant rate in the same chamber in which it was stored. Usually in plasticlike, caked form, the solid-fuel mixture, known as the "grain" or "charge," needs no tanks, pumps, or fuel lines. There are two types of solid-propellant rocket engines—*restricted*, in which the fuel burns from one end to the other; and *unrestricted*, in which fuel burns on several surfaces at once, developing greater thrust than the other. Again, various combinations produce different *specific impulses*. Here are examples:

Fuel Base	Oxidizer	Specific Impulse
Asphalt	Perchlorate	200
Polyurethane	Perchlorate	245
Boron	Perchlorate	270
Metal hydride	Fluoride	300

• **Airframe**—the supporting structure for everything else in the missile. The casing must be light enough to permit maximum range but strong enough to support components and propellants during flight. *Multistage design*, in which one or more engine sections are jettisoned during powered flight, reduces the mass that must be accelerated through the entire distance to thrust cutoff.

How Fast . . . How Far

The function of a rocket propulsion system is to develop *velocity*. Velocity may be increased in the following three ways:

1. By increasing the energy yield of the propellant.
2. By increasing the velocity of the exhaust.
3. By reducing the weight of the rocket.

The higher the velocity, the more involved the mission that may be undertaken. Here are some examples:

Mission	Velocity Feet per Second
Intermediate-range ballistic missile	14,000
Intercontinental ballistic missile	24,000
Minimum equatorial orbit	25,000
Minimum polar orbit	26,000
Escape from earth	36,680
Flight to Venus	37,000
Orbit to moon	38,000
Soft lunar landing	44,300
Orbit Mars or soft landing	38,000 to 56,700
Land on Mars and return	56,700 to 100,000
To the outer planets	50,000
Reconnaissance of Jupiter	50,000 to 100,000
Escape from the solar system	53,850

Propulsion . . . Fission to Photon

Chemical combustion is now used in rocket propulsion because no other means of accelerating mass to high exhaust speeds has yet been perfected. Such chemical systems seem limited to specific impulses of from 250 to 400 seconds. The systems of tomorrow, now under study in laboratories, will have higher performance:

System	Specific Impulse
Solar	450
Nuclear fission	600 to 1,500
Free radicals	1,200
Electric arc	2,000
Ionic	10,000 to 20,000
Nuclear fusion	600,000 to 1,000,000
Photon	30,000,000

• **Solar**—In a solar rocket engine sunlight would be converted to heat energy, which would be used to expand a fluid such as liquid hydrogen, producing thrust.

• **Nuclear fission**—In such an engine the enormous heat energy of atomic power would help create thrust by heating a substance such as liquid hydrogen, helium, or ammonia to a high temperature. When the heated substance was ejected through the rocket's nozzle, thrust would be produced.

• **Free radicals**—Free radicals are groups of atoms broken away from a stable compound by the application of external energy. Their use in propulsion systems, now theoretical, depends on their being isolated and available in bulk, either in pure form or dissolved in another fuel.

• **Electric arc**—In such a system an electric arc would be used to heat a working fluid which would be expelled through the nozzle. Energy for the arc might be derived from a nuclear reactor, batteries, or solar radiation.

• **Ionic**—If liquid cesium is vaporized by heat from a nuclear reactor, it becomes ionized in the process (ions are atoms unbalanced electrically by the removal of one or more atoms). The ions can be accelerated to high speeds by an electrical field and ejected from the engine. Because of the low mass of ion particles, such an engine would have low thrust and would have to be boosted into space by chemical or other means or launched from orbit.

• **Nuclear fusion**—Such a powerplant must await a satisfactory means of controlling thermonuclear energy—the power of the H-bomb. In the thermonuclear process, when two nuclei of heavy hydrogen collide at high energies, they interact, forming a new nucleus and liberating either a proton or neutron of high energy. To obtain a useful power yield from this reaction, a gas of deuterium or deuterium mixed with tritium (both forms of hydrogen) must be brought together at enormously high temperatures (estimated as high as 350,000,000 degrees). Gas at these temperatures would have to be confined away from contact with any solid material. One proposal to solve this problem is to create a "magnetic bottle," whereby a flow of heavy electrical current through the hot gas would at once contain the gas and bring it up to the necessary high temperature by compressing it.

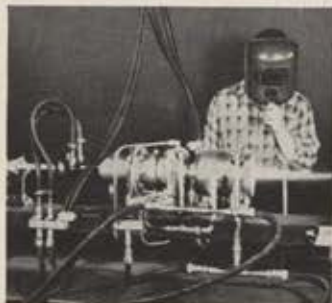
• **Photon**—Perhaps the ultimate in propulsion would be the photon rocket, in which matter would be converted into radiation and ejected at the speed of light, resulting in low thrust and acceleration but high specific impulse. In theory a vehicle powered by photons (or light particles) could accelerate to nearly the speed of light, 186,284 miles per second. However, at this time there is no known method of radiating tremendously intense beams of light.

—RICHARD M. SKINNER

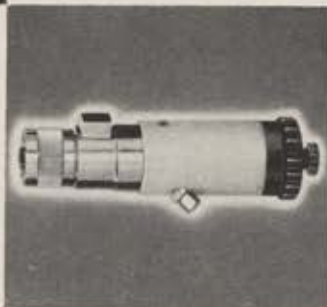
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Plasma Generator PG-030, designed as ultra-reliable laboratory heat source, consumes from 2 to 30 KW of power, sprays tungsten, carbides, alumina, zirconia, etc. Uses inert gases as working fluid to avoid reactance.

HYPERVELOCITY INSTRUMENTATION



Shadowgraph and Schlieren Systems record events associated with hypervelocity aerodynamic phenomena; include light source, lenses, catadioptric light screen, Kerr Cell Shutter and Camera. Record shock waves, flow patterns and impact deformations of space age research.

Avco Kerr Cell Shutter permits any exposure from .005 to .1 μ sec., is available as an independent module. Large 2-inch aperture unit may be remotely positioned for maximum utility. Useful for ultra-high speed shuttering in ballistic, chemical and thermal research.



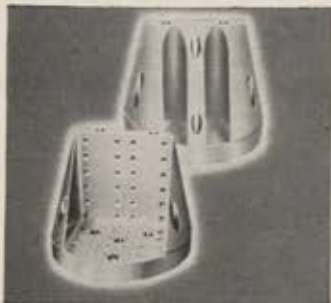
ENVIRONMENTAL TEST EQUIPMENT



Shock Machines, SM-010 and SM-030 with shock pulses up to 1000 g's, meet ballistic missile test specifications by providing sawtooth, quarter- and half-sine, and triangular pulses. Models SM-005 and SM-020 available June, 1960.



Acoustic Noise Test Systems available in a variety of configurations to meet specialized requirements. Systems available with random noise outputs of 163, 150, 140, and 120 db. Larger systems feature Avco Acoustic Noise Generator AG-012, simulating random noise of rocket engine firing.

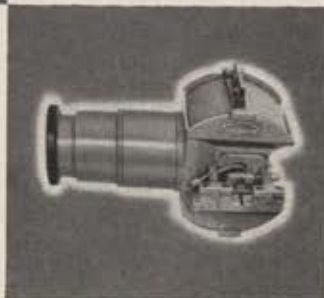


Environmental Test Fixture TF-006-1 is compact and versatile, virtually resonance-free up to 2000 cps, mounts on standard vibration exciters, centrifuges and shock machines; also handles several specimens along three mutually perpendicular axes.



Package Light Sources, providing from .3 to 1 μ sec. light pulse durations, are general purpose, spark-type units of cylindrical construction with coaxial discharge path; pre-determined triggering; also provide synchronized output pulse for balance of system.

Rotating Mirror and Drum Cameras for accurate position-versus-time recording of hypervelocity events. Mirror camera writes at rate of 4mm/ μ sec. on 70 mm film; Rotating Drum Camera writes at rate of .19 mm/ μ sec. on 76mm film for streak and Schlieren recording.

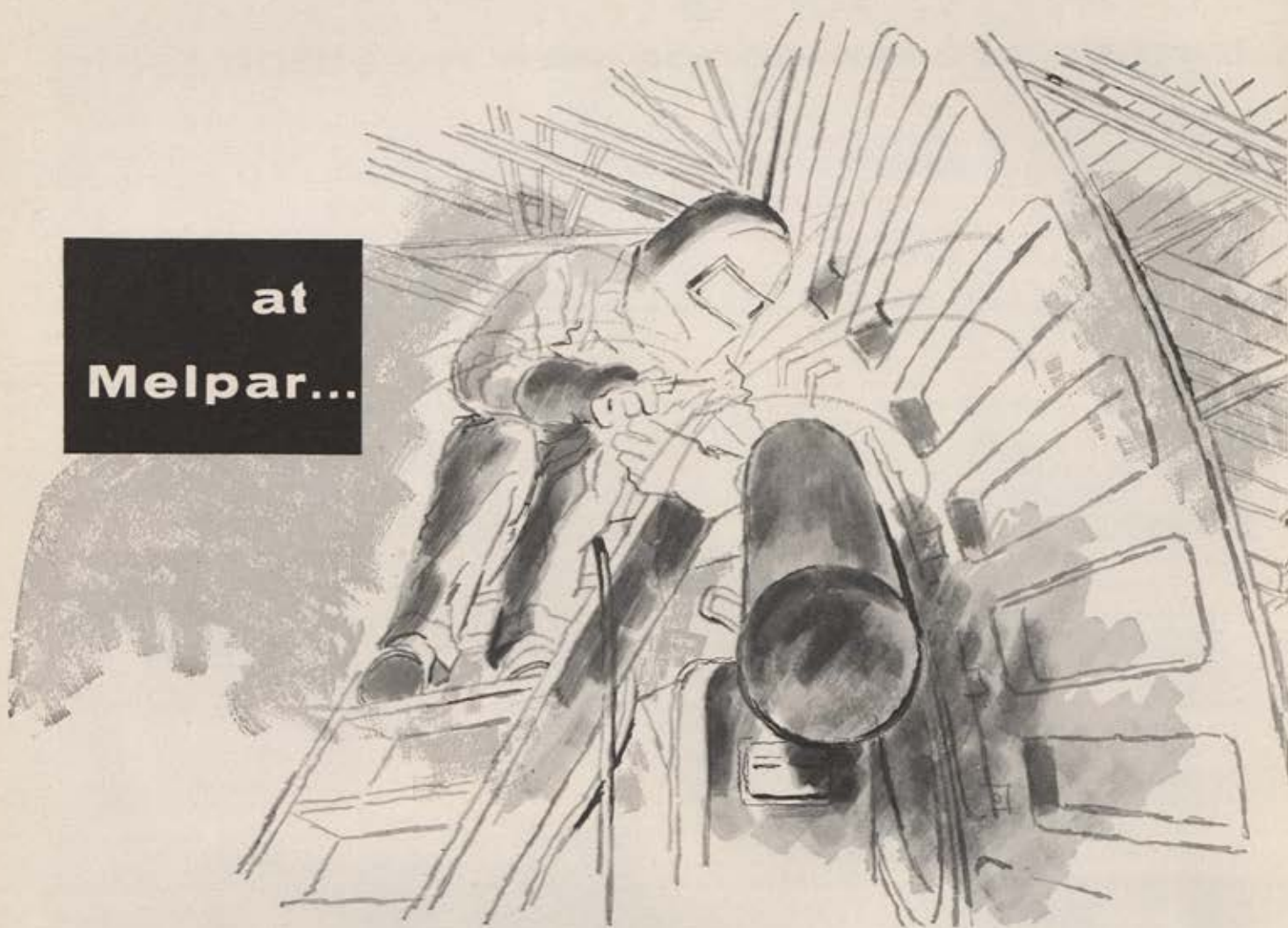


Avco

Research & Advanced Development

For more information write: Products and Services Department, Research and Advanced Development Division, Avco Corporation, Wilmington, Massachusetts.

**at
Melpar...**

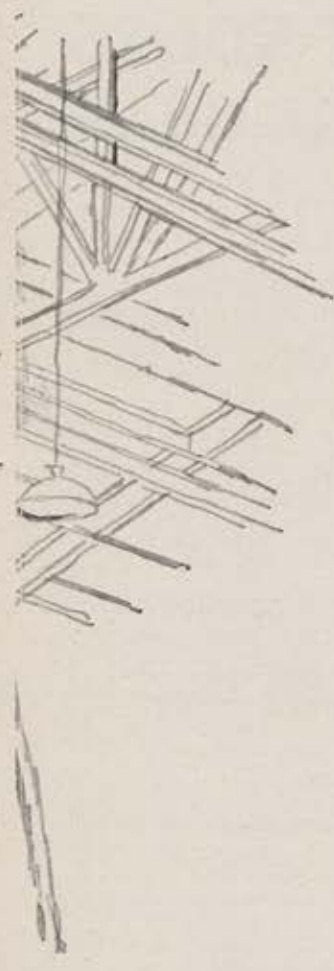


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ADDRESS _____



Sputnik III model on display in Moscow museum.

SATELLITES AND SPACE PROBES ... US AND USSR

SUCCESSFUL SATELLITES

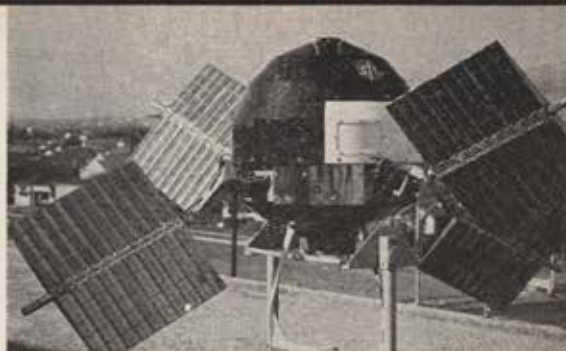
	Still in Orbit on March 1, 1960	Official Name	Object	Originating Nation	Launch Date	Launch Site	Status as of March 1, 1960
1.		1957 Alpha I	Rocket body for Sputnik I	Soviet Union	October 4, 1957	Near Caspian Sea	Down December 1, 1957
2.		1957 Alpha II	Sputnik I	Soviet Union	October 4, 1957	Near Caspian Sea	Down January 4, 1958
3.		1957 Beta	Sputnik II ("Muttnik")	Soviet Union	November 3, 1957	Near Caspian Sea (?)	Down April 14, 1958
4.	●	1958 Alpha	Explorer I	United States	January 31, 1958	Cape Canaveral	Expected to remain in orbit until 1962
5.	●	1958 Beta I	Rocket body for Vanguard I	United States	March 17, 1958	Cape Canaveral	Expected to remain in orbit until 21st century
6.	●	1958 Beta II	Vanguard I	United States	March 17, 1958	Cape Canaveral	Expected to remain in orbit until 21st century
7.		1958 Gamma	Explorer III	United States	March 26, 1958	Cape Canaveral	Down June 28, 1958
8.		1958 Delta I	Rocket body for Sputnik III	Soviet Union	May 15, 1958	Near Caspian Sea (?)	Down December 3, 1958
9.	●	1958 Delta II	Sputnik III	Soviet Union	May 15, 1958	Near Caspian Sea (?)	Expected to remain in orbit until March 1960
10.		1958 Epsilon	Explorer IV	United States	July 26, 1958	Cape Canaveral	Down October 23, 1959
11.		1958 Zeta	Atlas	United States	December 18, 1958	Cape Canaveral	Down January 21, 1959
12.	●	1959 Alpha I	Vanguard II	United States	February 17, 1959	Cape Canaveral	Expected to remain in orbit until 21st century
13.	●	1959 Alpha II	Rocket body for Vanguard II	United States	February 17, 1959	Cape Canaveral	Expected to remain in orbit until 21st century
14.		1959 Beta	Discoverer I	United States	February 28, 1959	Vandenberg AFB	Down March 5, 1959
15.		1959 Gamma	Discoverer II	United States	April 13, 1959	Vandenberg AFB	Down April 26, 1959
16.	●	1959 Delta	Explorer VI	United States	August 7, 1959	Cape Canaveral	Expected to remain in orbit until late 1960
17.		1959 Epsilon I	Discoverer V	United States	August 13, 1959	Vandenberg AFB	Down September 28, 1959
18.	●	1959 Epsilon II	Discoverer V Capsule	United States	August 13, 1959	Vandenberg AFB	In orbit
19.		1959 Zeta	Discoverer VI	United States	August 19, 1959	Vandenberg AFB	Down October 20, 1959
20.	●	1959 Eta	Vanguard III	United States	September 18, 1959	Cape Canaveral	Expected to remain in orbit until 21st century
21.	●	1959 Theta	Lunik III	Soviet Union	October 4, 1959	Soviet Union	Expected to remain in orbit until March 1960
22.	●	1959 Iota I	Explorer VII	United States	October 13, 1959	Cape Canaveral	Expected to remain in orbit until 1975
23.	●	1959 Iota II	Rocket body for Explorer VII	United States	October 13, 1959	Cape Canaveral	Expected to remain in orbit until 1975
24.		1959 Kappa	Discoverer VII	United States	November 7, 1959	Vandenberg AFB	Down November 26, 1959
25.	●	1959 Lambda	Discoverer VIII	United States	November 20, 1959	Vandenberg AFB	Expected to remain in orbit until March 1960

DEEP-SPACE PROBES

OBJECT	ORIGINATING NATION	LAUNCH DATE	LAUNCH SITE	STATUS ON MARCH 15, 1960	SHAPE	SIZE	WEIGHT	REMARKS
Lunik I ("Mechta" or "Dream")	Soviet Union	January 2, 1959	USSR	In 15-month orbit around the sun.	Sphere	Unknown	3,245-lb. final rocket stage; 797-lb. instrument package.	First successful deep-space probe. Aphelion: 123,- 250,000 mi. Peri- helion: 91,500,- 000 mi.
Pioneer IV	United States	March 3, 1959	Cape Canav- eral	In 13.5-month orbit around the sun.	Cone	20" long 9" diameter	13.4 lb.	Aphelion: 106,100,- 000 mi. Perihelion: 91,700,000 mi.
Lunik II	Soviet Union	September 12, 1959	USSR	Impacted moon on September 13, 1959.	Sphere	Unknown	3,324-lb. final rocket stage; 858.4-lb. instru- ment package	Hit moon after traveling 236,876 mi.
Lunik III	Soviet Union	October 4, 1959	USSR	Now orbiting earth as 1959 Theta (see above).	Ellipsoid	4.3' long 3.9' diameter	3,416-lb. final rocket stage; with 344-lb. instrument package; plus 613-lb. "Automatic Interplanetary Station."	Photographed far side of moon and returned to trans- mit photos and then orbit earth as 1959 Theta (see above).
Pioneer V	United States	March 11, 1960	Cape Canav- eral	In 311-day orbit around the sun, between earth and Venus.	Sphere	26" diameter with 4 vanes.	94.8 lb.	"Paddlewheel" satellite. Aphelion: 93,000,- 000 mi. Perihelion: 74,700,- 000 mi.

The three tables below give a comprehensive picture of all known American and Soviet space shots through March 1, 1960. The first summarizes the twenty-five objects that have orbited to date. Of these launches, thirteen satellites or their rocket bodies are still in orbit, as shown in color. The second table summarizes deep-space probes, including moon shots, while the third gives launch data and reasons for failure of twenty-four American orbital or space-probe attempts. This material has been compiled entirely from unclassified sources, and we gratefully acknowledge the assistance of the National Aeronautics and Space Administration's Goddard Spaceflight Center and the Air Research and Development Command's National Space Surveillance Control Center, Hanscom Field, Mass.

—THE EDITORS



Payload of the Explorer VI satellite.

Shape	Size	Apogee in Statute Miles	Perigee in Statute Miles	Period of Revolution in Minutes	Total Weight in Orbit	Weight of Instrumentation in Payload	Remarks
Cylinder	Unknown	590	141	96.2	About 4 tons	None	Final stage of launch vehicle.
Sphere	22.8" diameter	588	142	96.17	184 lb.	Unknown	History's first earth satellite.
Cone	5½" long, 39" diameter at base	1,038	140	103.70	1,120 lb. (with third stage)	Unknown	Contained the dog "Laika."
Cylinder	80" long, 6" diameter	1,242	216	108.7	30.8 lb.	18.13 lb.	Discovered Van Allen radiation belt.
Bottle	7" long, 20" diameter	2,684	402	138.2	50 lb.	None	Third-stage casing.
Sphere	6.4" diameter	2,446	405	133.8	3.25 lb.	3.25 lb.	Helps determine earth's shape.
Cylinder	80" long, 6" diameter	1,746	121	115.87	31.0 lb.	18.56 lb.	Provided data on micrometeorite impacts.
Cylinder	Unknown	1,167	370	105.9	About 5 tons	None	Final stage of launch vehicle.
Cone	11' 9" long, 5' 8" wide at base	354	109	91.5	About 3.5 tons	2,925 lb.	Heaviest test vehicle orbited.
Cylinder	80.39" long, 6.25" diameter	1,380	163	110.27	38.4 lb.	25.8 lb.	Provided data on radiation belts.
Atlas ICBM	85' long, 10" diameter	920	110	101.46	4,375 tons	150 lb.	Project SCORE "Talking Atlas"; beamed message from President Eisenhower.
Sphere	20" diameter	2,050	347	122.5	20.74 lb.	20.74 lb.	Weather satellite; developed wobbling motion.
Bottle	7" long, 20" diameter	2,279	347	129.6	50 lb.	None	Third-stage casing.
Cylinder	19.2' long, 5" diameter	605	99	95.9	1,300 lb.	245 lb.	First satellite in polar orbit.
Cylinder	19.2' long, 5" diameter	220	142	90.5	1,610 lb.	245 lb. plus 195-lb. capsule	Attempt to recover reentry capsule was unsuccessful.
Spheroid with vanes	29" deep, 26" diameter	23,980	117	686.2	142 lb.	142 lb.	"Paddlewheel" satellite; has 4 vanes, each 18"x18".
Cylinder	19.2' long, 5" diameter	450	136	94	1,700 lb.	38.4 lb. plus 300-lb. capsule	Reentry capsule became 1959 Epsilon II.
Cylinder	About 2' long, About 3" diameter	1,041	125	103.9	About 300 lb.	Unknown	Unrecovered reentry capsule of Discoverer V.
Cylinder	19.2' long, 5" diameter	537	139	101.5	1,700 lb.	150 lb.	Reentry capsule not recovered.
Sphere	20" sphere and 26" tube	2,325	315	129.8	100 lb.	50 lb.	Measures magnetic field and conducts X-ray environmental tests.
Ellipsoid	4.3' long, 3.9' diameter	292,785	25,480	15.5 days	614 lb.	Unknown	Photographed moon before returning to orbit earth (see Lunik III below).
Two united cones	30" long, 30" diameter	672	346	101.2	91.5 lb.	70 lb.	Designed for radiation and micrometeorite studies.
Cylinder	5' long, 6" diameter	671	343	101.2	Unknown	None	Final stage of launch vehicle.
Cylinder	19.2' long, 5" diameter	550	104	95	1,700 lb.	300-lb. capsule	Reentry capsule could not be separated, causing tumbling.
Cylinder	19.2' long, 5" diameter	427	108	92.2	1,700 lb.	300-lb. capsule	Capsule ejected but could not be found.

UNSUCCESSFUL LAUNCHES

VANGUARD (Test Vehicle 3)

Launched: December 6, 1957. Malfunction in first stage caused loss of thrust and destruction after two seconds.

VANGUARD (Test Vehicle 3 Backup)

Launched: February 5, 1958. Faulty connection in first stage caused destruction at 20,000 feet after 57 seconds of flight.

EXPLORER II

Launched: March 5, 1958. Last stage failed to ignite. Flight time: 823 seconds.

VANGUARD (Test Vehicle 5)

Launched: April 28, 1958. Third stage failed to fire; second and third stages impacted 1,500 miles from launch site.

VANGUARD (Satellite Launch Vehicle 1)

Launched: May 27, 1958. Second-stage engine did not cut off properly, causing third stage to fly arclike trajectory to peak altitude of 2,200 miles. Third stage traveled 7,500 miles to near coast of South Africa.

VANGUARD (Satellite Launch Vehicle 2)

Launched: June 26, 1958. Second-stage motor cut off prematurely.

THOR-ABLE I (Lunar Probe)

Launched: August 17, 1958. Engine failure in first stage caused vehicle to blow up.

EXPLORER V

Launched: August 24, 1958. After successful launch and flight time of 659 seconds, orbit was not achieved because parts of booster collided with instrument compartment.

VANGUARD (Satellite Launch Vehicle 3)

Launched: September 26, 1958. Second-stage failure caused vehicle to fall back into atmosphere and burn up after apparently making one complete orbit of the earth.

PIONEER I (Lunar Probe)

Launched: October 11, 1958. Reentered atmosphere after reaching altitude of about 70,700 miles. Flight time: 43 hours, 17.5 minutes.

BEACON (Inflatable Satellite)

Launched: October 23, 1958. Payload separated from booster before burnout.

PIONEER II (Lunar Probe)

Launched: November 8, 1958. Third stage failed to ignite. Reached altitude of 963 miles. Flight time: 42.4 minutes.

PIONEER III (Space Probe)

Launched: December 6, 1958. Discovered second radiation band around earth. Reentered atmosphere December 7, 1958, after 38 hours, 6 minutes. Reached altitude of 63,580 miles.

VANGUARD (Satellite Launch Vehicle 5)

Launched: April 13, 1959. Second-stage failure. Flight time: about 500 seconds.

DISCOVERER III (Reentry Capsule)

Launched: June 3, 1959. Second stage apparently fired but tracking stations received no telemetry, indicating satellite probably did not achieve orbit.

VANGUARD (Satellite Launch Vehicle 6)

Launched: June 22, 1959. Faulty second-stage pressure valve caused failure at about 90 miles.

DISCOVERER IV (Reentry Capsule)

Launched: June 25, 1959. Though second stage fired, insufficient velocity was believed to have caused failure to achieve orbit.

EXPLORER V

Launched: July 16, 1959. Vehicle destroyed after 5.5 seconds when power to guidance failed.

BEACON

Launched: August 14, 1959. Payload failed to orbit because of premature fuel depletion in booster and malfunction in attitude control system for upper stages.

TRANSIT I (Sphere)

Launched: September 17, 1959. Satellite failed to achieve orbit when third stage did not fire.

PIONEER (Lunar Probe)

Launched: November 26, 1959. Three-stage Atlas-Able, designed to put 372-lb. instrument package in lunar orbit, failed apparently because of premature release of protective shroud covering the satellite, after about 45 seconds.

DISCOVERER IX (Reentry Capsule)

Launched: February 4, 1960. Successful launch but vehicle failed to orbit because of a fueling malfunction.

DISCOVERER X (Reentry Capsule)

Launched: February 19, 1960. Destroyed by range safety officer 56 seconds after launch at altitude of 20,000 feet.

MIDAS I (Early-Warning Satellite)

Launched: February 26, 1960. Second stage of Atlas-Agena failed to ignite.



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from Mach 4 sleds
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On a 7-mile long track, these sleds test warheads, missiles, airfoils, missile components, and human tolerances, transmitting their data to a telemetry building which is the intelligence center for track operations. There, a digital telemetering system receives, translates and processes the data. The entire telemetry system—from output of the sled-borne transducers to computer input—was designed and built by Radiation Incorporated.

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OUT FROM THE SUN . . .

THE SOLAR SYSTEM

The most splendid and, to life on earth, the most important object in the heavens is the sun, whose mass represents ninety-nine percent of the mass of the solar system. Above, a solar flare, a violent form of sun-spot activity.

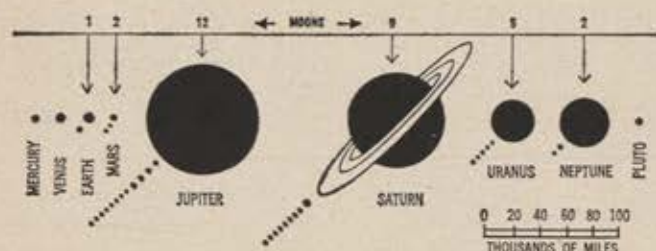
ONE of the tribes of ancient India is said to have envisioned the earth as a huge tea tray supported on the backs of three giant elephants which in turn stood on the shell of an enormous tortoise. We now take the more prosaic view that earth is, instead, the third planet of a quite ordinary star, located far out on a spiral arm of an average galaxy.

Our galaxy, in turn, is but one of billions of other galaxies, some grander, some less so than ours. These great star clusters—of such size that even the special yardsticks man has devised to measure them and their distances from

us are all but incomprehensible—make up the vast entity we call the universe.

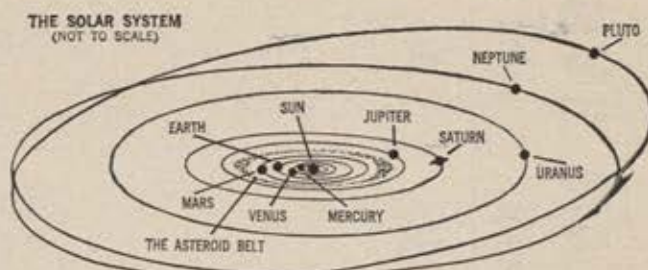
To us, the most important object in the “tidal pool” of the space “ocean” that is our solar system is the sun. Of only medium size and brightness as stars go, the sun provides the light and heat upon which life on earth is absolutely dependent. The sun produces this radiant energy (which has no material form but does have mass) by converting something like 6,000,000,000 tons of hydrogen into 596,000,000 tons of helium each second. This process

(Continued on page 146)



THE SOLAR SYSTEM • THE PLANETS AND THEIR SATELLITES

The family of planets of our solar system, showing relative sizes. Distances from each other are not to scale. Details of the planets appear on the following two pages.



Each planet rotates on its own axis as well as revolving around the sun. Except for Pluto, whose orbit is inclined some 17°, the plane of the solar system is nearly flat.



Venus at one of closest points to earth appears as a crescent. Dense cloud cover prevents observation of planet's surface.



Polar cap, other surface features of Mars show up in this photo taken during the planet's latest close approach, in 1945.



Jupiter, showing great red spot and atmospheric belts. Largest satellite, Ganymede, is just visible at upper right.



Saturn and its ring system. Outermost ring has fewer particles, appears fainter. The atmosphere belts also show.

THE SOLAR SYSTEM — VITAL STATISTICS

	MERCURY	VENUS	EARTH	MARS	JUPITER	SATURN	URANUS	NEPTUNE	PLUTO
Symbol	☿	♀	⊕	♂	♃	♄	♅	♆	♇
Diameter (in miles)	3,010	7,610	7,918	4,140	86,900	71,500	29,500	26,800	3,600
Mean distance from sun (in millions of miles)	36.0	67.25	92.9	141.5	483.3	886	1,783	2,791	3,671
Mean distance from sun in astronomical units (the distance from the sun to earth or 92,907,000 miles)	0.387	0.723	1.000	1.524	5.203	9.539	19.18	30.06	39.52
Period of revolution around the sun	88 days	224.7 days	365.25 days	1.88 years	11.86 years	29.46 years	84.01 years	164.79 years	248.43 years
Mean period of axial rotation	88 days	Unknown; believed longer than 20 days	23 hr. 56 min.	24 hr. 37 min.	9 hr. 50 min.	10 hr. 2 min.	10 hr. 42 min.	15 hr. 48 min.	6 days (?)
Mean velocity in orbit (in miles per second)	30	22	18.5	15	8	6	4	3	less than 3
Mass (measure of quantity of matter) (earth = 1)	0.0543	0.8136	1.000	0.1069	318.35	95.3	14.54	17.2	0.033 (?)
Mean density (weight divided by volume) (water = 1)	5.46	5.06	5.52	4.12	1.35	0.71	1.56	2.47	2 (?)
Mean surface gravity (earth = 1)	0.27	0.85	1.00	0.38	2.64	1.17	0.92	1.12	0.16 (?)
Weight of a 150-pound man on each planet	57 lb.	132 lb.	150 lb.	58½ lb.	398 lb.	176 lb.	157½ lb.	185 lb.	24 lb. (?)
Albedo (fraction of sunlight reflected)	0.058	0.76	0.39	0.148	0.51	0.50	0.66	0.62	0.16
Magnitude (as seen from earth)	-1.9	-4.4	Not applicable	-2.8	-2.5	-0.4	+5.7	+7.6	+14
Inclination of equator to orbital plane (in degrees)	7.0 (?)	Unknown	23.5	25.2	3.1	26.7	98	29	7 (?)
Inclination to the ecliptic (in degrees)	7.0	3.4	0	1.8	1.3	2.5	0.8	1.8	17.1
Eccentricity of orbit (circle = 0)	0.206	0.007	0.017	0.093	0.048	0.056	0.047	0.009	0.249

	MERCURY	VENUS	EARTH	MARS	JUPITER	SATURN	URANUS	NEPTUNE	PLUTO
When discovered and by whom	Known in antiquity	Known in antiquity	Not applicable	Known in antiquity	Known in antiquity	Known in antiquity	March 13, 1781, by Sir William Herschel	Sept. 23, 1846, by Johann Gottfried Galle acting on computations of Adams and Leverrier	March 13, 1930, by Clyde W. Tombaugh (in position predicted by Percival Lowell)
Named for	Roman messenger of the gods	Roman goddess of love	Not applicable	Roman god of war	Chief Roman deity	Roman god of harvest	Greek mythological ruler of the universe	Roman god of the sea	Greek ruler of the underworld
Notable features	One side constantly faces sun while the other is in perpetual night with temperature at near absolute zero.	Brightest object in sky other than sun and our moon. Surface has never been seen because of dense cloud cover.	Only planet in the solar system definitely known to support life.	Ruddy in appearance, has "canali," discovered in 1877 by Schiaparelli, patches of apparently blue-green vegetation, polar caps.	Tremendous axial speed has flattened poles, caused equator to bulge. At times giant red spot can be seen on surface.	Planet's specific density less than water. Unique rings believed to be particles coated with or composed of ice.	Equator tilts to orbit more than 90° so Uranus presents first one pole then the other to the sun.	May once have had Pluto as one of its satellites.	Orbit so eccentric that when Pluto is closest to the sun, it is nearer than Neptune.
Atmosphere	Believed to have none.	Carbon dioxide; otherwise undetermined because of cloud cover.	78% nitrogen, 21% oxygen, traces of carbon dioxide and argon.	Nitrogen, argon, little oxygen, some carbon dioxide.	Methane, ammonia.	Methane, some ammonia.	Methane, ammonia.	Hydrogen, methane.	Believed to have none.
Probable temperature (in degrees F)	+700 to -450	+68	+120 to -60	+80 to -130	-270	-330	-380	-400	Unknown
Known satellites	None	None	1	2	12	9	5	2	None known
Names of satellites	None	None	Moon	Phobus Deimos	Io, Europa, Ganymede, Callisto, plus numbers V to XII	Mimas, Enceladus, Tethys, Dione, Rhea, Titan, Hyperion, Iapetus, Phoebe	Miranda, Ariel, Umbriel, Titania, Oberon	Triton Nereid	None
Escape velocity (in miles per second)	2.2	6.3	7	3.1	37	22	13	14	7 (?)
Minimum distance from earth (in millions of miles)	48	24	Not applicable	34.6	367	745	1,608.8	2,679.6	2,650
Time radio waves would take from earth	4½ min.	2 min. 18 sec.	Not applicable	4 min. 21 sec.	35 min. 11 sec.	1 hr. 11 sec.	2 hr. 32 min.	4 hr. 2 min.	6 hr. 25 min.
Time to travel from earth at 25,000 mph	83 1/3 days	43 1/3 days	Not applicable	57 2/3 days	611 2/3 days	1,241 2/3 days	2,681 1/3 days	4,466 days	4,446 2/3 days



Comets, strange objects with little mass but great size, travel in highly elongated paths around the sun. Some take as much as 50,000 years to complete one orbit. Best known comet is Halley's (above), next due here in 1986.

produces about 4,000,000 tons of light each second (of which four pounds per second reach earth).

This great solar thermonuclear furnace has been operating for some five or six billion years and, having used only about ten percent of its entire supply of hydrogen, appears good for at least another six billion.

The nine known planets whose features are summarized on the two preceding pages (one more planet, Planet X, beyond outermost Pluto, has been hypothesized) move around the sun in the same direction and, generally, the same plane. They are kept in orbit by the sun's great gravitational attraction. Mercury, Venus, our earth, and Mars form an inner group of dense, dwarf planets, separated from the outer group of huge liquid planets and far smaller and denser Pluto by millions of miles and a belt of asteroids.

More than 2,000 of these asteroids, or tiny planets—some no more than "mountains broken loose"—are known. The largest, Ceres, is only 480 miles in diameter. It has been estimated that as many as 40,000 may exist. Some authorities believe the asteroids may be the fragmentary remains of a planet that once existed between Mars and Jupiter.

In addition to the planets, their satellites, and the asteroids, the solar system contains comets, meteors, dust, and interplanetary gas. Of these, the comets are, perhaps, the strangest of all. A French physicist once called comets



The beauty of a spiral nebula is apparent in this view of star cluster in Triangulum, 1,400,000 light-years distant.



Nearly edge-on view of "Sombrero" spiral galaxy in Virgo constellation shows disc with bulging nucleus made up of millions of stars, a configuration not unlike our Milky Way galaxy. Dust clouds in the system cause the dark band.

"visible nothings." Their number is unknown but very large. They have little mass but great size and usually travel highly elongated paths around the sun that may take as long as 50,000 years for a single orbit.

The "shooting stars" that can almost always be seen on a dark night are meteors—tiny particles that approach earth at speeds up to fifty miles a second and vaporize when they enter earth's upper atmosphere.

Our sun, with its planets and other impedimenta, is but one star in the Milky Way galaxy, the total population of which has been estimated at up to 100,000,000,000 stars. The galaxy is fried-egg shaped, about 100,000 light-years wide (each light-year being 5.88 trillion miles) and 5,000 light-years thick at the "yolk."

Our galaxy is only one among billions of others, all retreating from one another at speeds up to that of light itself, in an "expanding universe."

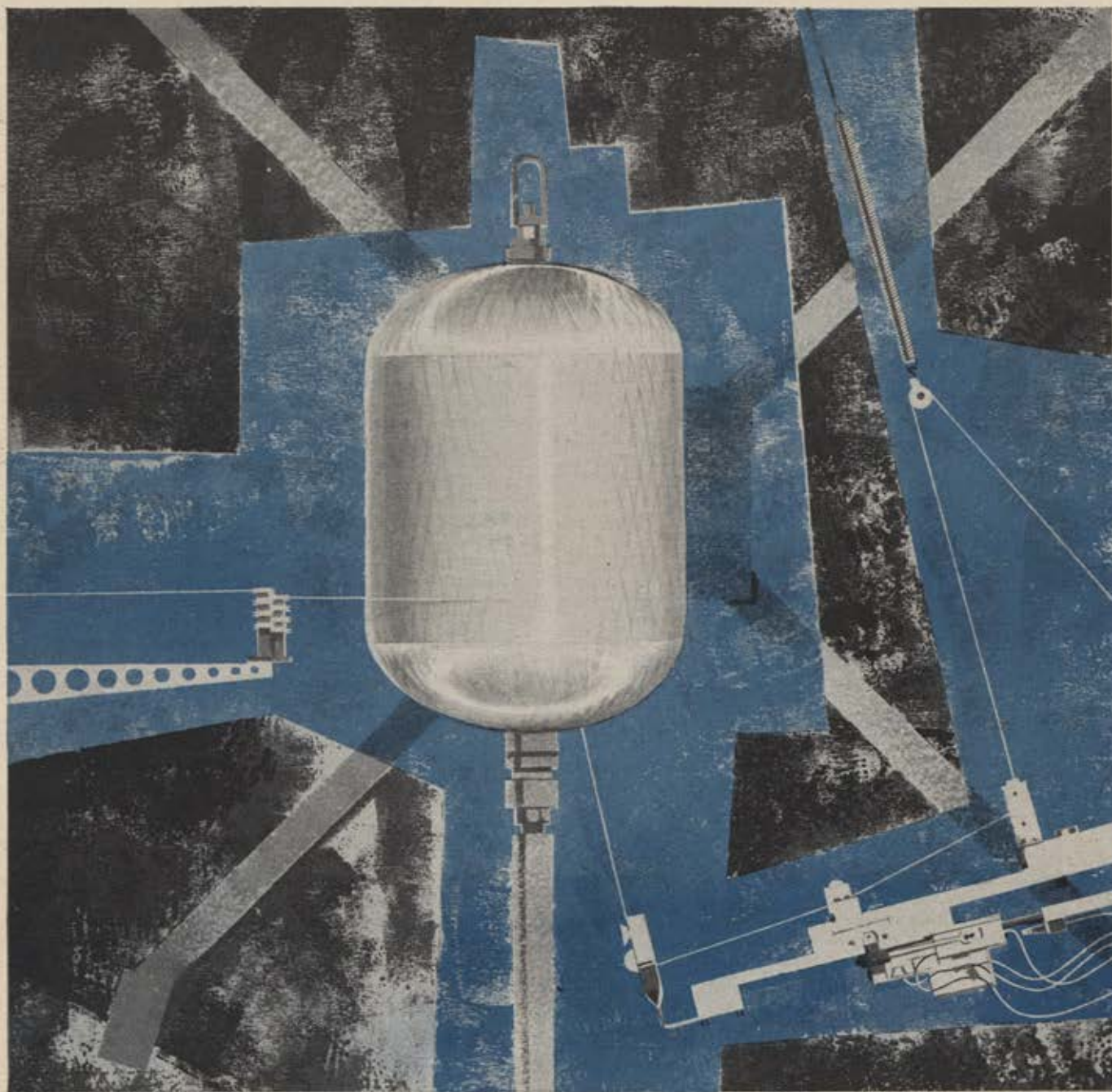
How did this all come about? Three theories are prevalent:

- The "evolutionary" or "big-bang" theory suggests that about 6,000,000,000 years ago all matter was concentrated in a "superatom" of inconceivably high density in a relatively small region of space and that a titanic explosion threw matter apart at great speeds. After a period of expansion, clusters of galaxies formed which have since continued moving apart, as they will continue to do throughout eternity.

- The "expansion-contraction" theory takes this a step further and says the outward expansion will continue but at a decreasing rate until mutual gravitational attraction reverses the direction. Then the universe will contract to form another superatom, when another explosion will start the process all over again.

- The third theory is the "steady-state" or "continuous-creation" theory. It suggests that creation of hydrogen—the fundamental stuff of the universe—may be continuously going on at a rate matching the expansion of the universe so that space is constantly being replenished with new matter. In these terms, the *total* universe had no beginning and will have no end, although each individual hydrogen atom had a beginning. Further, an observer anywhere in the universe would be correct to regard himself at the center of the universe, since all else would be receding from him at a uniform rate.

—RICHARD M. SKINNER



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A Missile and Space GLOSSARY

Ablation. Melting of nose-cone materials during reentry of spacecraft or other vehicles into the earth's atmosphere at hypersonic speeds to dissipate kinetic energy and prevent excessive heating of the main structure.

Abort. In research and development: an uncompleted missile flight or an uncompleted hold-down test resulting from a failure of equipment or of a system other than the one undergoing test. In a tactical operation, simulated or real: a missile failure either on the ground or in flight; a missile that fails to complete a programmed flight.

Absolute zero. Theoretical temperature at which all thermal motion or heat action ceases, approximately -273.16 degrees C, -459.69 degrees F, zero degrees K, and zero degrees R.

Acceleration. Velocity increase or the rate of velocity increase. In physics, any velocity change—increase or decrease.

Accelerometer. An instrument that measures one or more components of the accelerations of a vehicle.

Acid trailer. A trailer used to transport acid fuels or oxidizers.

Actuating system. A system in a guided or ballistic missile supplying and transmitting energy for operation of devices within the missile.

Adapter skirt. Flange or extension of a missile stage or section providing a means of fitting another stage or section to it.

Additive. A substance added to a propellant to achieve some purpose such as a more even rate of combustion.

Advanced Research Projects Agency (ARPA). Agency of Department of Defense sponsoring research in missile defense, solid propellants, materials, communications satellites, and tracking.

Aeroballistics. Term derived from aerodynamics and ballistics, dealing primarily with the motion of bodies whose flight path is determined by applying the principles of both sciences to different portions of the path.

Aerodynamic heating. The heating of an aerospace vehicle due to friction of air, significant at high speeds as during reentry.

Aerodynamic missile. Missile using aerodynamic forces to maintain its flight path, generally winged and guided; Snark, Matador, and Bomarc are aerodynamic missiles.

Aerodynamics. Science of motion of bodies relative to the air and the forces acting on the bodies, especially in flight through the air.

Aeroembolism. Formation of gas bubbles (principally nitrogen) in body tissues after exposure to low atmospheric pressure, as in high-altitude flying without benefit of a pressure suit or pressurized cabin. Danger to unprotected travelers in vacuum of space.

Aeromedicine. See aerospace medicine. Alternate term for aviation medicine or aerospace medicine.

Aeronautics. Art, science, or business of designing, manufacturing, and operating vehicles that move through the air.

Aeronomy. Science of the atmosphere of the earth or other spatial bodies, especially in respect to properties, motions, reactions, and changes in reaction to radiation bombardments from space, or its relations to its primary body.

Aeropause. Upper region of the atmosphere, in which the atmosphere ceases to support manned or unmanned flight.

Aerospace. The earth's envelope of air and the space above it, the two considered as a single realm for activity in the flight of air vehicles and the launchings, guidance, and control of ballistic missiles, earth satellites, space vehicles, and the like.

Aerospace craft. An aerospace vehicle.

Aerospace power. The entire aeronautical and astronautical capacity of a nation.

Aerothermodynamic border. Area above an altitude of about 100 miles, where the atmosphere becomes so rarefied that there is no longer any significant heat-generating air friction on the skin of vehicles.

Aerothermodynamics. Branch of thermodynamics that treats of mechanical actions or relations of heat generated by friction between air particles and a moving body.

Afterbody. A companion body that trails a satellite, or an unprotected section, or piece of a ballistic missile that reenters the atmosphere behind the nose cone or other body protected for reentry.

Afterburning. Characteristic of some rocket engines to burn irregularly after main burning and thrust have stopped.

Agenda. Second stage of Air Force Discoverer vehicle, containing payload, all of which is designed to attain orbit.

Agravic. Unaffected by gravitation. Weightless.

Aimed missile. Missile aimed on its launcher so as to attain a desired trajectory, but not guided during flight. Unguided missile.

Air. The mixture of gases in the earth's atmosphere. The element that gives lift to aircraft.

Air breakup. Destruction of a vehicle by aerodynamic forces on its reentry into the atmosphere, sometimes deliberately done to retard fall of certain pieces and aid in recovery of records and instruments.

Air-breathing missile. Missile with an engine requiring intake for air combustion of its fuel, contrasted with a rocket-propelled missile carrying its own oxidizer and operable beyond the atmosphere.

Aircraft rocket. Rocket-powered missile carried by, and launched from, an aircraft, guided or unguided.

Air drag. Drag exerted by air particles on a moving object, as an aircraft or rocket moving through the air, or on an artificial satellite that comes within the upper reaches of the atmosphere during orbit.

Air Force Ballistic Missile Division (AFBMD). Division of Hq. ARDC located at Inglewood, Calif. Responsible for research, development, and initial operational capability of Air Force intercontinental- and intermediate-range ballistic missiles.

Airframe. Assembled structural and aerodynamic components of an aircraft or missile.

Airglow. Nighttime luminescence of the sky caused by the upper atmospheric release of energy absorbed from the sun during the daylight hours.

Air-launched ballistic missile (ALBM). A ballistic missile, generally utilizing a solid propellant, carried aloft and launched from an aircraft.

Air Research and Development Command (ARDC). A United States Air Force major air command at Andrews AFB, Md., conducting research and development on Air Force aerospace weapon systems and equipment.

Air-to-air missile (AAM). Missile launched from an aircraft at an air target.

Air-to-surface missile (ASM). Missile launched from an aircraft at a surface target.

Air-to-underwater missile (AUM). Missile launched from an aircraft toward an underwater target.

Albedo. The ratio of light reflecting from an unpolished surface to the light falling upon it. Term is used in reference to light reflected from the moon or planets.

ALBM. Air-launched ballistic missile.

Alcohol. Ethyl alcohol (C_2H_5OH) or methyl alcohol (CH_3OH), used with liquid oxygen as a bipropellant.

Alga (usually plural, algae). Unicellular and multicellular

plants considered as a potential source of food in a closed ecological system for space vehicles.

Alpha Centauri. Star in the constellation Centaurus, seen in the Southern Hemisphere, about as near to our sun as Proxima Centauri, some 4.3 light-years distant. Alpha Centauri is the third brightest star in the heavens.

Alpha particle. The nucleus of a helium atom.

Ambient conditions. Environmental conditions such as pressure or temperature.

Anacoustic zone. Zone of silence in space. The region of altitude where distances between rarefied air molecules are so great that sound waves are not propagated.

Angstrom unit. Unit for measuring the wave length of light, equal to one hundred-millionth of a centimeter.

Anhydrous. Free of water.

Aniline. Liquid compound $C_6H_5NH_2$ used as a rocket fuel.

Anoxia. An absence of oxygen in the blood cells or tissues of the body; hazard of high-altitude flight without protective oxygen equipment.

Antiatom. Postulated elemental particle consisting of a negative nucleus with positive electrons in orbit. The atom of the known world consists of a positive nucleus with negative electrons in orbit.

Antigravity or antigravitation. A still-to-be-discovered energy field or technique to cancel or reduce gravitational effects.

Anti-G suit. A tight flying suit that covers parts of body below the heart, designed to retard the flow of blood to the lower body in reaction to acceleration or deceleration. An antiblackout suit. Bladders or other devices may be used to inflate and increase body constriction as G force increases.

Antimatter. Matter theoretically considered to exist, consisting of antiatoms.

Antimissile missile. Now-hypothetical defensive missile launched to intercept and destroy other missiles in flight.

Aphelion. Point on an elliptical orbit around the sun which is farthest from the sun.

Apogee. Point on an elliptical orbit (of the moon or artificial satellite) around the earth which is farthest from the earth.

APU. Auxiliary power unit.

Aral'sk. Russian town some seventy miles southwest of a space-probe launch site, located in Kazakh Republic.

Area defense. Defense against air or missile attack designed to protect a large area surrounding the specific target such as a city or base rather than the target point alone.

Argon. A colorless, odorless, and inert gaseous element, comprising nearly one percent of air.

Argus theory. Theory that a shield of radiation placed above the earth's atmosphere would burn up incoming nuclear warheads or make infrared targets of them.

Arming. Process of changing a fuze or warhead from a safe condition to a state of readiness for initiation.

Arming signal. Radio signal for arming a warhead.

Army Ballistic Missile Agency (ABMA). An agency of the US Army with missile research and development facilities at Huntsville, Ala.

Army Rocket and Guided Missile Agency (ARGMA). Army research agency for development of rockets and guided missiles at Huntsville, Ala.

ARPA. Advanced Research Projects Agency.

Artificial gravity. Proposed system to simulate gravity by rotating a cabin about the longitudinal axis of a spacecraft.

Asteroid, or minor planet. The many thousands of small bodies revolving around the sun, mainly between the orbits of Mars and Jupiter. Ceres, the largest known, is 480 miles in diameter.

Astrionics. Electronics as applied to astronautics.

Astro. Prefix meaning "star" used as combining form, as in astrobiology.

Astrobiology. Branch of biology concerned with the discovery or study of life on other planets.

Astronaut. Navigating in space. Astronautics.

Astronaut. One who flies or navigates through space.

Astronautics. The art or science of designing, building, and operating space vehicles.

Astronautics. To guide and direct a spacecraft from within the vehicle, by means of observations on celestial bodies.

Astronomical unit. Mean distance of the earth from the sun, equal to 92,907,000 miles.

Astronomy. Oldest of the sciences. Treats of the celestial bodies, their magnitudes, motions, constituents, location, etc.

Astrophysics. The study of the physical and chemical nature of celestial bodies and their environs.

Astrotracker. A star tracker.

Atlantic Missile Range (AMR). A 5,000- to 6,000-mile instrumented range for testing ballistic and guided missiles located between Cape Canaveral, Fla., and a point beyond Ascension Auxiliary AFB, near the middle of the South Atlantic.

Atmosphere. The body of air surrounding the earth; also, the body of gases surrounding or comprising any planet or other celestial body.

Atmospheric braking. Action of atmospheric drag in decelerating a body approaching a planet; can be deliberately used where sufficient atmosphere exists, to reduce velocity before landing.

Atmospheric flare. Projection beyond the upper limits of the normal atmosphere. Comparable to a solar flare.

Atmospheric refraction. Refraction of light from a distant point by the atmosphere, caused by its passing obliquely through varying air densities.

Atomic rocket. Projected rocket engine in which energy for the jet stream would be generated by atomic fission or fusion.

Attenuation. Diminution of effectiveness of an emission of radiant energy, such as a radio signal, caused by distance or passage of the emitted wave through the exhaust flame of the rocket engine, etc.

Attitude. Orientation of an air vehicle as determined by the inclination of its axis to a frame of reference, usually the earth.

Attitude control system. System within the flight-control system to maintain the desired attitude of a vehicle.

Attitude jets. Sometimes called steering jets, attitude-control jets, or roll, pitch, and yaw jets; fixed or movable gas nozzles on a rocket, missile, or satellite operated continuously or intermittently to change the attitude or position either in the atmosphere or in space.

Auntie. Slang for antimissile missile.

Aurora. Commonly known as northern and southern lights; high-altitude airglow caused by solar particles, predominantly protons, moving as charged particles in the earth's magnetic field and interacting with the earth's atmosphere.

Auto-igniting propellant. Any propellant that ignites at room temperature with a small time delay.

Auto-ignition temperature. The temperature at which combustible materials ignite spontaneously in air.

Avionics. Contraction of aviation electronics.

Azusa system. Launch site tracking system developed by Convair for measuring missile velocity and position during early flight of the missile.

Backout. Reversing the countdown sequence because of the failure of a component in a missile or a hold of unacceptable duration.

Backup. Designed to come along closely behind an earlier missile system or project to complement the latter or take advantage of techniques and processes learned on the earlier development.

Ballistic missile. Any projectile, guided during powered flight in the upward part of its trajectory that becomes, usually after a successive loss of fallaway sections, a free-falling or ballistic body after fuel cutoff.

Ballistic Missile Division. Air Force Ballistic Missile Division.

Ballistic Missile Early Warning System (BMEWS). Electronic system to provide detection and early warning of attack by enemy intercontinental ballistic missiles, supplementing the present Distant Early Warning (DEW) Line built across the top of the continent to warn against bomber attack.

Ballistic Missiles Center. An office of Hq. Air Materiel Command at Inglewood, Calif., providing logistics support for specified missiles.

Ballistics. Science of the motion, behavior, appearance, or modification of missiles or other vehicles as they are acted upon by propellants, wind, gravity, temperature, or any other modifying substance, condition, or force.

Ballistic trajectory. The curved portion of a missile trajectory traced after the propulsive force is cut off and the body is acted upon only by gravity, aerodynamic drag, and wind.

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Balloon-type missile. A missile that requires the pressure of its propellants (or substitute gases) within it to give it structure integrity. Atlas is an example.

Barber chair. An adjustable type of seat that can quickly position the occupant from an upright seated position to a supine or semisupine position to increase tolerance to high acceleration.

Beam-rider guidance. A scheme of guidance in which the missile follows a radar beam to the target by means of onboard computers and controls sensitive to radar beams.

Beast. Familiar term for a large rocket.

Bends. Acute pain and discomfort in the arms, legs, and joints resulting from the formation of nitrogen and other gas bubbles in body tissues and fluids, caused by exposure to reduced barometric pressure.

Beta rays. Electrons given off by radioactive atoms.

Binary star. Two stars revolving around a common center of gravity.

Bioastronautics. Study of the effects of astronautics upon animal or plant life.

Biodynamics. Study of forces acting upon bodies in motion or in the process of changing motion, as they affect living beings.

Biomedicine. Combined discipline of biology and medicine for analysis of human tolerances to and protection against environmental variances.

Biopak. Container for housing a living organism in a habitable environment and to record biological functions during spaceflight.

Biosatellite. Satellite designed to carry an animal (as man) or plant.

Biosphere. That part of the earth and its atmosphere in which animals and plants live.

Bipropellant. A rocket propellant consisting of two unmixed or uncombined chemicals (fuel and oxidant) fed to the combustion chamber separately.

Bird. Figurative name for a missile or earth satellite.

Black box. Electronic unit, as a robot pilot, that may be mounted in, or removed from, a missile or the like as a single package. Module.

Blastoff. Missile launch. Slang.

Blockhouse. Heavily reinforced building, to withstand blast and heat, housing electronic controls and equipment for preparing and launching a missile.

Blowoff. Separation of a section from the remainder of the rocket vehicle by application of explosive force for purposes of retrieving instruments after they have collected required information.

Boattail. Rear section of a ballistic body, sometimes tapered but squared off at the end, and serving as the base of the missile during launch.

Boiloff. Vaporization of a cold propellant such as liquid oxygen or hydrogen as the propellant mass rises to higher temperatures because of exposure to ambient conditions through walls of the missile tank or other uninsulated containers.

Boost. Rocket propulsion, either by solid or liquid propellants, during the initial climb, the liftoff, and the first phase of propelled flight of a missile.

Booster. Propulsion unit used in initial stage of flight.

Booster engine. An engine, especially a booster rocket, that adds thrust to the thrust of the sustainer engine, or provides propulsion for a special phase of flight.

Boost-glide vehicle. A rocket-booster winged vehicle capable of leaving the atmosphere and reentering under aerodynamic control in low-angled unpowered gliding maneuvers.

Boron or boron hydride. High-energy fuel with a high specific impulse.

Braking ellipses. A series of orbital approaches to the earth's or any other planet's atmosphere for the purpose of slowing a rocket preparatory to landing.

Breakoff phenomenon. Feeling during high-altitude flight of being totally detached from earth and human society.

Bremsstrahlung (German: brake radiation). Radiation of energy from charged particles after they have been decelerated or retarded, as in the case of atomic particles entering the earth's atmosphere, slowed down by collision with air particles.

Brennschluss (German: combustion termination). Cessation of fuel burning in a rocket, resulting from consumption of the propellants, from deliberate shutoff or other cause.

Bubble colony. Colony of persons placed on the moon or other spatial body provided with individual or group environmental capsules.

Burnout. Point in time or in the missile trajectory when propellant is exhausted or its flow cut off.

Burnout velocity. The velocity attained at the time the propellant is exhausted or fuel cutoff occurs.

Can. A shield or container for a missile, by which environment can be controlled.

Canopus. The second brightest star in the heavens, a star in the constellation Argos.

Cape Canaveral. Cape on the East Coast of Florida, the site of Cape Canaveral Auxiliary AFB, used as laboratory for launching missiles and/or space vehicles. The Air Force Missile Test Center operates launching site. Officially known as the Atlantic Missile Range.

Capsule. Sealed, pressurized cabin with an acceptable environment, usually for containing a man or animal for extremely high-altitude flights, orbital spaceflight, or emergency escape.

Captive firing. Test firing of a complete missile where all or any part of the propulsion system is operated at full or partial thrust while the missile is restrained in the test stand.

Capture. Of a central force field, as of a planet; to overcome by gravitational force the velocity or centrifugal force of a passing body and bring the body under the central force field's control, in some cases absorbing its mass.

Cardiovascular reactivity. The response and function of heart and blood vessels to various types of stress, such as exercise, acceleration, heat, and cold.

Carrier rocket. A rocket vehicle used to carry something, as in the "carrier rocket" of the first artificial earth satellite.

Cavitation. Rapid formation and collapse of vapor pockets in a flowing liquid under very low pressures, a frequent cause of structural damage to rocket components.

Celestial. Pertaining to the sky or universe.

Celestial guidance. Onboard guidance of a missile or vehicle by reference to celestial bodies.

Celestial mechanics. Branch of astronomy concerned with the laws governing the motions of heavenly bodies, natural and now man-made also.

Celestial navigation. Onboard navigation using the celestial bodies for reference; celestial guidance.

Celestial sphere. Imaginary sphere of infinite radius, assumed for navigational purposes, the center of which coincides with the center of the earth.

Centaur. Projected rocket test vehicle to consist of a modified Atlas as the first stage, a liquid-oxygen and hydrogen second stage.

Center of mass. Commonly called center of gravity, the point at which all the given mass of a body or bodies may be regarded as being concentrated as far as motion is concerned. (The center of mass in the earth about which the moon revolves is not at the same point as the center of mass of the *two* bodies as they revolve about the sun.)

Central force field. Gravitational or electromagnetic field that attracts and limits behavior of surrounding objects or particles.

Centrifugal force. Force away from the center of rotation.

Centrifuge. A large motor-driven apparatus with a long rotating arm at the end of which human and animal subjects or equipment can be revolved at various speeds to simulate accelerations encountered in high-performance vehicles.

Centripetal force. A force which is directed toward the center of rotation.

Chamber pressure. The pressure of gases within a firing chamber.

Characteristic length. In propulsion, the ratio of the chamber volume to its nozzle throat area. A measure of the length of travel available for the combustion of propellants.

Charge spectrum. The range and magnitude of electric charges with reference to cosmic particles at a certain altitude.

Checkout. A sequence of operational and calibrational tests needed to determine the condition and status of a weapon system.

Chemical fuel. A fuel depending upon an oxidizer for combustion or for development of thrust, such as liquid or solid rocket fuel, jet fuel, or internal-combustion engine fuel. Distinguished from nuclear fuel.

Chemosphere. A stratum of the atmosphere marked for its photochemical activity. By some meteorologists the chemosphere is considered to be an extension of the stratosphere.

Chlorate candles. Usually, a mixture of solid chemical compounds which, when ignited, liberates free oxygen into the air.

Chromosphere. One of the atmospheric shells of the sun, lying above the photosphere and best visible at time of total eclipse; can be observed spectroscopically at other times.

Chuffing. The characteristic of some rockets to burn intermittently with an irregular puffing noise.

Circular error probable (CEP). An indicator of the accuracy of a missile; used also as a factor in determining the probable damage to a target.

Circular velocity. Critical velocity at which a satellite will move in a circular orbit around its primary, a special case of orbital velocity.

Circumplanetary space. Space relatively close by a planet, especially the space close by the earth, including the outer reaches of the atmosphere.

Cislunar space. Space around the earth beyond the outermost reaches of the terrestrial atmosphere and within the orbit of the moon.

Closed ecological system. A system providing for the body's metabolism in a spacecraft cabin by means of a cycle wherein expired gases and body wastes are reconstituted into oxygen, water, and food.

Closest approach. The place or time at which two planets are nearest each other as they orbit about the sun.

Cluster. Two or more rocket engines bound together so as to function as one propulsive unit.

Coasting flight. The flight of a rocket missile or other vehicle between burnout or thrust cutoff of one stage and ignition of another, or between final burnout and summit altitude or maximum range. Also the unpowered portion of an interplanetary flight.

Cold-flow test. Test of a liquid rocket without firing to check efficiency of a propulsion subsystem that provides for the conditioning and flow of propellants, including tank pressurization, propellant loading, and propellant feeding.

Combustible. Any material or structure which can burn. A relative term; many materials will not burn in one state but will in another. For example, steel wool will burn, structural steel will not.

Comet. One of many loose bodies of gases and solid matter revolving around the sun.

Command destruct. Remote control system which destroys a flight-borne missile, actuated on command of the range safety officer whenever performance degrades enough to be a safety hazard.

Command guidance. The guidance of a missile or vehicle by radio command or by wire.

Companion body. A nose cone, last-stage rocket, or other body that orbits along with an earth satellite. Afterbody; fallaway section.

Conic section. A curve formed by the intersection of a plane and a right circular cone. The conic sections are circular, elliptic, parabolic, or hyperbolic; curves that are used to describe the paths of bodies moving in space.

Conjunction. The passing of two or more celestial bodies in the same degrees of the zodiac. Inferior conjunction is when the planet is between the earth and the sun; superior conjunction is when the sun is between the earth and the planet.

Console. Master instrument panel from which rocket and missile launchings and tests are controlled.

Constellation. Any one of the arbitrary groups of fixed stars, some ninety of which are now recognized. A division of the heavens in terms of any one of these groups.

Contraorbit missile. Missile sent backward along the calculated orbit of a space vehicle.

Controlled environment. Environment in which matters such as humidity, pressure, temperatures, etc., are under control.

Controlled leakage system. A system that provides for the body's metabolism in an aircraft or spacecraft cabin by a controlled escape of carbon dioxide and other waste from the cabin, with replenishment provided by stored oxygen and food.

Controller. Device which receives a measured value of a variable from a sensor, compares that value with some reference value, and supplies a control signal to a control element to maintain the value of the variable within a certain range about the reference value.

Control rocket. A vernier rocket, retrorocket, or other such rocket, used to guide, accelerate, or decelerate a ballistic missile, spacecraft, or the like.

Control system. A system in a missile that serves to maintain attitude stability during powered flight and to correct deflections caused by gusts or other disturbances.

Coriolis effect. Deflection of a body in motion due to the earth's rotation, diverting horizontal motions to the right in the Northern Hemisphere and to the left in the Southern Hemisphere.

Cosmic rays. Extremely fast particles continually entering the upper atmosphere from space which have very great energies because of enormous velocities; potentially dangerous to humans experiencing extended exposure.

Cosmos. Totality of the observed and postulated physical universe.

Countdown. Series of numbered events and checks that take place from the start of rocket-launching operations until the rocket lifts off the launch stand.

Courier. An ARPA project to develop a capability for a delayed communication repeater for use in a satellite.

Creep. Property of a metal which allows it to be permanently deformed when subjected to a stress. Accelerated at elevated temperatures.

Cryogenic fuel. A rocket fuel that either in itself is kept at very low temperatures or combines with an oxidizer kept at very low temperatures.

Cryogenics. The science of low-temperature conditions.

Cutoff. The shutting off of a liquid or solid-propellant combustion process of a rocket engine, causing a rapid drop toward zero thrust.

Cycle checkout. The periodic action of giving a complete physical checkout on missiles held in alert status.

Deceleration. Negative acceleration (slowing down).

Declination. In astronomy and celestial navigation, the angular distance of a celestial equator measured through ninety degrees and named "north" or "south" as the body is north or south of its celestial equator measured on an hour circle.

Decompression sickness. A disorder in deep-sea divers and aviators caused by reduced barometric pressure and evolved gas bubbles in the body, marked by pain in the extremities, occasionally leading to severe central nervous system and neurocirculatory collapse.

Deimos. The outer of the two moons of Mars.

Deluge collection pond. Facility at launch site into which water used especially to cool the flame deflector is flushed as the rocket begins its ascent. Also called a "skinner basin."

Destruct. Deliberate destruction for safety reasons of a rocket missile after it has been launched, but before it has completed its course.

Destruct line. Graphic representation drawn on a geographical map to show the boundary which a missile must not cross during flight. A missile which starts beyond the destruct lines on either side is immediately destroyed.

Detonation. Extremely rapid reaction in which an oxidizer and fuel combine with large evolution of heat. A high-order detonation, or "true detonation," proceeds with very high speed, generally several thousand feet per second.

Discoverer. Air Force Ballistic Missile Division series of launchings from Vandenberg AFB, Calif., of payloads into polar orbits to obtain data on maneuverability, attitude control, recovery, etc.

Diversionary missile. A missile decoy.

Doppler drift. The drift of a missile as determined through use of Doppler principle by means of radar.

Doppler principle. A principle of physics that, as the distance between a source of constant vibrations and an observer

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diminishes or increases, the frequencies appear to be greater or less.

Doppler radar. Radar that measures the velocity of a moving object by measuring the shift in carrier frequency of the return signal, the shift being proportional to the velocity with which the object approaches or recedes from the radar station.

Doppler shift. A shift of a luminous body's lines in a spectrum toward the red indicating an increase in distance.

Downrange. In a direction away from the launch site and along the line of a missile test range.

Down the slot. Vernacular expression for successful flight of a missile down the test range and within the limits established by range safety personnel.

Drag. Aerodynamic force in a direction opposite to that of flight and due to the resistance of the body to motion in air.

Dry-fuel rocket. A solid-fuel rocket that uses a mixture of fast-burning powder. Used especially as a booster rocket.

Dry weight. Weight of a rocket vehicle without its fuel.

Dual thrust. Thrust derived from two propellant grains using the same propulsion section of a missile.

Dyna-Soar. Projected manned orbital glider or bomber under USAF study.

Dyne. Unit of force that will accelerate a particle having a mass of one gram one centimeter per second per second.

Dysbarism. A general term which includes a complex variety of symptoms within the body caused by changes in ambient barometric pressure, exclusive of hypoxia. Characteristic symptoms (other than hypoxia) are bends and abdominal gas pains at altitudes above 25,000 to 30,000 feet. Increased barometric pressure, as in descent from high altitude, is characterized by painful distention of the ear drums and sinuses.

Earth fixed reference. An oriented system using some earth phenomena for positioning.

Ebullism. Formation of bubbles, with particular reference to water vapor bubbles and the boiling effect in body fluids caused by reduced barometric pressure.

Eccentricity. The degree of deviation from a circular orbit.

Ecliptic. Plane of the earth's orbit around the sun, used as a reference plane for other interplanetary orbits. Also the name for the apparent part of the sun through the celestial sphere.

Ecosphere. Spherical extent inhabited by living organisms or suitable for life of such organisms. Also, layer of space about the sun extending from and including Venus through Mars.

EDP center. Electronic data-processing center.

Effective atmosphere. That part of the atmosphere which effectively influences a particular process of motion, such as aerodynamic support, or air friction, its outer limits varying according to the terms of the process of the motion considered.

Effective exhaust velocity. The velocity of an exhaust stream after the effects of friction, heat transfer, nonaxially directed flow, and other conditions have reduced it.

Effector. The mechanical means of maneuvering a missile during flight, an aerodynamic surface, a gimbaled motor, or an auxiliary jet.

Egads button. Button used by range safety officer to destroy a missile in flight if its plotted course is predicted to go beyond destruct line.

Electric engine. Projected ion or plasma engines, so named because of the separation of charged particles.

Electrojet. Current sheet or stream moving in an ionized layer in the upper atmosphere. Electrojet move around the equator following the subsolar point and also in polar regions where they give rise to auroral phenomena; generally caused by solar activity.

Electromagnetic wave. Form in which radiant energy travels, produced by oscillation of an electric charge, and including waves of radio, infrared, visible light, ultraviolet light, X-rays, gamma rays, cosmic rays, when considered as quanta of energy.

Electrons. High-speed, negatively charged particles forming outer "shell" of atom.

Ellipse. A curve described about two fixed points (the foci) so that the sum of the distances between any point on the curve and foci is equal to the sum of the distance between any other point on the curve and foci. Paths of planets in solar system are elliptical.

Emissivity. The term for relative power (of a surface or a material composing a surface) to emit heat by radiation.

Engine. The powerplant of a vehicle.

Ephemeris. Book of tables giving daily positions of celestial bodies.

Erector launcher. A mobile equipment that erects a missile onto launching position, then serves as a launcher.

Escape. To achieve a sufficient velocity outward from a primary body, as earth, so as neither to fall back to the body nor to orbit it.

Exhaust stream. The stream of gaseous, atomic, or radiant particles that emit from the nozzle of a rocket or other reaction engine.

Exhaust velocity. The velocity of gases that exhaust through the nozzle of a rocket engine or motor relative to the nozzle.

Exosphere. The outermost fringe or layer of the atmosphere, where collisions between molecular particles are so rare that only the force of gravity will return escaping molecules to the upper atmosphere.

Exotic fuel. New fuel combinations under study and development for aircraft and rocket use with the purpose of attaining far greater thrusts than now possible.

Explorer. Any of the earth satellites launched under the research and development program of the Army Ballistic Missile Agency or under programs of the National Aeronautics and Space Administration.

Exterior ballistics. That branch of ballistics concerned with the behavior of a missile during flight, influenced by conditions of air density, temperatures, velocity, and the like. Sometimes called "external ballistics."

Extragalactic nebulae. Star systems outside our own galaxy.

Fallaway section. Any section of a rocket vehicle that is cast off and falls away from the vehicle during flight, especially such a section that falls back to earth.

Final trim. Action in the flight of a ballistic missile that adjusts it to the exact direction programmed for its flight, normally accomplished by use of vernier engines.

Fin-stabilized. Directional stability of a projectile obtained by placement of fixed or adjustable airfoils on the airframe.

Firing Chamber. Chamber in rocket engine in which the fuel and oxidizer are ignited, and in which pressure of gases is built up to provide an exhaust velocity sufficient for thrust.

First motion. First indication of motion of the missile or test vehicle from its launcher. Synonymous with "takeoff" for vertically launched missiles.

Fission. The release of nuclear energy through splitting of atoms.

Flame bucket. Opening built into the pads of some rockets into which the hot gases of the rocket pour as thrust is built up.

Flight readiness firings (FRF). Missile system tests of short duration conducted with the propulsion system operating while the missile is secured to the launcher.

FPS. Feet per second.

Free fall. The motion of any unpowered body traveling in a gravitational field.

Free-flight trajectory. That part of a ballistic missile's trajectory that begins with thrust cutoff and ends at reentry.

Freeze-out method. A method for controlling the composition of gases or liquids by freezing and separating frozen matter from the remaining liquids or fluids.

Fuming nitric acid. A highly concentrated solution of nitric pentoxide (N_2O_5) in water, red, brown, or white in color, and more active than the clear nitric acid, sometimes used as an oxidizer in a rocket engine.

Fusion. The combining (fusing) of atoms to release energy.

G or G-force. The measure or value of the gravitational pull of the earth as modified by the earth's rotation, equal to the acceleration of a freely moving body at the rate of 32.16 feet per second per second.

Galaxy. Spiral system of stars; our galaxy, a disc-shaped aggregation of stars called the Milky Way, includes the solar system, far out on one of its spiral arms.

Gamma radiation. Electromagnetic radiation similar to X-rays
(Continued on page 155)



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originating from the nucleus, having a high degree of penetration.

Gantry. Crane-type structure, with platforms on different levels, used to erect, assemble, and service large rockets or missiles; may be placed directly over the launching site and rolled away just before firing.

Gasoline. A hydrocarbon fuel used as a bipropellant with liquid oxygen.

Gegenschein. Faint light area of the sky always opposite the position of the sun on the celestial sphere. Believed to be the reflection of sunlight from particles moving beyond the earth's orbit.

Geocentric. Relating to or measured from the center of the earth; having, or relating, to the earth as a center.

Geodesy. The science which treats mathematically of the figure and size of the earth.

Gimbale motor. A rocket motor mounted on a gimbal, i.e., on a contrivance having two mutually perpendicular axes of rotation, so as to obtain pitching and yawing correction moments.

Goddard, Robert H. American rocket pioneer.

Goddard Space Flight Center (GSFC). NASA research center at Greenbelt, Md.

Goldstone tracking facility. A radio telescope located at Army's Camp Irwin in Barstow, Calif.

Go-no-go. A missile launch controlled at the end of the countdown as to permit an instantaneous change in decision on whether to launch or not to launch.

GOX. Gaseous oxygen.

Grain. Body of a solid propellant used in a rocket fashioned to a size and shape to burn smoothly without severe surges or detonations.

Gravireceptors. Specialized nerve endings and organs in skeletal muscles, tendons, joints, and in the inner ear, furnishing information to the brain on body position, equilibrium, the direction of gravitational forces, and sensation of "up" and "down."

Gravisphere. Spherical extent in which the force of a given celestial body's gravity is predominant in relation to that of other celestial bodies.

Gravitation. Force of mutual attraction between all matter in the universe. Varies directly as the product of the bodies' masses, and inversely as the square of the distance between them.

Gravity. Force of gravitation which tends to pull bodies toward the center of mass of the earth, giving them weight.

Gravity well. Analogy in which the gravitational field is considered as a deep pit out of which a space vehicle has to climb to escape from a planetary body.

Gross error. A missile strike at such distance from the target as to do no useful damage.

Ground start. A propulsion starting sequence through ignition to main stage which is initiated and cycled through to completion on the ground. In large rocket vehicles this ground start is commonly effected from pressurized propellant tanks external to the missile.

Ground-support equipment. All ground equipment that is part of the complete weapon system and that must be furnished to ensure complete support of the weapon system.

Ground-to-ground. Of a missile: launched from the surface to strike at a target on the surface.

G-tolerance. A tolerance in a person or other animal, or of a piece of equipment, to G-force of a particular value.

Guidance. The effect on a missile or vehicle that moves it in a desired direction, in response to controls exercised by a person inside the vehicle or by a preset or self-reacting automatic device within it, or by an onboard device reacting to outside signals.

Guided aircraft missile. A type of self-propelled missile, normally carried by a parent aircraft, which after launching can be guided to surface targets.

Guided aircraft rocket. A type of self-propelled armament carried by aircraft for attack on airborne targets, and which after launching can be guided to the target.

Guided missile. An unmanned vehicle moving above the earth's surface whose trajectory or flight path is capable of being altered subsequent to launch, or substantially throughout flight, as distinguished from a ballistic missile.

Gyroscope. Device consisting of a wheel so mounted that its spinning axis is free to rotate about either of two other axes perpendicular to itself and to each other; once set in rotation, its axle will maintain a constant direction, even when the earth is turning under it; when its axle is pointed due north, it may be used as a gyro-compass.

Half stage. A booster unit in a stage-and-a-half rocket.

Hard base. Missile launching base that is protected against nuclear bomb attack.

Heat exchanger. A device for transferring heat from one substance to another, as by regenerative cooling.

Heat sink. A contrivance for the absorption or transfer of heat away from a critical part or parts, as in a nose cone where friction-induced heat may be conducted to a special metal for absorption.

Heat transfer. In missilery, spread of heat across the combustion chamber of walls of a rocket engine; an acute design problem.

Heaviside layer. Region of the ionosphere that reflects radio waves back to earth; also called Kennelly-Heaviside layer.

Heavy cosmic ray primaries. Positively charged nuclei of elements heavier than hydrogen and helium up to, but not including, atomic nuclei of iron, comprising about one percent of the total cosmic ray particles.

Heliocentric. Measured from the center of the sun; related to, or having the sun as a center.

Heterosphere. That part of the upper atmosphere wherein the relative proportions of oxygen, nitrogen, and other gases are unfixed and wherein radiation particles and micrometeoroids are mixed with air particles.

Hohmann orbit. Proposed paths of flight from earth's orbit to orbits of other planets, using minimum energy.

Hold. Scheduled or unscheduled delay or pause in the launching sequence or countdown of a missile or space vehicle.

Hold-down test. Testing of some system or subsystem in a missile or other vehicle while the vehicle is restrained in a stand.

Homing guidance. The guidance of a missile or other vehicle by means of an internal receiver that is sensitive to emissions at the objective, such as infrared or electronic radiations.

Homosphere. That part of the atmosphere made up, for the most part, of atoms and molecules found near the earth's surface, and retaining through the entire extent the same relative proportions of oxygen, nitrogen, and other gases.

Hot configuration. Test missile equipped and ready for firing, either static or live.

Hot test. Conducted by actually firing the propellants. A hot test may be live or static, or conducted in a confined place.

Hydrazine. Liquid base, NH_2NH_2 rocket fuel.

Hydrazone. An exotic fuel formed by the action of hydrazine or one of its derivatives on a compound containing the carbonyl group CO.

Hydrocarbon fuel. Gasoline or kerosene.

Hydrogen (H). Lightest chemical element, flammable, colorless, tasteless, odorless gas in its uncombined state. Used in liquid state as a rocket fuel.

Hydrosphere. The water envelope of a planet.

Hydrostatic effects. The pressures exerted by a column of liquid under normal gravitational conditions on the surface of the earth or in a gravitational field during an acceleration.

Hydne. Also Hidyne. Hydrazine-based liquid rocket fuel.

Hyperacoustic zone. The region in the upper atmosphere above sixty miles where the distance between the rarefied air molecules roughly equals the wave length of sound, so that sound is transmitted with less volume than at lower levels. Above this zone, sound waves cannot be propagated.

Hyperbola. A conic section made by a plane intersecting a cone of revolution at an angle smaller than that of a parabola. The value of its eccentricity is greater than one.

Hypergol. A rocket fuel or propellant that ignites spontaneously upon contact with the oxidizer. A propulsion system that utilizes such a fuel.

Hypersonic. Velocities of five or more times the speed of sound in the surrounding medium.

(Continued on following page)

Hypoxia. Oxygen deficiency in the blood, cells, or tissues of the body in such degree as to cause psychological and physiological disturbances. May result from scarcity of oxygen in the air being breathed, or from inability of the body tissues to absorb oxygen under conditions of low barometric pressure.

ICBM. Intercontinental ballistic missile.

Ice frost. A thickness of ice that gathers on the outside of a rocket vehicle over surfaces supercooled by liquid oxygen inside the vehicle.

IGY. International Geophysical Year.

Inertial force. The force produced by the reaction of a body to an accelerating force, equal in magnitude and opposite in direction to the accelerating force. Inertial force endures only as long as the accelerating force endures.

Inertial guidance. An onboard guidance system for missiles and satellite vehicles where gyros, accelerometers, and possibly a gyro-stabilized platform satisfy guidance requirements without use of any ground-located components; entirely automatic, following predetermined trajectory.

Infrared light. Light in which the rays lie just below the red end of the visible spectrum.

Inhibitor. A substance bonded, taped, or dip-dried onto a solid propellant to restrict the burning surface and to give direction to the burning process.

Initial mass. Takeoff mass of a rocket.

Integral tank. A fuel or oxidizer tank built within the normal contours of an aircraft or missile and using the skin of the vehicle as part of the walls of the tank.

Intercontinental ballistic missile (ICBM). A ballistic missile with sufficient range to strike at strategic targets from one continent to another. ICBM minimum range is approximately 5,000 miles.

Interface. In a rocket vehicle or other system, a common boundary between one component and another.

Interior ballistics. That branch of ballistics concerned with the behavior, motion, appearance, or modification of a missile when acted upon by the ignition and burning of a propellant. Sometimes called "internal ballistics."

Intermediate-range ballistic missile (IRBM). A ballistic missile with a range of 200 to 1,500 miles.

Interplanetary. Between planets.

Interstellar. Between stars.

IOC. Initial operational capability.

Ion. An electrically charged atom or group of atoms. A positively charged ion is an atom or group of atoms with a deficiency of electrons; a negatively charged ion is an atom or group of atoms with an added electron.

Ion engine. Projected type of engine in which the thrust to propel the missile or spacecraft is obtained from a stream of ionized atomic particles, generated by atomic fusion, fission, or solar energy.

Ionized layers. Layers of increased ionization within the ionosphere. Responsible for absorption and reflection of radio waves and important in connection with communication and the tracking of satellites and other space vehicles.

Ionosphere. An outer belt of the earth's atmosphere in which radiations from the sun ionize, or excite electrically, the atoms and molecules of the atmospheric gases. The height of the ionosphere varies with the time of day and the season.

IRBM. Intermediate-range ballistic missile.

Isostatic. Under equal pressure from every side.

Isothermal region. The stratosphere considered as a region of uniform temperature.

Ivory tower. Vernacular for vertical test stand.

Jetavator. A control surface that may be moved into or against a rocket's jet stream, used to change the direction of the jet flow for thrust vector control.

Jet steering. The use of fixed or movable gas jets on a space weapon, ballistic missile, or sounding rocket to steer it along a desired trajectory, during both propelled flight (main engines) and after thrust cutoff.

Jet stream. The stream of gas or fluid expelled by any reaction device, especially the stream of combustion products expelled from a jet engine or rocket engine. Also, a narrow

band of high-velocity wind, especially near the base of the stratosphere.

Jodrell Bank. Site of a large radio telescope, located near Manchester, England, with a paraboloidal receiver 250 feet in diameter, sixty feet deep.

Jovian. Of or pertaining to the planet Jupiter; associated with Jupiter.

Jovian planet. Any one of the giant planets, i.e., Jupiter, Saturn, Uranus, or Neptune. Usually in plural "Jovian planets."

JPL. Jet Propulsion Laboratory.

Kapustin Yar. A town some sixty miles east southeast of Stalingrad on the Akhtuba River, near which the Russians developed launch sites for short-range missiles and later for their Sputniks.

Kelvin scale. A temperature scale that uses centigrade degrees but makes the zero degree signify absolute zero.

Keplerian trajectory. Elliptical orbits described by celestial bodies (and satellites) according to Kepler's first law of celestial motion.

Kepler's laws. The three laws of planetary motion discovered by Kepler (1571-1630) that explain the movements of planets in terms of Copernican concept.

Kerosene. A liquid fuel used in certain rocket engines. Kerosene is a mixture of hydrocarbons produced by distillation from petroleum or oil shale.

Kick rocket. A small rocket engine attached to the base of a satellite or other object capable of giving additional speed of fifty to 100 mph if desired.

Kiwi. An experimental, atomic engine, under study by Atomic Energy Commission.

Knot. A nautical mile per hour, i.e., 1.1516 statute miles per hour.

Laika. Female dog carried as a passenger in Sputnik II.

Laminar flow. A nonturbulent airflow over and about a nose cone or other surface, made up of thin parallel layers.

Launch. Initial motion in transition from static repose to dynamic flight. The moment when the missile is no longer supported by the launcher. Takeoff. See **liftoff**.

Leveled thrust. A rocket powerplant equipped with a programmer or engine-control unit that maintains the output at a relatively constant thrust.

Liftoff. Initial motion along the trajectory of a space weapon or ballistic missile as it rises from the stand under rocket propulsion; the takeoff.

Light-year. Distance traveled in one year by light, which covers 186,284 miles in one second; equal to some 5,880,000,000,000 miles.

Limb. The outer edge of a celestial body, as of the sun.

Limb of the earth. The edge of the earth at the horizon.

Liquid hydrogen. Liquid rocket fuel that develops a specific impulse, when oxidized by liquid oxygen, ranging between 317 and 364 seconds depending upon the mixture ratio.

Liquid oxygen. Oxygen supercooled and kept under pressure so that its physical state is liquid. Used as an oxidizer in a liquid-fuel rocket.

Liquid propellant. Any liquid ingredient fed to the combustion chamber of a rocket engine.

Little Joe. A solid-rocket test vehicle developed by NASA, used especially to test the Mercury capsule.

Logbalnet. Air Materiel Command network for the exclusive use of transmitting ballistic missiles logistical data via electrical media. This includes both ICBM and IRBM.

Lox. Liquid oxygen.

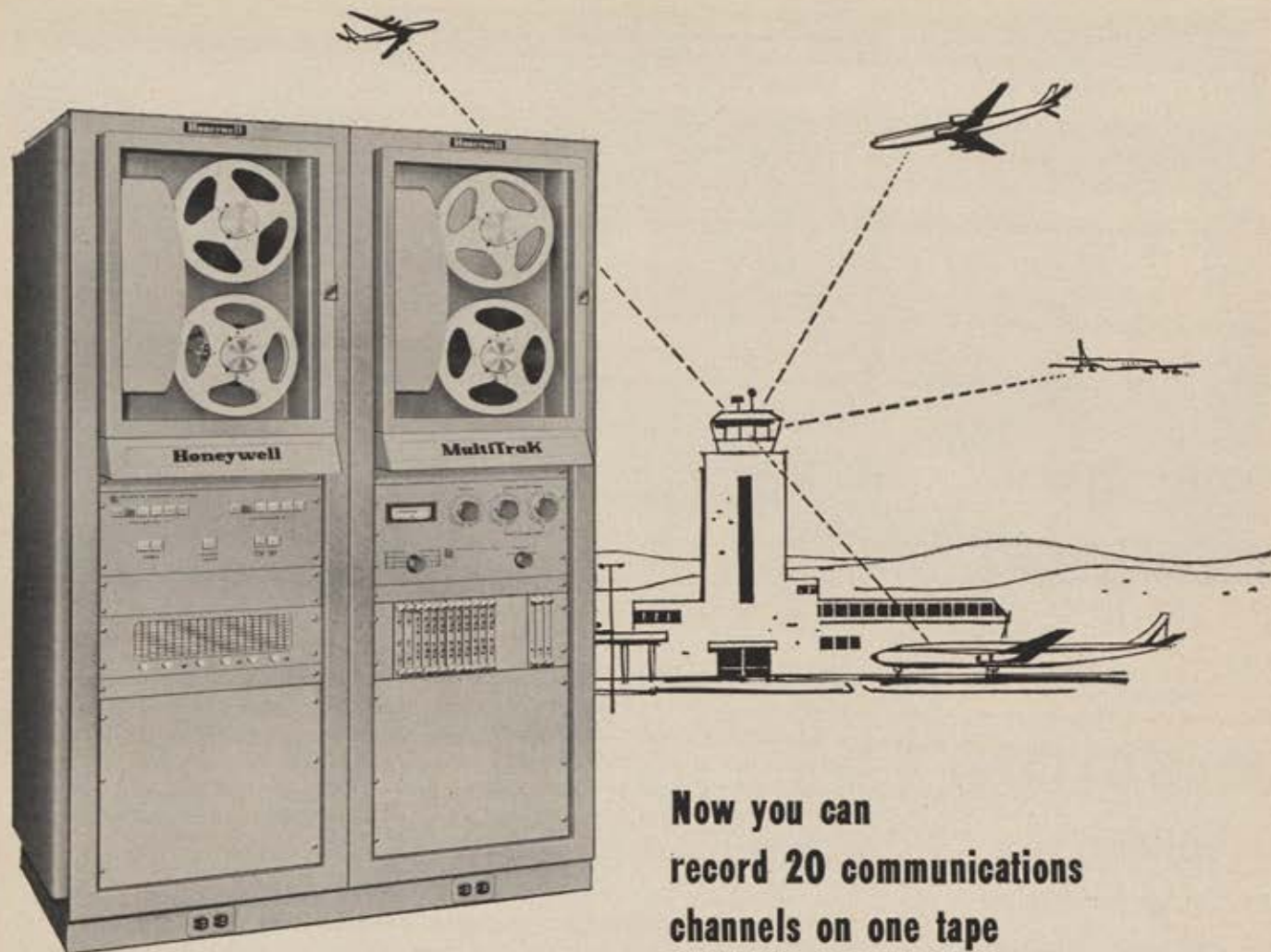
Luminous bands. Faint bands of luminosity appearing in the night airglow.

Lunik. Russian term for space probe launched to moon's vicinity or to impact on moon.

Magnetohydrodynamics. New science dealing with employment of ionized gases in propulsion systems.

Magnitude. Brightness of a star; first magnitude is the brightness of a candle flame at a distance of 1,300 feet. Order of magnitude decreases from first to twentieth at a ratio of intensity.

(Continued on page 159)



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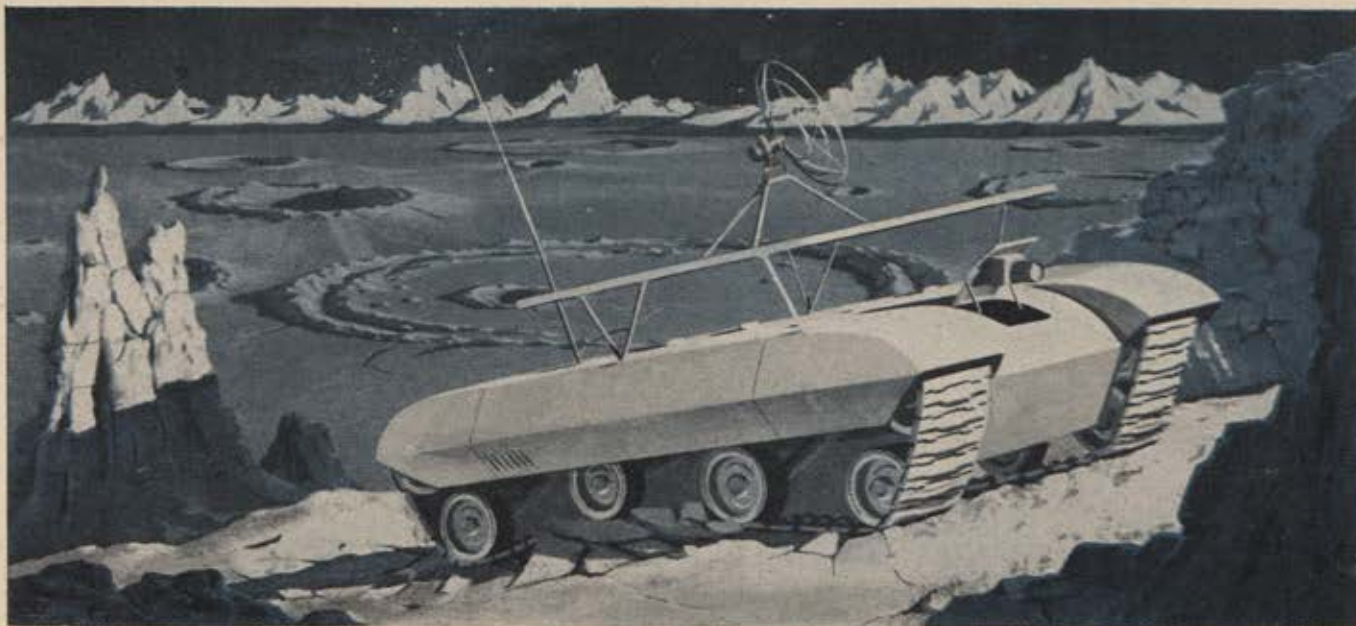
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sity of 2.5; the first magnitude is 100 times brighter than the sixth; stars of the first six magnitudes are visible to the naked eye. Negative value used for objects brighter than first magnitude.

Main stage. In a single-stage rocket vehicle powered by one or more engines, the period when full thrust (at or above ninety percent) is attained. Also, in a multistage rocket, the stage that develops the greatest amount of thrust. Also, a sustainer engine, considered as a stage after booster engines have fallen away.

Map-matching guidance. Guidance of a flightborne vehicle by means of a radarscope film previously obtained by a reconnaissance flight over the terrain of the route.

Mars. The sun's fourth planet, its orbit outside the orbit of the earth.

Mass. The quantity of matter in an object.

Mass ratio. Ratio of a rocket's mass at launch to its mass at burnout.

Mechanical border. That layer in the atmosphere where air resistance and friction become negligible.

Mechanoreceptor. A nerve ending that reacts to mechanical stimuli, as touch, tension, and acceleration.

Mechta. (Russian "Dream"). A Russian space probe or asteroid launched on January 2, 1959, now in orbit around the sun.

Mercury. The planet nearest the sun. Also, the man-in-space program of NASA.

Mesosphere. In the nomenclature of Chapman, a stratum of atmosphere that lies between the stratosphere and the ionosphere, sometimes called the chemosphere. In the nomenclature of Wares, a stratum that extends approximately from 250 to 600 miles, lying between the ionosphere and the exosphere.

Metagalaxy. The entire system of galaxies including the Milky Way.

Meteor. Body originating in space but entering the earth's atmosphere with such velocity as to become incandescent and to appear as a falling star. Such a body encountered outside the atmosphere is normally called a "meteorite" or "meteoroid."

Meteor safe wall. Refers to the protective blanket of atmosphere through which meteors only rarely can penetrate instead of being burned up and vaporized by friction with air molecules.

Midas. Air Force project aimed at developing a system of satellites for detecting ballistic missile launching by infrared and other techniques.

Milky Way. The galaxy to which the earth's sun belongs.

Millstone Hill. Lincoln Laboratory site near Lexington, Mass., location of an eighty-four-foot dish radar antenna.

Minitrack. System for tracking artificial satellite by means of radio waves transmitted from the vehicle itself; several ground stations are required.

Missile. The art or science of designing, developing, building, launching, directing, and sometimes guiding a missile.

Module. A combination of components, contained in one package or so arranged that together they are common to one mounting, which provides a complete function. Sometimes called black box vernacularly.

Momentum. Product of mass times velocity.

Monopropellant. A rocket propellant in which the fuel and oxidizer are premixed ready for immediate use.

MOR. Missile operationally ready.

M storm. Magnetic storm, produced by disturbances on the sun.

Multipropellant. A propellant that consists of two or more liquid ingredients each separated from the others until introduced into the combustion chamber.

National Aeronautics and Space Administration (NASA). Civilian agency exercising control over "aeronautical and space activities" sponsored by the US, except those activities peculiar to or primarily associated with the development of weapon systems, military operations, or the defense of the US.

Nautical mile (NM). A measure of distance equal to 6,076.103 feet or approximately 1.15 mile.

Nebula. Any celestial structure outside the solar system that occupies a perceptible extent in the sky and is not resolvable into stars by large telescopes.

Negative G. Opposite of "positive G." In a gravitational field

or during an acceleration, when the human body is so positioned that the force of inertia acts on it in a foot-to-head direction, i.e., the headward inertial force produced by a footward acceleration.

Neptune. The sun's eighth planet.

Nitrogen tetroxide. A toxic liquid oxidizer, N_2O_4 , insensitive to shock and stable at room temperatures.

Nitromethane. An oily, colorless liquid compound (CH_3NO_2) used as a propellant.

Noctilucent cloud. High-altitude cloud lying at an altitude of fifty miles, appearing only after sunset or before sunrise when contrasted against a dark sky; may consist of volcanic dust or interplanetary matter trapped by temperature inversion.

Node. Either of two points where the orbit of an orbiting body intersects the plane of the orbit of its primary.

Nose cone. Assembly at the upper end of a ballistic missile from which it is separated after the end of propelled flight. The nose cone may contain a warhead or scientific payload.

Nova. Star which undergoes a sudden and enormous increase in brightness; about twenty-five appear every year in our galaxy. (Supernova is a star which explodes with a liberation of most of its energy into space.) Also, a projected satellite vehicle of NASA, powered by liquid multistage rockets.

Nozzle. The exhaust duct of a rocket thrust chamber in which gases are accelerated to high velocities.

Nuclear rocket. Projected rocket in which the energy for the exhaust stream would derive from nuclear fission or fusion.

Null circle. Theoretical point in space where the gravitational attraction of one planet balances that of another planet; there is no actual null point or region because of the constant movement of celestial bodies in relation to each other.

Oberth, Hermann. German pioneer in rocketry theory.

Oculo-graviv illusion (perceptual illusion). During subgravity states, luminous targets seen in the dark appear to move and to be displaced in an upward direction.

Optical star tracker. A star tracker that locks onto the light of a particular celestial body. Distinguished from a radiometric star tracker. See star tracker.

Orb. A spherical body, especially a celestial sphere, as the moon, a planet, or a man-made satellite of that shape.

Orbit. The path described by a celestial body in its revolutions around another body.

Orbital bomber. A vehicle with the capability of orbiting speeds to allow circling the earth one or more times at very high altitudes and then gliding home to earth.

Orbital period. The period of time taken by an orbiting body to make a complete orbit.

Orbital velocity. Velocity needed to keep a body moving in a closed orbit around a sun, planet, or satellite. Orbital velocity of the earth is some 18,000 mph.

Orbit nodes. Points in an orbit where the orbit crosses a reference plane, such as the ecliptic or the equatorial plane.

Orion. Project Orion, ARPA-USAF study of a space platform to weigh several thousands tons, movable by controlled nuclear explosions.

Oxidizer. A rocket propellant component, such as liquid oxygen, nitric acid, fluorine, and others, which supports combustion when in combination with a fuel.

Oxygen-hydrocarbon engine. A rocket engine that operates on propellant of liquid oxygen as oxidizer and a hydrocarbon fuel, such as the petroleum derivatives.

Ozonosphere. A stratum in the upper atmosphere having a relatively high concentration of ozone, important for absorption of ultraviolet solar radiation.

Pacific Missile Range. National missile range located on the West Coast. The Navy is executive agent, with headquarters at Point Mugu, Calif.

Pad. A permanent or semipermanent load-bearing surface constructed or designed as a base upon which a launcher can be placed. Short for launch pad.

Parabola. A conic section made by an intersecting plane parallel to the side of the cone.

Parallax. The apparent displacement of an object, or the

(Continued on following page)

apparent difference in its direction of motion, if viewed from two different points.

Parsec. Astronomical unit of distance equal to 19,150,000,000,000 miles, indicating the distance at which the mean radius of earth's orbit would subtend an angle of one second of arc.

Payload. Useful cargo.

Perigee. Point in an elliptical orbit around the earth which is closest to the earth.

Perihelion. That point on an elliptical orbit around the sun which is nearest to the sun.

Period. Time required for an orbiting body to make a single revolution around its primary.

Perturbation. Effect of the gravitational attraction of one body on the orbit of another.

Phobos. Inner of the two moons of Mars.

Photon rocket. Hypothetical reaction-type powerplant based on directional emission of photons, a continuous quantum of radiant energy moving with the velocity of light.

Photosphere. The outermost luminous layer of the sun's gaseous body.

Picket ship. One of the ocean-going ships used on a missile range to provide added instrumentation for tracking or recovering the missiles.

Pioneer. Any of the space probes launched by the Air Force and Army, under coordination of the National Aeronautics and Space Administration.

Pitch. The movement about an axis that is at once perpendicular to the missile's longitudinal axis and horizontal with respect to the earth.

Pitchover. Turning of a vertically rising vehicle into a course leading to a particular target.

Planet. A spatial body that revolves about the sun or other star.

Planetoid. One of the numerous small planets nearly all of whose orbits lie between Mars and Jupiter. Also called asteroid and minor planet.

Planetology. The study of planets and satellites.

Plasma. An electrically charged gas or body of gas, formed when the gas is subjected to very high temperatures.

Plasma jet. High-temperature jet of electrons and positive ions that has been heated and ionized by the magnetohydrodynamic effect of a strong electrical discharge.

Pluto. The sun's ninth planet, discovered in 1930.

Point defense. Point defense has as its purpose the air defense of specified geographical areas, cities, and vital installations.

Point Mugu. A point on the Pacific coast near Oxnard, Calif., the site of the US Naval Air Missile Test Center, and of the headquarters of the Pacific Missile Range.

Polaris. Navy IRBM. Solid-propellant rocket designed to be launched from nuclear-powered submarines.

Polar orbit. The orbit of an earth satellite that passes over or near the earth's poles.

Polyurethane. A polymeric compound of urethane, used as a fuel in a solid propellant. With its oxidizer, polyurethane has a relatively high specific impulse.

Pontus. Code name for an ARPA project aimed at improvement of structural and power conversion materials.

Positive G. In a gravitational field or during an acceleration, when the human body is normally so positioned that the force of inertia acts on it in a head-to-foot direction, i.e., the footward inertial force produced by a headward acceleration.

Pound of thrust. A measurement unit of the reaction force generated in a jet or rocket engine and available for propulsion.

Power landing. The landing of a spacecraft on a body in space in which the thrust of its motors is used as a brake.

Pressurized cabin. A cabin in an aircraft or spacecraft kept at, or designed to be kept at, an adequate internal air pressure to permit normal respiratory and circulatory functions of persons within it.

Pressurized suit. A garment designed to provide pressure upon the body so that respiratory and circulatory functions may continue normally, or nearly so, under low-pressure conditions, such as occur at high altitudes or in space without benefit of a pressurized cabin.

Prestage. Sequential phase in the starting of a large liquid-propellant rocket engine where initial partial flow of propellants

into the thrust chamber is ignited, and this combustion is satisfactorily established before main stage is ignited.

Primary. The body around which a satellite orbits. Sun is primary of earth, earth of moon, etc.

Principia. Code name for an ARPA project in advanced solid propellants.

POC. Production operational capability.

Programmed roll. An automatically controlled roll of a ballistic missile or satellite vehicle, usually executed during its vertical ascent before pitchover.

Programmed turn. The turn of a ballistic missile from vertical motion, after liftoff, to a curved path approximating the desired powered flight trajectory prior to the initiation of guidance.

Propagation. In missile terminology, to describe the manner in which an electromagnetic wave such as a radar signal, timing signal, or ray of light, travels from one point to another.

Propellant. A liquid or solid substance burned in a rocket for the purpose of developing thrust.

Proxima Centauri. One of the two nearest known stars to the earth, about 4.3 light years distant.

PSI or psi. Pounds per square inch. Used especially as a measure of overpressure.

Pyrophoric fuel. A fuel that ignites spontaneously in air.

Radial velocity. Speed of approach or recession of a body from the point of observation with respect to the earth; can be determined by measuring the Doppler shift between lines of the same elements in the spectra of the star and of a laboratory on the earth.

Radiant energy. Energy that travels as a wave motion, as with radio waves, infrared rays, visible light, etc.

Radiation. The emission and propagation of energy or matter. Energy traveling as a wave motion; the energy of electromagnetic waves. Radiant particles, such as alpha rays or beta rays.

Radio astronomy. Branch of astronomy that utilizes radio waves emitted by certain celestial bodies as a means of obtaining data.

Radio guidance system. A guidance system that uses radio signals to guide a flightborne vehicle.

Radio-inertial guidance. Missile or space weapon guidance system divided into two major groups: the onboard guidance system and flight-control system and the ground-located guidance station.

Radiometer. An instrument that detects and measures the intensity of thermal radiation, especially infrared radiation.

Rate receiver. A guidance antenna that receives a signal from a launched missile as to its rate of speed.

Reaction engine. An engine or motor that derives thrust by expelling a stream of moving particles to the rear.

Readout. A radio transmitter transmitting data either instantaneously with computation of the data or by play of a magnetic tape on which the data has been recorded.

Reconnaissance satellite. An earth satellite designed to obtain strategic information, as through photography, television, etc.

Recovery. The act of retrieving a portion of a launched missile or satellite which has survived reentry.

Red shift. A displacement toward the red in the spectra of extragalactic nebulae that indicates a recession of the structures involved.

Redstone Arsenal. Army facility at Huntsville, Ala., headquarters of the Army Ordnance Missile Command.

Reentry. Return of a part of a ballistic missile or other vehicle to the atmosphere after flight above the sensible atmosphere.

Regenerative cooling. Cooling of a rocket engine by circulating the fuel or oxidizer fluid in coils about the engine prior to use in the combustion chamber.

Reliability. Dependability.

Remaining body. That part of a missile or other vehicle that remains after the separation of a fallaway section or companion body.

Remaining mass. Mass of a rocket missile or vehicle after separation of fallaway section and afterbodies and after the expenditure of fuel; the payload remaining.

Restricted propellant. A solid propellant with restricted sur-

(Continued on page 163)

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faces exposed for burning, the other surfaces being covered by an inhibitor.

Retrograde motion. Orbital motion opposite in direction to that normal to spatial bodies within a given system.

Retrorocket. Relatively small rocket unit, usually solid propellant, installed on a rocket-propelled vehicle and fired in a direction opposite to the main motion to decelerate main unit.

Revolution. The motion or the apparent motion of a body in orbit.

Right ascension. Arc of the celestial equator, or the angle at the celestial pole measured eastward from the hour circle of the vernal equinox to the hour circle of a given celestial body, either through hours or 360 degrees.

RJ-1. A liquid fuel somewhat denser than the kerosene-based fuel RP-1, and with greater energy yield.

Rocket. Self-contained, thrust-producing system that moves by ejecting a stream of hot gas from its rear; powered by either solid or liquid propellant, containing its own means of oxidation, making it independent of the atmosphere.

Rocket airplane. An airplane using rocket propulsion for its main or only propulsive power. Also, an airplane fitted out to carry and fire rocket ammunition.

Rocket sled. A sled that runs on a rail or rails and is accelerated to high velocities by a rocket engine. This sled is used by the Air Force in determining G tolerances and for developing crash survival techniques.

Rockoon. A rocket research vehicle designed to be carried up to very high altitudes by a balloon before being fired.

Roll. The movement of a missile body about its longitudinal axis.

Rotation. The turning of a body about its axis.

Rover. AEC program for the development of a nuclear rocket reactor, initiated by the USAF, supported by NASA.

RP-1. A rocket liquid propellant consisting essentially of kerosene.

Rubber-base propellant. A solid-propellant mixture in which the oxygen supply is obtained from a perchlorate and the fuel is provided by a synthetic rubber latex.

SAC-Mike. Strategic Air Command ballistic missile staff at BMD, Inglewood, Calif.

Satellite. An attendant body that revolves about another body.

Satellite reconnaissance. Strategic reconnaissance conducted by means of data obtained from a satellite.

Satelloid. An artificial body or vehicle like an artificial satellite except that it uses engine thrust (intermittent or continuous) to remain in orbit.

Saturn. The sun's sixth planet. Also, a NASA rocket engine cluster in research and development expected to develop some 1,500,000 pounds of first-stage thrust.

Scintillating counter. An instrument that measures radiation indirectly by counting the light flashes emitted when radiation particles are absorbed.

Scout. A projected solid-fueled probe sponsored by NASA to sound space near the earth.

Scrub. Vernacular for canceling out a scheduled test firing, either before or during countdown.

Sealed cabin. Cabin, especially a spacecraft cabin, sealed against exfiltration or infiltration of any gas, liquid, or solid.

Secondary cosmic radiation. The energetic nuclear debris and ionization caused by the impact of primary cosmic ray particles on atoms and molecules of the upper atmosphere.

Second-of-arc. A measure of an angle 1/60th of a minute.

Seeker. A guidance system which homes on energy emanating or reflected from a target or station.

Selenoid. A lunar satellite.

Sensible atmosphere. That part of the atmosphere that may be felt, i.e., that offers resistance.

Separation. Moment when a full stage, half stage, a warhead, or a nose cone is separated from the remainder of the rocket vehicle; the moment when staging is accomplished.

Shake-table test. A laboratory test in which an instrument component is placed in a vibrator that simulates one of the conditions during the launch of a missile or other vehicle.

Shot. A missile launching.

Shutdown. Synonymous with cutoff. See cutoff.

Sidereal. A measurement of time. A sidereal day, for example, is the time it takes the earth to make a complete revolution measured from the stars. A sidereal day is four minutes shorter than our solar day.

Sidereal period. Time taken by a planet or satellite to complete one revolution about its primary as seen from the primary and as referred to a star.

Silo. A missile shelter that consists of a hardened vertical hole in the ground with facilities either for lifting the missile to a launch position, or for direct launch from the shelter.

Sirius. Brightest star in the heavens, a star of the constellation Canis Major.

Skin tracking. The tracking of an object by means of radar.

Skip-glide bomber. Winged vehicle that is boosted above the atmosphere by rocket power and turned into a somewhat circular orbit before thrust is cut off. From this point, follows an undulating trajectory, glancing or skipping off the upper regions of the atmosphere to slow its speed prior to reentry.

Skirt fog. Cloud of steam and water that surrounds the engines of a missile being launched from a wet emplacement.

Sky screen. An element of equipment used by range safety officer. The sky screen, electronic or optical, provides indication to the range safety officer whenever the missile deviates from planned trajectory.

Slenderness ratio. A configuration factor expressing the ratio of a rocket vehicle's length to its diameter.

Sloshing. Back-and-forth splashing of a liquid fuel in its tank, creating problems of stability and control in the vehicle.

Smithsonian Astrophysical Observatory. An observatory of the Smithsonian Institution established in 1890 in Washington, D. C., but with its headquarters moved to Cambridge, Mass., in 1956.

Soft base. Launching base not protected against atomic attack.

Soft landing. Landing on the moon or other spatial body at such slow speed as to avoid destruction of the landing vehicle. Soft landings on the moon are anticipated by use of retrorockets.

Solar constant. Amount of energy arriving per unit area exposed to unobstructed solar rays at the mean radius of the earth's orbit around the sun.

Solar corona. Outer atmospheric shell of the sun.

Solar corpuscular rays. Cosmic radiation originating from the sun.

Solar flare. Solar phenomenon which gives rise to intense ultraviolet and corpuscular emission from the associated region of the sun, affecting the structure of the ionosphere, interfering with communications.

Solar noise. Electromagnetic radiation which radiates from the atmosphere of the sun at radio frequencies.

Solar time. Time measured by reference to the apparent motion of the sun about the earth.

Solid propellant. Rocket propellant in solid state consisting of all the ingredients necessary for sustained chemical combustion, consisting of a compound of fuel and oxidizer, usually in plasticlike caked form. They burn on their exposed surface, generating hot exhaust gases to produce a reaction force.

Sounding rocket. Rocket used for carrying instruments to high altitudes for "sounding" upper atmosphere.

Space. That part of the universe between celestial bodies.

Space equivalence. A state of being in which a condition or conditions within the atmosphere are virtually identical with a condition or conditions beyond the atmosphere.

Space-fixed reference. An oriented reference system in space independent of earth phenomena for positioning.

Space law. A projected code of international law that would govern the use or control of space.

Space medicine. Study of the medical factors involved in spaceflight.

Space platform. A habitable orbiting installation (normally geocentric) used as a platform for the launch of other space vehicles or for space research.

Space station. Space platform.

Spacesuit. Pressure suit designed for wear in space or at very low-pressure altitudes within the atmosphere, designed to

(Continued on following page)

permit the wearer to leave the protection of a pressurized cabin.

Space-time dilemma. According to Einstein's theory of relativity, time would slow down increasingly for occupants of systems moving at velocities approaching the speed of light, relative to the earth. This slowdown would not be apparent to the inhabitants of the moving system (the spacecraft) until they return to earth.

Spatiography. System proposed by Dr. Hubertus Strughold for charting a "geography" of space.

Specific gravity. The ratio of the weight of any volume of a substance to the weight of an equal volume of another substance taken as standard at a constant or stated temperature. Solids and liquids are usually compared with water at four degrees centigrade.

Specific impulse. The thrust produced by a jet-reaction engine per unit weight of propellant burned per unit time, or per mass of working fluid passing through the engine in unit time. Equal to thrust in pounds divided by weight flow rate in pounds per second.

Speed of light. The speed at which light travels, 186,284 miles per second.

Speed of sound. The speed at which sound waves travel through a medium. In air at standard sea-level conditions, some 750 mph.

Sphere of gravitational influence. Gravisphere.

Spin rocket. A small rocket that imparts spin to a missile's airframe.

Spin-stabilized. Directional stability of a projectile obtained by the action of gyroscopic forces which result from spinning of the body about its axis of symmetry.

Spin table. A flat, round platform on which human and animal subjects can be placed in various positions and rapidly rotated, much as on a phonograph record in order to simulate and study the effects of prolonged tumbling at high rates.

Splash. Proving-ground vernacular for the intentional destruction or impact of a missile that is deviating from the preselected safe range limits or is malfunctioning.

Sputnik. The Russian name for its man-made moons or satellites. The full Russian designation is *Iskustvenyi Sputnik Zewli* "artificial companion of the earth."

Squib. A small pyrotechnic device which may be used to fire the igniter in a rocket or for some similar purpose. Not to be confused with a detonator.

Stage. In a rocket vehicle powered by successive units, one or other of the separate propulsion units.

Stand talker. A person on a static test stand responsible for coordinating and timing preparations.

Star. A self-luminous celestial body exclusive of nebulae, comets, and meteors; any one of the suns seen in the heavens. Distinguished from planets or planet satellites which shine by reflected light.

Star-grain propellant. A solid propellant, its cross-section shaped like a star.

Star tracker. A telescopic instrument on a missile or other flightborne object that locks onto a celestial body and gives guidance to the missile or other object during flight. May be optical or radiometric.

Static testing. Testing of a missile or other device in a stationary or hold-down position, to verify structural integrity, the effects of limit loads, or to measure the thrust of a rocket engine.

Stationary orbit. Also, in reference to earth, known as a twenty-four-hour orbit; a circular orbit around a planet in the equatorial plane, having a rotation period equal to that of the planet.

Step rocket. A rocket with two or more stages.

Strain gauge. A device for measuring thrust on a test stand. See rocket thrust.

Stratopause. The upper limit or limits of the stratosphere.

Stratosphere. A calm region of the upper atmosphere characterized by little or no temperature change in altitude, separated from the lower atmosphere, or troposphere, by the tropopause. Stratosphere is free from clouds and convective currents of the troposphere.

Subgravity. A gravitational effect that is less than one G, i.e., less than the normal measure of the earth's gravity.

Subsatellite. An object designed to be carried into orbit in-

side an artificial earth satellite, but later ejected to serve a particular purpose. For example, an inflatable subsatellite has been designed to measure air density and satellite drag.

Sun. The earth's sun, or star, about which the earth and other planets revolve.

Sunseeker. Two-axis device actuated by servos and controlled by photocells to keep instruments pointed toward the sun despite rolling and tumbling of the rocket vehicle carrier.

Superior planet. A planet that is farther from the sun than the earth, i.e., Mars, Jupiter, Saturn, Uranus, Neptune, or Pluto.

Supersonic. Beyond the speed of sound.

Surface-to-air missile (SAM). A missile, especially a guided missile, launched from the surface to intercept a target in the air.

Sustainer engine. An engine that sustains or increases the velocity of a missile or other aerospace vehicle once it has achieved its programmed velocity by use of booster or other engines.

Sweat cooling. Method of controlling the excessive heating of a reentering body. Surfaces subjected to excessive heating are made of porous material through which liquid of high-heat capacity is forced. The evaporation of this coolant completes the sweat-cooling process.

Synergic curve. A curve plotted for the ascent of an aerospace vehicle determined to give the missile or other vehicle an optimum economy in fuel with an optimum velocity.

Synodic period. The time between two successive inferior conjunctions or between two successive oppositions, as seen from the earth.

Systems engineering. Process of applying science and technology to the study and planning of an over-all missile or aerospace vehicle system, whereby relationships of various parts of the system and the utilization of various subsystems are fully planned and comprehended prior to time hardware designs are committed.

Takeoff mass. The mass of a rocket vehicle and its payload at the time of takeoff.

Takeoff weight. Weight of a rocket vehicle ready for takeoff. This weight includes the weight of the vehicle, the fuel, and the payload.

Tangential ellipse. Also known as a Hohmann orbit. The transfer ellipse from earth orbit to orbits of other planets, designed to use a minimum of fuel.

Telemetering. The technique of recording space data by radioing an instrument reading from a rocket to a recording machine on the ground.

Terminal velocity. Hypothetical maximum speed a body could attain along a specified straight flight path under given conditions of weight and thrust if diving through an unlimited distance in air of specified uniform density.

Terrella. Self-contained manned spaceship in which crew life is maintained during spaceflight by a closed-cycle breathing system.

Terrestrial reference guidance. Technique of missile control wherein predetermined path set into the control system of a missile can be followed by a device in the missile which reacts to some property of the earth, such as magnetic or gravitational effects.

Theodolite. A sighting and measuring telescopic instrument that gives a reading on horizontal or vertical angles.

Thermal barrier. Speed at which friction heat generated by rapid passage of an object through the atmosphere exceeds endurance compatible with the function of the object.

Thermal load. Stresses imposed upon a missile structure because of expansion or contraction (or both) of certain structural elements by aerodynamic heating during flight and reentry, by exposure to the heat of a rocket flame, or by cooling effects of liquid oxygen in the oxidizer system.

Thermosphere. The ionosphere considered as a region of temperature variation from minus twenty-eight degrees F to several thousand degrees F.

Thindown. The process by which cosmic rays, atomic particles, meteoroids, or the like lose their identity or their force as they penetrate into the atmosphere.

(Continued on page 167)

Symbol of Progress

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PYROTECHNICS	THRUSTERS
EXPLOSIVE CHARGES	MOTOR DESIGN & DEVELOPMENT
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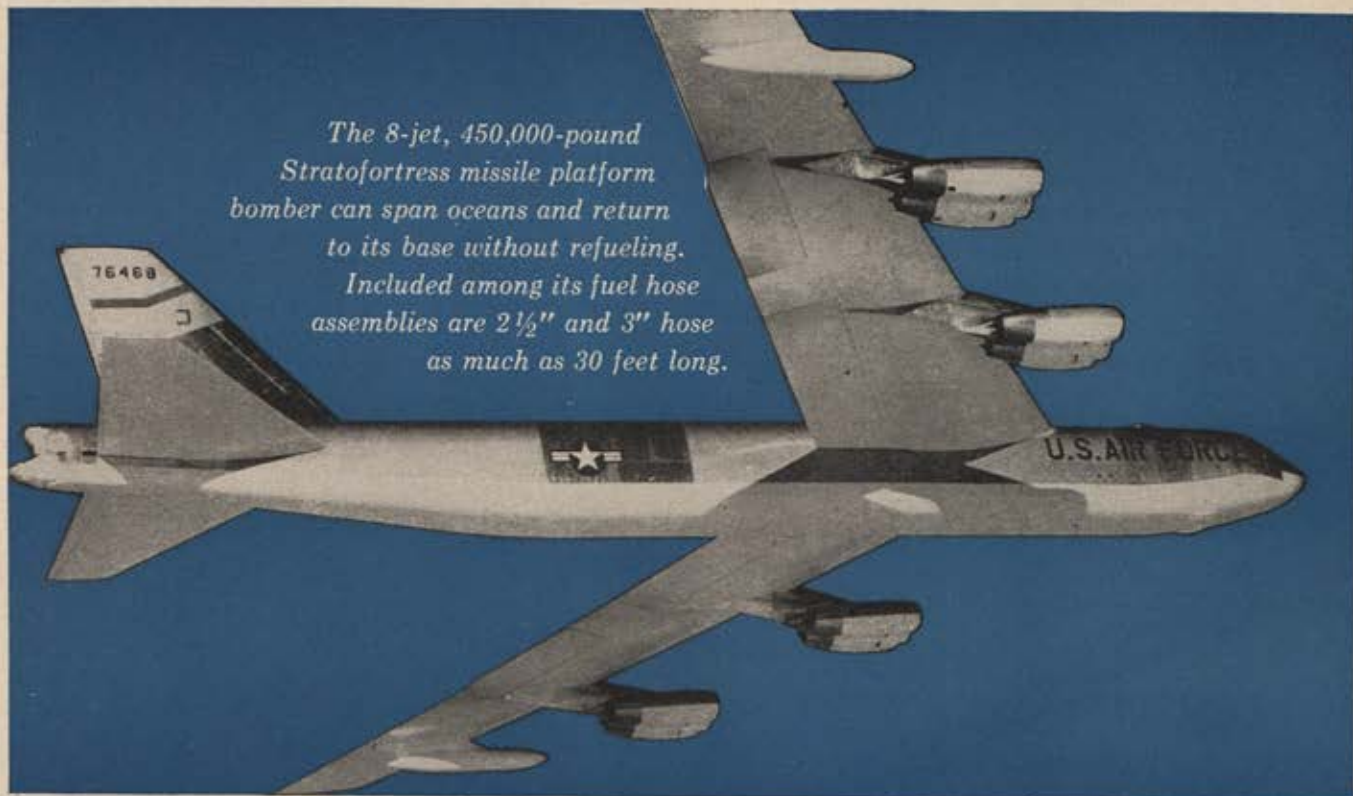
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Throat. In rocket and jet engines, the most constricted section of an exhaust nozzle.

Throatable. Of a nozzle: Designed so as to allow a change in the velocity of the exhaust stream through changing the size and shape of the throat of the nozzle.

Thrust. The amount of "push" developed by a rocket; measured in pounds.

Thrust decay. When a rocket motor burns out or is cut off, propulsive thrust does not fall to zero instantaneously, but progressively declines over some fraction of a second. This graduated reduction and loss of thrust is known as "thrust decay."

Thrust-weight ratio. A quantity used to evaluate engine performance and obtained from dividing the thrust output by the engine weight less fuel. If the pound is used as the unit of measure for thrust and weight, the result is pounds of thrust per pound of engine.

Time dilation. Space-time dilemma. See above.

Tiros. A projected weather satellite using infrared and television, under development by NASA.

Topping the tank. Ground propellant supply system adjacent to the launch stand that replaces the boiloff or vapor loss of propellant as it is consumed during the thrust buildup before liftoff.

Total impulse. The thrust of a jet engine, rocket motor, or rocket engine for the entire time that fuel is burning. Units are expressed in pound sections.

Touchdown. Landing of a manned or unmanned space vehicle on the surface of a planet by any method except gliding. Reverse jets would be the probable method of touchdown.

Trajectory. The path described by a missile or a space vehicle.

Tranquilizer. An instrument that adds stability to a missile's guidance system. Slang.

Transcontinental ballistic missile (TCBM). A ballistic missile with a range capability of 11,000 miles or more.

Transfer ellipse. Path followed by a body moving from one elliptical orbit to another.

Transit. A Navy navigation satellite in development.

Translunar. Beyond the moon.

Transverse acceleration; transverse G. The inertial force produced by an acceleration acting across the body, perpendicular to the long axis of the body, as in a chest-to-back direction.

Tropopause. The upper limit or limits of the troposphere.

Troposphere. The lower layer of the earth's atmosphere, extending to about 60,000 feet at the equator and 30,000 feet at the poles.

Tsiolkovsky, K. E. A Russian engineer and scientist (1857-1935) whose paper "Rockets into Cosmic Space" (1903) was one of the pioneer works in the achievement of rocket flight.

T-time. The moment at the end of a countdown when action is taken to fire a rocket propulsion unit that launches a rocket vehicle or missile.

Tumble. Of an oblong earth satellite: to rotate about its horizontal axis, end over end.

Two-stage rocket. A rocket that has two propulsion systems, each housed in a separate section with its own fuel source, the upper one ignited after separation from the first.

Ultrasonic. Speeds between sonic and hypersonic.

Umbilical cord. Any one of the servicing electrical or fluid lines between the ground and an upright rocket missile or vehicle before the launch.

Universe. The entire spatial cosmos.

UOC. Ultimate operational capability.

Upper air. The atmosphere region embracing the ionosphere and the exosphere. See aerospace.

Uranus. The sun's seventh planet.

Van Allen radiation belts. Two doughnut-shaped belts of high-energy particles, trapped in the earth's magnetic field, which surround the earth. These belts, which form an obstacle to interplanetary explorations, were first discovered by Dr. James A. Van Allen of Iowa State University.

Vanguard. Experimental satellite project developed by US Naval Research Laboratory, later taken over by NASA. The first Vanguard, launched in 1958, is expected to remain in orbit some 200 years.

Vector steering. Vernacular for a steering method where one or more thrust chambers are gimbal-mounted so that the direction of the thrust force (thrust vector) may be tilted in relation to the center of gravity of the missile to produce a turning movement.

Velocity. A vector quantity that includes both magnitude (speed) and direction relation to a given frame of reference. Rate of motion in a given direction, employed in its higher magnitudes as a means of overcoming the force of gravity.

Velocity vector. Combination of two ballistic missile trajectory values; the speed of the missile's center of gravity at a designated point on the trajectory and the angle between the local vertical and the direction of the speed.

Venus. The sun's second planet, and the nearest of the sun's other planets to the earth when at inferior conjunction.

Vernier. Small rocket engines or gas nozzles mounted on missiles which can be fired by commands from the flight-control system to control the roll, pitch, and yaw attitudes during propelled flight. Second function is to make final adjustment of missile velocity as it approaches the thrust-cutoff point.

Warhead. That part of a missile that constitutes the explosive, chemical, or other charge intended to damage the enemy.

Weight. Gravitational force on a mass.

Weight flow rate. The flow rate of a liquid propellant expressed in pounds per second.

Weightlessness. The absence of any apparent gravitational pull on an object. Any object deprived of support and freely falling in a vacuum is weightless. An orbiting satellite above the earth's atmosphere is a special case of "free fall" as is an aircraft when flying a parabolic curve. Weightlessness is experienced in each case.

Wet emplacement. A launch emplacement that provides a deluge of water for cooling the flame bucket, missile engines, and other equipment during the launch of a missile.

Wet-fuel rocket. A liquid rocket.

White Sands Missile Range (WSMR). A proving ground in New Mexico under the control of the Army Ordnance Missile Command as executive agency, used especially for testing short-range missiles over an instrumented range.

Wind tunnel. A tunnel through which a stream of air is drawn at controlled speeds for aerodynamic tests and experimentation.

Wire-guided. Of a missile: Guided by electrical impulses through a wire over a closed circuit between the guidance operator and the missile.

Woomera Rocket Range. A rocket range located in inland South Australia, at which British missile flight tests are made.

Wright Air Development Division (WADD). An ARDC center at Wright-Patterson AFB, Ohio, conducting research, development, tests, and evaluation in aerodynamics, human factors, materials, electronics equipment, and aerospace sciences.

X. Symbol for experimental.

X-15. Manned research vehicle being built for USAF, NASA, Navy by North American; to make exploratory flight studies of aerodynamic heating, stability, control, and reentry problems of hypersonic flight and spaceflight, probably at altitudes of 50-100 miles.

X-time. Time remaining before launching of a missile, according to a schedule established by launch control personnel.

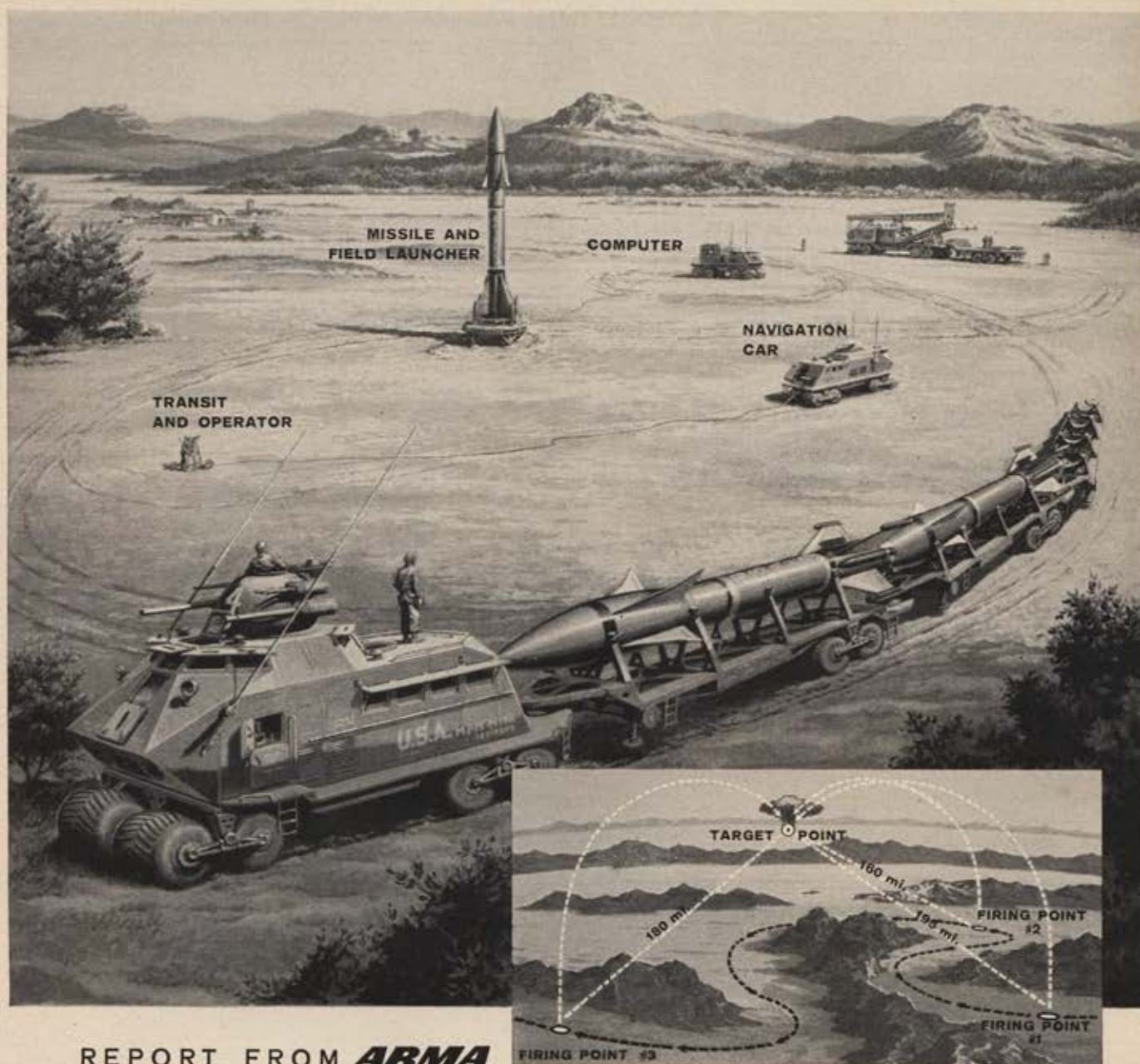
Y. Symbol for prototype.

Zero. To zero in. To bring a missile exactly into a position where it can be directed toward target. To adjust any device to an intended purpose so that automatic synchronization results.

Zero gravity. Weightlessness.

Zodiac. Belt on the celestial sphere on which the moon, sun, and planets appear to move about the earth, the middle line of the belt being the ecliptic or the sun's path.

Zodiacal band. Faintly luminous band of light appearing on the celestial sphere, connecting the zodiacal light with the Gegenschein. Caused by an extension of the solar corona out and beyond the earth.—END



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A Missile and Space BIBLIOGRAPHY

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9:00 AM USAF Command Briefing
9:00 AM AFA Leaders Meeting
11:00 AM USAF Command Briefing
12:30 PM Aerospace Luncheon
3:00 PM USAF Command Briefing
3:00 PM 1st AFA Business Session
7:00 PM Panorama Preview Reception

FRIDAY—SEPTEMBER 23

9:00 AM 2d AFA Business Session

9:00 AM USAF Procurement Seminar
12:00 N Buffet Luncheon
12:00 N Panorama Open
3:00 PM USAF Command Briefing
3:00 PM 3d AFA Business Session
7:45 PM Awards Banquet

SATURDAY—SEPTEMBER 24

9:00 AM Annual Symposium
12:00 N Panorama Open
6:00 PM Nob Hill Reunion Party
9:30 PM Golden Gate Reunion Ball

SUNDAY—SEPTEMBER 25

12:00 N Panorama Open to Public

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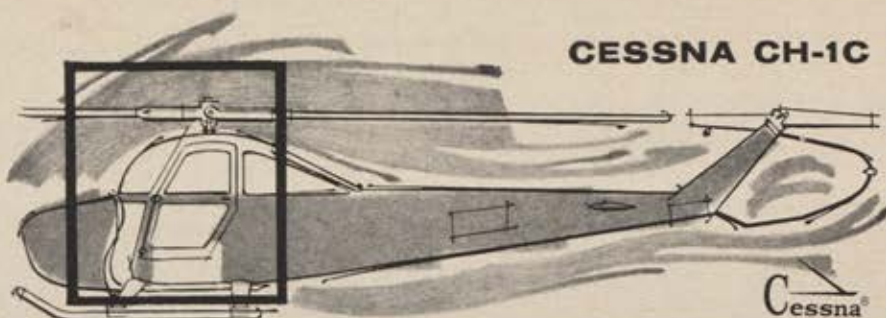
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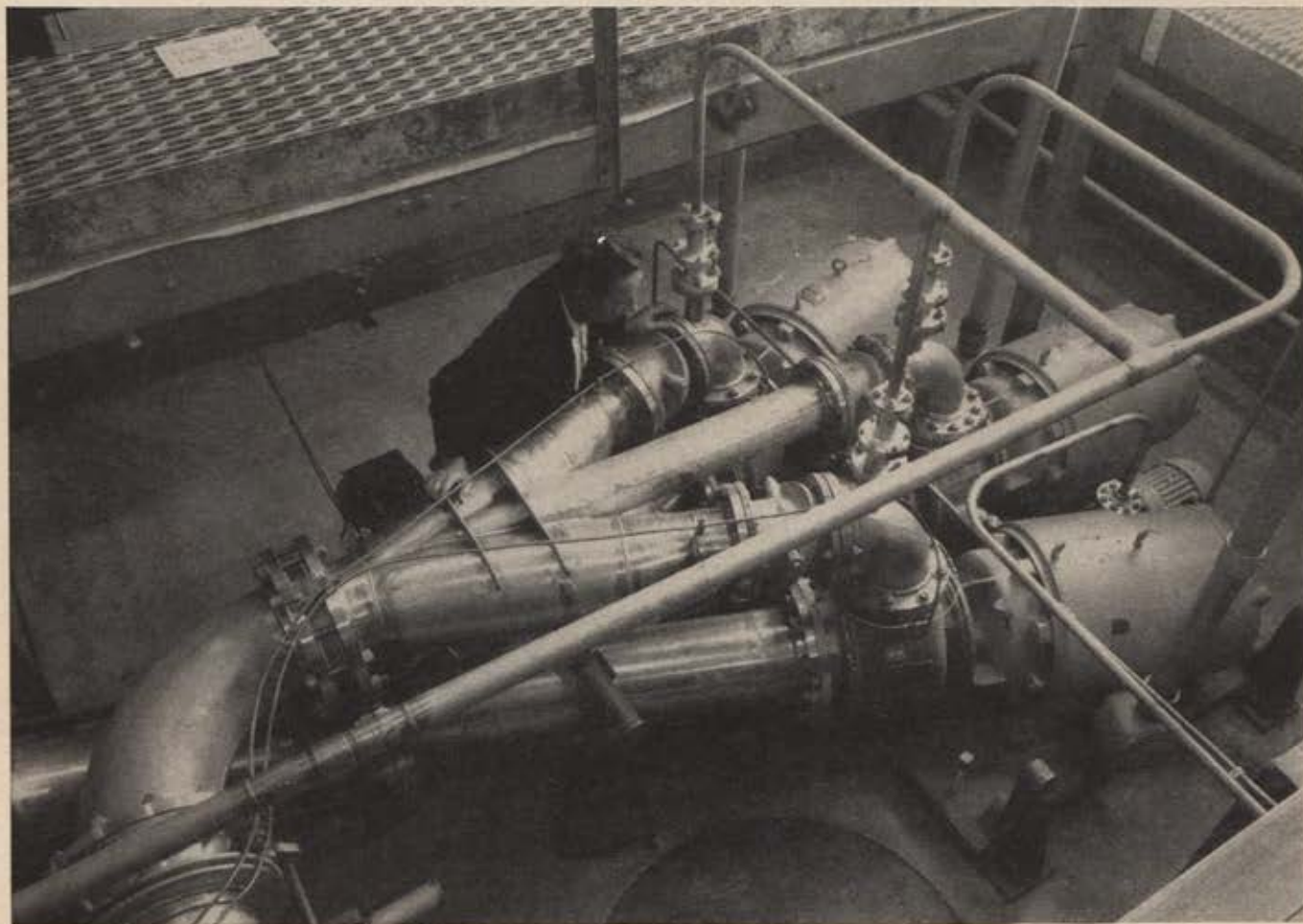
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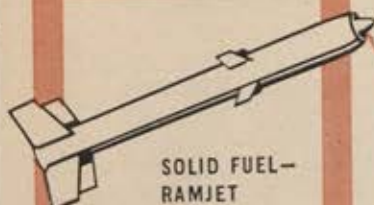
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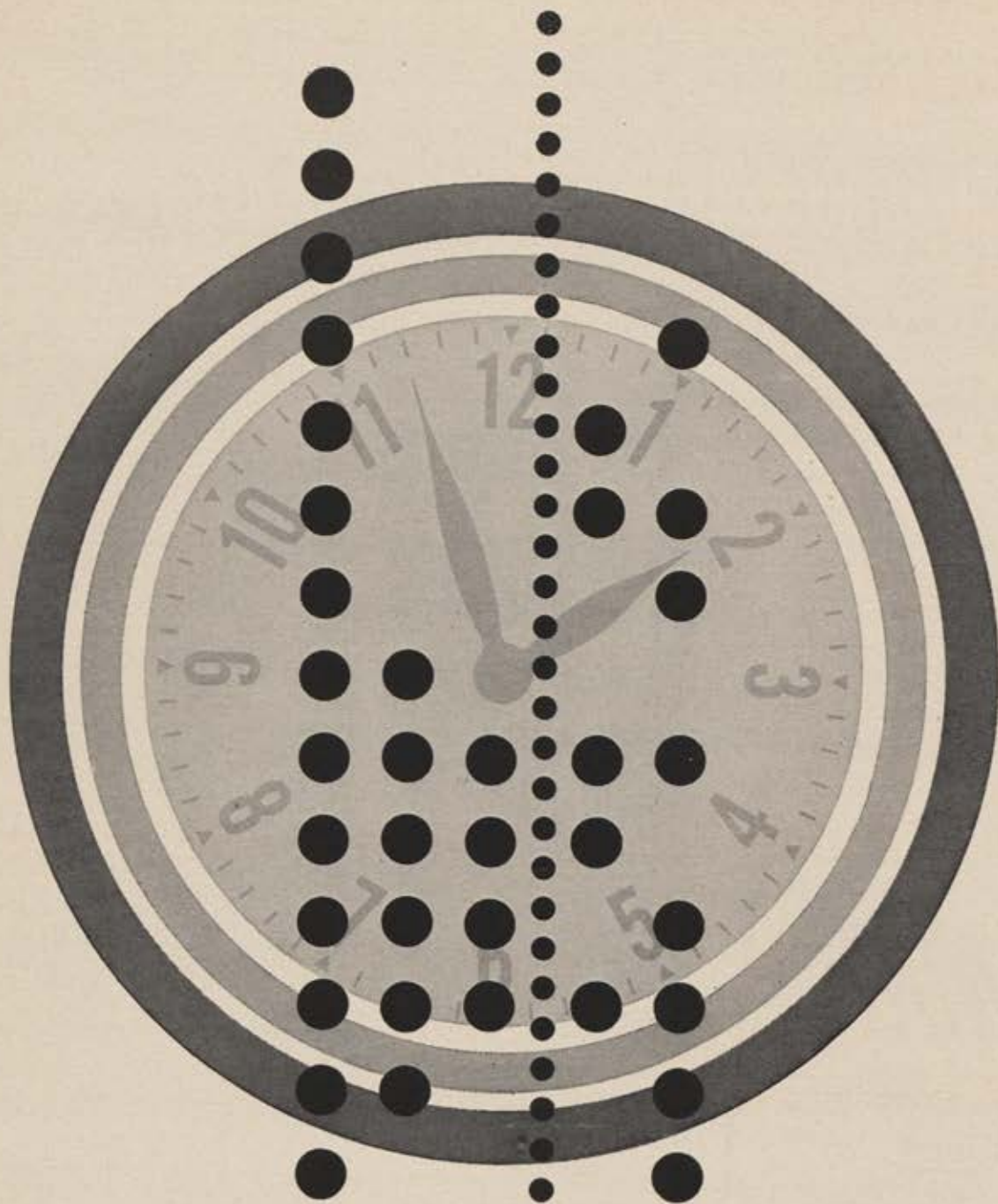
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TACTICAL COMMUNICATIONS:

*
CRIMEA
1854

... 'Forward the Light Brigade!
Charge for the guns!' he said.
Into the valley of Death
Rode the six hundred.

* ... Was there a man dismay'd?
Not tho' the soldier knew
Someone had blunder'd.
Theirs not to make reply,
Theirs not to reason why,
Theirs but to do or die,
Into the valley of Death
Rode the six hundred.

... Cannon to right of them,
Cannon to left of them,
Cannon behind them,
Volley'd and thunder'd;
Storm'd at with shot and shell,
While horse and hero fell,
They that had fought so well
Came thro' the jaws of Death...
... All that was left of them,
Left of six hundred.

ALFRED LORD TENNYSON



RICHARD CATON WOODVILLE, JR. "Charge of the Light Brigade." Parker Gallery, London

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